Semantic Annotation of Anaphoric Links in Language¹

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Abstract The main purpose of this paper is to make some linguistic contributions to an ISO initiative to formulate a standard on the semantic annotation framework of reference, coreference, and other types of anaphoric phenomena in natural language. For this purpose, we first make a brief review of some of the existing coreference annotation (CA) schemes. We then formulate an abstract syntax *ASyn_{ana}* for anaphoric annotation on which a variety of concrete syntaxes such as an XML-based concrete syntax *CSyn_{anaX}* can be developed to provide an interoperable representation format for the annotation. To satisfy the semantic adequacy of the proposed abstract syntax even partially, we check the possibility of developing formal semantics based on it. Such a semantics may be accepted as a valid application of the proposed annotation scheme. We finally consider the multilingual applicability of proposed *ASyn_{ana}* by applying it to Korean, a non-inflectional agglutinating language with *pro*-drop properties.

Keywords Abstract Syntax, Anaphoric Link, Annotation, Concrete Syntax, Coreference, Formal Semantics, Semantic Annotation

1 Introduction

Datasets are important for any linguistic analysis at least in two respects.

- (1) a. Datasets make the analysis data-oriented with its focus on real data.
- b. Datasets provide a basis of validating theoretical claims.¹

This paper thus presents two sorts of datasets of language fragments: one sort of datasets in English and another in Ko-

rean. The English datasets are used to carry the general discussion of anaphoric links in language, whereas the Korean datasets are used to check how it applies to non-European languages like Korean, a non-inflectional language known as an *agglutinating* language with *pro*-drop properties.

While the Korean datasets are introduced in Section 7 Application to Korean, here is a fragment of the English dataset as in (2), a somewhat bizarre story from an undisclosed, but freely available source:²

- (2) Not long ago {a retired professor_{mt1} of a small university_{mt2} in Essex_{mt3}}_{mt4} lost {his_{mt5} wealthy wife_{mt6}}_{mt7}, who_{mt8} had been ill for {over ten years}_{mt9}. After {her_{mt10} death_{mt11}}_{mt12}, {the professor}_{mt13} and {their_{mt14} only daughter_{mt15}}_{mt16} found {a large sum of money}_{mt17} left for them_{mt18} to share.

Billy Jones_{mt19}, 84, wanted to remarry and found {a charming young Vietnamese woman_{mt20}}_{mt21}, aged 24, 40 years younger than his_{mt22} own daughter_{mt23}. He_{mt24} told her_{mt25} that, if she_{mt26} agreed to marry him_{mt27}, she_{mt28} would receive {eighty million pounds}_{mt29} – {a million pounds}_{mt30} a year_{mt31} – right after their_{mt32} marriage_{mt33} and also inherit the rest_{mt34} after his_{mt35} death_{mt36}. The lady_{mt37} refused his_{mt38} tempting offer_{mt39}, instead marrying {a young British bandmaster_{mt40}}_{mt41} with {no promising career_{mt42}}_{mt43}.

This short story contains at least 43 noun phrases (NPs) of various forms that mention or refer to something, called *discourse entity*, in the universe of discourse, a non-empty set of discourse referents (see [38] and [39]). Each of these phrases, which are technically called *mentions*, is uniquely identified with an integer and its prefix *mt* that stands for *mention* in the text.³

Most of the mentions are referentially grounded, namely referring expressions, and some of them are also identified as having coreferentially or, in more general terms, anaphorically related to others. To understand the whole story told by this short item, one should recognize these coreferential relations among the so-called mentions. The noun phrase *A former head teacher*_{mt1} or the larger phrase *a retire professor*_{mt1} and the name *Billy Jones*_{mt19}, for instance, refer to the same

¹This paper focuses on the design aspect of semantic annotation schemes based on the notion of *abstract syntax* validated with some consistent semantic interpretation of annotations. It does not present any corpus-based statistical analysis nor follows any big data approach to check the efficiency or other computational properties of an annotation scheme proposed.

²Its grammaticality and relevance were checked by two native speakers of English, David Lovisek and Gary Clay Rector.

³Not every mention refers to an (individual) entity (e.g., *no man*).

person and so do the noun phrase *a charming young Vietnamese woman*_{mt21} and the noun phrase *The lady*_{mt36}.

Each of such pairs that refer to the same entity in the discourse referents consists of two mentions, one called ‘anaphor’ and the other its ‘antecedent’. They are also said to co-refer or be coreferential.

The antecedent of an anaphor may be split into more than one. The pronoun *their*_{mt14} in the first paragraph of the story, for instance, has its antecedent split into two mentions, *a retired professor*_{mt1} or *the professor*_{mt13} and *his wealthy wife*_{mt7}.⁴ There are half a dozen occurrences of pronouns such as *his*, *her*, *he*, *she*, *their*, and *them* that refer to either *Billy Jones*_{mt13}, *his wife*_{mt6}, their daughter or the Vietnamese lady. The two pronouns *their*_{mt14} and *them*_{mt18} have two different sets of antecedents: the first one has *professor*_{mt1} and *wife*_{mt6} and the second one *professor*_{mt1} and *daughter*_{mt15} as their respective antecedents.

The scope of mentions can be taken as being either wide or narrow. In ordinary practice, this difference does not matter. The antecedent of the pronouns *his*_{mt5} may be taken narrowly as being *professor*_{mt1} or widely as being a retired professor of a small university in Essex_{mt4}. Only if necessary, this difference can be marked up as is being done by [30].

The study of reference, coreference, and other anaphoric relations has a long history with a very long list of literature. In the past several decades alone, a tremendous amount of work has been done in the area of syntax and semantics: generative grammar, for instance, has proposed various structural conditions and constraints on pronominalization and reflexivization, while formal semantics such as Montagovian semantics adopted model-theoretic denotational approaches, especially to the treatment of general quantification and variable binding. To cite a few, [77] started discussing constraints on variables that appear transformational rules in syntax and [49] introduced the structural notion of *command* between a referring expression and an anaphoric expression that played an important role in determining coreference and other related relations. [60] opened a new arena where both linguists and philosophers got engaged in analyzing and interpreting various types of quantifiers and pronouns or variables in language in the framework of higher-order formal logic and their scope and binding phenomena. This paper, however, has no intention to survey all this linguistic history that extends from syntax to semantics to pragmatics with discourse analysis, but focuses on a small area of most recent work by computational linguists on so-called *coreference annotation* (CA).

Reference or coreference resolution is a big issue in computational linguistics, especially in the area of information extraction (IE). There have been several important publications that deal with that issue: to cite some, we have: [30], [15], [23], [24], [72], [83], [84], [73], and [86]. We do refer to them at times, although coreference resolution (CR) differs technically from coreference annotation (CA) in which this paper focuses on.

While referring to these works and others to be cited, this paper aims at constructing a semantic annotation scheme (AS) for coreference and other anaphoric link phenomena in a language (English) that may be proposed as an ISO standard for language resources management.⁵

The rest of the paper develops into seven sections. Section 2 reviews the five existing ASs, but in a non-critical way:

1. [5],
2. [85],
3. [30]’s MUC-7 Coreference Task Definition (CTD),
4. [64] and [65, 66]’s MATE/GNOME scheme revived by [82], and
5. [70]’s ISO-Space AS.

Section 3 shows how it adopts a two-level AS for anaphoric annotation, as followed by most of the anaphoric ASs. Given an input text, the first level simply identifies the whole set of referring or anaphoric expressions, called ‘mentions’, as possible markables. The second level is complex, consisting of three steps:

- (3) a. Selecting possible anaphors from the set of possible markables.
- b. Paring each of the selected anaphors with their antecedent(s).
- c. Specifying the type of each anaphor-antecedent relation, called ‘anaphoric’ link.

Each of these three steps listed in (3a,b,c) is constrained and triggered by a small set of attribute-value specifications for each anaphor-antecedent pair of the mentions and each type of the anaphoric link.

Section 4 Formal description forms the main part of the paper that proposes (1) an integrated annotation scheme *ASyn_{ana}* for coreference and other anaphoric relations as an abstract syntax and (2) an XML-based concrete syntax *CSyn_{anaX}* derived from it with concrete attribute-value specifications. It is followed by section 5 Illustrations.

Section 6 shows how semantic forms are compositionally derived from each of the XML-represented annotations (XML-elements). This semantic section is an attempt to prove the semantic adequacy of the proposed *ASyn_{ana}* at least in informal terms. This task is required by the general semantic principles on semantic annotation frameworks which are laid down in [36].

⁴ [70] calls this a case of split antecedent, whereas [78] views this as an instance of multiple antecedent.

⁵In July 2015, the 24 principal voting national members of ISO/TC 37/SC 4 (chair: Nicoletta Calzolari, secretary: Key-Sun Choi) approved the proposed work item on the semantic annotation of reference, coreference, and other anaphoric relations in language as part of an ISO international standard on semantic annotation framework and allocated it under its working group WG 2 Semantic Annotation (convenor: Kiyong Lee). This proposal is now at the drafting stage with the official title, *ISO AWI 24617-9 Language resource management - Part 9: reference (ISOREf)* (Project leaders: Laurent Romary and Kiyong Lee).

Section 7 Application to Korean is added to the original paper in order to test the multilingual extensibility of *ASyn_{ana}* with a possible modification of attribute-value specifications for a concrete syntax based on it. No corpus-based analysis is, however, presented, for that task alone requires a series of reports.

The abstract syntax of *ASyn_{ana}* with its concrete syntax *CSyn_{anaX}* presented in this paper is an extensively revised version of that presented by [54] with more formal rigor. Section 7 is a totally new addition to [54]. Section 8 concludes the paper with some summarizing remarks.

2 Review of Existing Annotation Schemes

2.1 Preliminaries

There are several types of the anaphoric relation. The best known type is coreference, an equivalence (symmetric, transitive, and reflexive) relation, that holds between two terms, called ‘mentions’, if and only if their denotations are identical.

(4) Definition-1: Coreference

Two terms t_1 and t_2 corefer iff $[[t_1]]^M = [[t_2]]^M$,
where $[[t_i]]^M$ is the denotation or referent of a term t_i with respect to a model M .

Coreference and binding are two different, but related linguistic phenomena, often discussed together. Consider examples (5a,b):

- (5) a. *John* loves *his* mother. [coreference]
b. *Everyone* loves *his* mother. [binding]

In (5a), the pronoun *his* may be understood as coreferring with the name *John* as its antecedent. In (5b), on the other hand, the pronoun *his* does not corefer with the quantified noun phrase *everyone*, but is treated in formal semantics as a variable bound by the universal quantifier. This paper attempts to accommodate both the type of coreference, as defined in (4), and some other types of anaphoric phenomena, such as the one illustrated in (5b), into the proposed *ASyn_{ana}* with an XML-based concrete syntax *CSyn_{anaX}*.

2.2 Coindexing

In linguistics, coreference and binding are both annotated in the same manner by coindexing, as shown below.

- (6) a. $John_i$ loves his_i mother. [coreference]
b. $Everyone_i$ loves his_i mother. [binding]

Split antecedents can also be represented by coindexing with a set index such as $\{x, y\}$. Here are some examples, (7a,b,c), taken from [78]:

- (7) a. $Mary_1$ told $John_2$ that $they_{\{1,2\}}$ should invest in the stock market.

- b. Every woman₁ told [her₁ husband]₂ that $they_{\{1,2\}}$ should invest in the stock market.
c. Every man₁ told [each of his₁ girlfriends]₂ that $they_{\{1,2\}}$ were going to get married.

Coindexing is not, however, expressively powerful enough to mark up details of anaphoric relations. The treatment of reciprocal pronouns is one of such cases.

- (8) a. $They_i$ love *each other_i*.
b. If *everyone_i* were to love *one another_i*, then *they_i* wouldn't want me to make a sacrifice, ...

More than mere coindexing is called for an adequate interpretation of the anaphoric phenomena shown in (8).

2.3 The TEI-based Annotation Schemes

2.3.1 Overview

There are two almost identical ASs for coreference: [5] and [85]. They are both based on XML and also on *the TEI Guidelines*. They differ from each other mainly because [5] followed a much earlier version of *the TEI Guidelines*, while [85] is the most recent version, updated December 2016.

2.3.2 [5]

The AS, proposed by [5], consists of two (XML) elements: <rs> for referring strings and <link> for coreference. For each of the two elements, we can specify their associated attributes and possible values:⁶

- (9) a. Attributes for the Element <rs>:
attributes = type, key;
type = "object";
key = ID;
b. Attributes for the Element <link>:
attributes = type, targets;
type = "coref";
targets = IDREF IDREF.

Here is an example:⁷

- (10) <s>Kill <rs type="object" key="01">an active, plump chicken</rs>. Prepare <rs type="object" key="02">it</rs> for the oven, cut <rs type="object" key="03">it</rs> into <rs type="object" key="04">four pieces</rs> and roast <rs type="object" key="05">it</rs> with thyme for 1 hour.</s>
<link type="coref" targets="02 01"/>
<link type="coref" targets="03 02"/>
<link type="coref" targets="04 03"/>
<link type="coref" targets="05 04"/>

⁶As a specification language, we adopt [31] Extended BNF (Backus-Naur Form) that can be converted into a document type definition (DTD).

⁷[5] annotated a French version of the original English example (16) that occurs in [4], page 202.

The chain of coreference relations may not preserve the original identity. In example (10), the live chicken₀₁ was killed and cut into four pieces₀₄ and became roasted chicken₀₅.⁸

2.3.3 [85]

[85] (16.5.1) discusses correspondence between textual segments:

- (11) `<title xml:id="SHIRLEY">Shirley</title>, which made its Friday night debut only a month ago, was not listed on <name xml:id="NBC">NBC </name>'s new schedule, although <seg corresp="#NBC" xml:id="NETWORK"> the network</seg> says <seg corresp="#SHIRLEY" xml:id="SHOW">the show </seg> still is being considered.`⁹

In this textual fragment, the name *Shirley* is annotated as the title of a show being broadcast over NBC, a television network. The text contains no pronominal forms, but the two nominal forms, *the show* and *the network*, are understood as corresponding to the two names *Shirley* and *NBC*, respectively. The annotation of the two segments, namely those nominal forms, right above introduces the attribute `@corresp` to indicate such a coreferential relation for each of the two.

As shown by (12), the use of the elements `<linkGrp>` and `<link>` makes correspondence relations more explicit:

- (12) `<linkGrp type="anaphoric_link" targFunc="antecedent anaphor"> <link target="#Shirley #show"/> <link target="#NBC #network"/> </linkGrp>`

The annotation (12) represents two instances of the anaphoric link involving anaphors and their antecedents. The attribute `@target` has two arguments, as specified by the attribute `@targFunc`: the first argument is antecedent and the second anaphor. The element `<linkGrp>` allows several instances of the anaphoric link to be grouped together, while simplifying the specification of the element `<link>` with a single attribute `@target`.

2.4 The MUC-7 Coreference Task Definition

2.4.1 Overview

[30]'s CTD (Coreference Task Definition) lists four purposes of constructing an AS in the order of their importance. The first two are: (1) to support the MUC (Message Understanding Conference) information extraction tasks and (2) to be able to achieve good (ca. 90%) inter-annotator agreement.

⁸The original annotation of the French version given in [5] was modified to suit the English example (10).

⁹The hash sign # indicates that each item preceded by # such as #NBC and #Shirley in example (11) has occurred somewhere in the annotated fragment. The #NBC which is given as a value of the attribute `@corresp` in the element `<seg>` occurs in the `<name xml:id="NBC">`.

Creation of a corpus for research on coreference and discourse phenomena is the last goal.

The MUC projects were taken up by [17] of NIST (National Institute of Standards and Technology) and other organizations working on linguistic data. [57] then produced detailed annotation guidelines on the annotation of entities and locations with the specification of their types. [1] then recently compared the annotation works, ACE, ERE, TAC-KBP, and FrameNet annotation standards focusing on event annotation. Besides the annotation of entities, the research interest in event annotation was kept by works such as [2]. The report by [67] introduces the CoNLL2011 project with OntoNotes. In this paper, we just focus on [30] to see how anaphoric annotation started in earlier stages.

2.4.2 Markables

[30]'s CTD restricts the set of its markables to nouns, that is, names, noun phrases, or pronouns¹⁰. Noun phrases include dates (*January 23*), currency expressions (*\$1.2 billion*), percentages (*17 %*), and temperatures (*70 degrees*) that contain numerical values. Possessive, demonstrative, and reflexive pronouns are markables. So are the first person pronouns. The interrogative pronouns (*who*, *which engine*) are not markables.

In [30], verbs and other verbal forms such as gerunds (*Slowing the economy*) are not markables.¹¹ Implicit pronouns, that is, null anaphora (*Bill_i called John and e_i spoke with him for an hour.*) and presumptive or intrusive pronouns (*the movie_i which I saw t_i*)¹² as well as relative pronouns (complementizers) are not treated as markables.

2.4.3 Extents

The extent of a markable is a maximal string, while its head is marked with an attribute MIN (minimal string). The maximal noun phrases thus include their modifiers, appositional phrases, non-restrictive relative clauses, and prepositional phrases (*Fred Frosty, the ice cream king of Tyson's Corner*, MIN="Fred Frosty").

2.4.4 Coreference Links

Coreference in [30] is not restricted to referential identity. Here is the general principle for the annotation of coreference that they proposed:

(13) Definition 2: Coreferential

Two markables are coreferential if they both refer to sets, and the sets are identical, or they both refer to types, and the types are identical.

The principle (13) thus allows the possible coreferentiality between bound anaphora and quantified NPs that are their antecedents.

¹⁰All of the examples given in subsection 2.4 are copied from [30].

¹¹The phrases *program trading*, *excessive trading*, *slowing of the economy* are noun-like, so they are treated as markables.

¹²See [16], [19], [20], and [88] for detailed discussions of interpreting various uses of pronouns and [80] for presumptive and intrusive pronouns.

Examples (14) are given by [30] to illustrate bound anaphoric relations.¹³

- (14) a. {Most computational linguists}_i prefer their_i own parsers.
 b. {Every TV network}_i reported its_i profits yesterday. They_i plan to release full quarterly statements tomorrow.

2.4.5 An SGML Serialization

[30] represents its coreference annotation in SGML. It introduces only one element <COREF> for the annotation of markables and also of their coreferential link type IDENT with the following specification of attribute-values:

- (15) List of Attributes and Possible Values for <COREF>
 ID=INTEGER;
 MIN=CDATA; { * Head of the whole extent * }
 REF=IDREF; { * Antecedent * }
 TYPE=IDENT;
 STATUS=OPT; { * if the reader is uncertain about the identity relation. * }

2.4.6 Illustrations

Examples (16) and (17) are copied from [30]:

- (16) <COREF ID="100">Lawson Mardon Group Ltd.</COREF> said <COREF ID="101" TYPE=IDENT REF="100">it</COREF>
 (17) Our <COREF ID="102" MIN="Board of Education">Board of Education</COREF> budget is just too high. The Mayor said <COREF ID="102" STATUS="OPT" TYPE="IDENT" REF="102">Livingstone Street</COREF> has lost control.

In example (17), the annotator is uncertain about the IDENT relation of the Board of Education and Livingstone Street, although they are locally identical. That is why STATUS="OPT" is introduced into the annotation (17).

Conjoined noun phrases are treated as one extent in example (18).

- (18) <COREF ID="1" MIN="boys and girls">The sleepy boys and girls</COREF> enjoy <COREF ID="2" REF="1" TYPE="IDENT">their</COREF> breakfast.

In example (19) there are two occurrences of *president*, but they are not annotated as being coreferential. <COREF ID="7"> has neither REF nor TYPE specified as being IDENT.

- (19) <COREF ID="5">Fred</COREF> resigned as <COREF ID="6" MIN="president" REF="5">president of IBM</COREF>; next month, <COREF ID="7">the president</COREF> will be <COREF ID="8" REF="7">Mary</COREF>

Bound anaphors are treated in (20).

- (20) <COREF ID="1" MIN="man">every man who knows<COREF ID="2" REF="1" TYPE="IDENT">his</COREF>own mind</COREF>

The entire string *every man who knows his own mind* and the pronoun *his* are annotated as coreferring with their relation type being IDENT. There are many other illustrations, for instance, for the annotation of apposition, predicate nominals and time-dependent identity, types and tokens, functions and values, and metonymy.

2.5 The MMAX2 Multi-level Annotation Scheme

2.6 Overview

[79] use [61]'s GUI-based MMAX2 annotation tool for coreference resolution to build a fully coreference-annotated large corpus of 266 scholarly papers from the ACL anthology. Here we briefly introduce the MMAX2 coreference AS.

2.6.1 Markables

Only proper names, noun phrases, and pronouns are markables, called possible entity 'mentions'. There are 8 mention types: (1) def-np (definite NPs), (2) pper (personal pronouns), (3) ne (proper names including citations), (4) ppos (possessive pronouns/determiners), (5) indef-np (indefinite NPs), (6) conj-np (coordinations), (7) pds (demonstrative pronouns), and (8) reflexive (reflexive pronouns).

Unlike [30], this AS treats relative pronouns (*who*, *which*, *whose*, *that*, ...) as markables and excludes bound anaphora (*{Every teacher}_i likes his_i job.*) as well as predicative nominals (*{A mason}_i is {a workman}_i.*).

2.6.2 Anaphoric Links

Following [86] and their two other related works, [47, 48], this AS differentiates coreference from other types of the anaphoric link. It suggests that the annotation of coreference proper be separated from other tasks such as annotation of bound anaphors and of the relation between a subject and a predicative NP. It calls for a division of labor that achieves better inter-annotator agreement.

2.7 The MATE Annotation Scheme

2.7.1 Overview

The MATE annotation scheme for anaphoric relations has been developed mainly by [64], [65], and [66]. It has accommodated several annotation schemes including the two

¹³Each extent is marked with a pair of stars (*) in [30], but these stars are replaced with curly brackets in this paper.

annotation schemes, the TEI-based AS by [5] discussed in 2.3 and the MUC-7 CDT by [30] discussed in 2.4. Its application domain extends from ordinary text to dialogues to discourses with the GNOME corpus. Its semantic theory, especially related to discourse modeling, is solidly based on [87] and [39]. The MATE website has, however, been shut down, whereas [82] attempted to restore it by introducing a short summary of the MATE annotation scheme.

2.7.2 Example

Here is an example, taken from [64] and also from [65], illustrating how the MATE annotation scheme works.

- (21) a. 5.12 : we're gonna take the engine E3
 15.13 : and shove it over to Corning
 15.14 : hook it up to the tanker car

15.15 : .and_
 15.16 : and send it back to Elmira

b. coref, xml :

```
15.12 : we're gonna take
      <de ID="de_15">the engine
E3</de>
15.13 : and shove <de ID="de_16"> it
      </de>
      over to Corning
15.14 : hook <de ID="de_17">it</de> up
      to
      <de ID="de_18">the tanker
car</de>
15.15 : .and_
15.16 : and send <de
ID="de_19">it</de> back
      to Elmira

<link href="coref, xml#id (de_16)"
type="ident">
  <anchor href='coref .xml#id
(de_15)"/>
</link>
<link href="coref.xml#id(de_17)"
type="ident">
  <anchor href="coref, xml#id
(de_16)"/>
</link>
<link href="coref.xml#id(de_19)"
type="ident">
  <anchor href="coref, xml#id (de_17)
"/>
  <anchor href="coref.xml#id(de_18)"/>
</link>
```

The XML element, named <de>, stands for discourse entities that referred to by referring and anaphoric expressions. These expressions are markables. In example (21), the links , <link>, that capture anaphoric relations are represented standoff as in (b), while the markables are inline annotated as in (a).

2.7.3 Attribute-Value Specifications

As illustrated with 2.7.2, the MATE annotation scheme in XML has two elements: <de> and <link>. The element <de> annotates expressions that refer to discourse entities, specifying its attribute @ID with a unique value referring to each of the markables such as noun phrases and pronouns. The element <link> specifies anaphoric relations, containing one or more <anchor> elements.

Both <link> and <anchor> have an attribute @href. The value of the attribute @href for <link> refers to an anaphoric expression, whereas the value of @href for <anchor> refers to an antecedent. As shown in the last <link>, an anaphoric expression may have more than one antecedent or an ambiguous antecedent.¹⁴

The element <link> has an attribute @type. The list of possible values includes ident for coreference and subset denoting a subset of the set denoted by a discourse entity. This list can be extended to include values like part by following the DRAMA scheme by [63] as mentioned in [66], Extended Relations.

2.8 The Brandeis ISO-Space Annotation Guidelines

The ISO-Space Working Group at Brandeis University produced a manual of annotation guidelines for spatial information [70] and proposed it as an annex of an earlier CD (committee draft) version of [35], an ISO international standard for spatial annotation. First, the annex of a CD version annotates spatial entities (*I am sitting in the car_{se}.*)¹⁵ as referring expressions. Second, it introduces an element <metaLink> to annotate the three different types of coreference between these spatial entities:

- (22) a. coreference,
 b. subcoreference, and
 c. split coreference.

Third, it specifies a set of attributes and their possible values for the element <metaLink>, as shown in (23):

- (23) Attributes and Possible Values for <metaLink>
 attributes = id, [objectID1],
 [objectID2], relType, [comment];
 { * the attributes in square brackets are
 implied. * }
 id = "meta"INTEGER;
 objectID1 = IDREF;
 objectID2 = IDREF;
 relType = "coref", "subCoref",
 "splitCoref";
 comment = CDATA;

¹⁴As specified in [33] or [85], the element <vAlt> for alternate values can represent ambiguous cases in a more explicit or correct way.

¹⁵A spatial entity is introduced in [35] as an element of a type of entity that participates in location-involving motions or non-motion events. Its identifier is marked with a prefix se.

Instead of using XML as its representation language, [70] adopts the predicate-logic-like forms to represent the three different types of coreference. Examples are given in (24):

- (24) a. {Two cars}_{se1} are on the street. One_{se2} of them_{se3} turns left.
- b. `spatialEntity(id=se1, extent=two cars, countable=yes)`
`spatialEntity(id=se2, extent=one, countable=yes)`
`spatialEntity(id=se3, extent=them, countable=yes)`
`metaLink(id=meta1, objectID1=se1, objectID2=se3, relType=coref)`
`metaLink(id=meta2, objectID1=se1, objectID2=se2, relType=subCoref)`

The list of annotations in (24) can be interpreted as stating that the referents of two spatial entities *cars_{se1}* and *them_{se3}* are identical, while *one_{se2}* partially corefers with the spatial entity type expressions *cars_{se1}*.

Here is example (25):

- (25) a. {John_{se6} and Mary_{se7}}_{se8} met at the store. They_{se9} went shopping.
- b. `metaLink(id=meta4 objectID1=se8 objectID2=se9 relType=coref)`
`metaLink(id=meta3 objectID1=se7 objectID2=se8 relType=subCoref)`
`metaLink(id=meta4 objectID1=se9 objectID2=se6 relType=splitCoref)`
`metaLink(id=meta5 objectID1=se9 objectID2=se7 relType=splitCoref)`

The names *John_{se6}* and *Mary_{se7}* in (25) are each treated as a referring expression. At the same time, the whole phrase {*John_{se6} and Mary_{se7}*}_{se8} as a group is also treated as a referring expression. And then the antecedent of the plural pronoun *They_{se9}* is split into two: *John_{se6}* and *Mary_{se7}*.

3 Steps of Annotating Coreference and Other Anaphoric Relations

3.1 Overview

Given an input text, the task of coreference or other anaphoric link annotation is three-fold:

- (26) Step A: Identification of a set of mentions in the text that refer to something in the domain of discourse referents as its *markables*,
 Step B-1: Identification of a set of anaphor-antecedent pairs of the mentions that are anaphorically related and
 Step B-2: Specification of the type of such a relation.

To trigger and constrain these annotation steps, the entity type of mentions and the anaphoric relation are assigned a set of

required or implied attribute-value specifications. Step B-1 and Step B-2 constitute two sub-processes unified into one, for they depend on each other. The input text can be of any size. It can range from a short sentence to a very large corpus.

3.2 Identifying Markables and Extents

The set of possible markables consists of terms or mentions, which comprise both referring and non-referring expressions in a text. As attested quantitatively by various reference resolution experiments such as [15], [24], [83], and [71], these mentions are mostly noun phrases (NPs). Noun phrases are then categorized into four forms as shown in (27):

- (27) a. Proper names: e.g., *Mary, Obama, The United States of America*
- b. Definite or indefinite nominals with *plurality* and other agreement specifications: e.g., *The boy, the girls, apples, oxen*
- c. (Generalized) universal or existential quantifiers: e.g., *every man, three women, some countries*
- d. Definite or indefinite pronouns with *gender* and *number* specifications.

Definite and indefinite pronouns listed in (27d) are divided into four sub-classes as shown (28): ,

- (28) a. Personal pronouns: e.g., *he, she, they, it*,
- b. Reflexives: e.g., *himself, herself, themselves*,
- c. Reciprocals: e.g., *each other, one another*, and
- d. Demonstratives: e.g., *this, these, those*.¹⁶

The list of features such as ‘gender’ and ‘number’ specifies what morphosyntactic features are required or implied for the identification of mentions. The annotation of these features could be done at earlier stages of annotating raw data such as tokenization and morphosyntactic annotation. The process, whether manual or automatic, of marking up these mentions as markables should be straightforward at this basic level.

3.3 Anaphoric Links

The main task of annotating coreference and other types of the anaphoric link is to recognize antecedent-anaphor pairs among the set of markables and also to identify the type of their anaphoric link.

3.3.1 Anaphor-antecedent Pairs

Anaphors are part of the set of mentions, being mostly pronouns and other pronominal forms (see [42]). They are thus easily identified.

- (29) a. Bob loves Jane, but *she* doesn’t love *him*.

¹⁶Interrogatives are excluded.

- b. Bob was tired, and *so* was I.

Some definite noun phrases can be anaphors, too. Here are some examples:

- (30) a. {The project leader}_i is refusing to help.
 {The jerk}_i thinks only of himself.
 b. {Hilary Clinton}_i, {Bill's wife}_i.

Among the list of pronouns, we may also include the use of *it* referring to propositions, facts, actions, etc., or the use of *so* that may involve so-called sloppy identities, as shown below:

- (31) a. John said {he has been to heaven}_i, but I don't believe {it}_i.
 b. John {loves his wife}_i and so {does}_i? Bob.

Examples such as these are often discussed in linguistic literature, but have been seldom treated in computational work.

The so-called expletive *it* and *there*, the complementizer *that*, and the impersonal use of the pronoun *it*, as shown in (32), are excluded from the list of possible anaphors as well as from the list of possible markables.

- (32) a. *It_{exp}*'s impossible to go out now, for *it_{imp}*'s raining cats and dogs.
 b. *It_{exp}* is also reported *that_{comp}* *there_{exp}* is a storm approaching from the south.

The identification of anaphors as well as mentions can also be triggered by the morphosyntactic features of markables.

3.3.2 Types of the Anaphoric Link

Unlike anaphors, antecedents can be of any class of a word, phrase, or clause. It should, however, be a subset of markables as specified by Step A of annotation, listed in (26). If verbal forms are excluded from the set of markables for some practical reasons, then they would not be in the set of possible anaphors or antecedents.

The extent of antecedents is not restricted to a single word or phrase, but may extend to larger phrases such as conjoined phrases:

- (33) {The boys_i and the girls_j}_k met at a party and they_k danced all night.

Antecedents may not be contiguous, either, but split into two or more phrases, as in:

- (34) I_i met {a farmer}_j and {his_j dog}_k and we_{i,j,k} all walked together.

There are at least two uses of pronouns:

- (35) a. anaphoric: *John_i loves his_i wife.*
 b. indexical or deictic: *Look at him₁. He₁ is naked.*
 Context: the speaker pointing to a person over there.

In the anaphoric use, the pronoun *his_i* finds its antecedent *John_i* in the given text. In the indexical use, the antecedent of the pronoun *him₁* is not found in the text, but provided contextually.

Pronouns can be antecedents as well as anaphors in the chain of an anaphoric link.

- (36) John_{i1} loves {his_{i2} wife}_j and she_j also loves him_{i3}.

Anaphoric links may be forward or backward. The term that corefers with a pronoun normally precedes it, thus being called 'antecedent'. This so-called antecedent may also come after its related anaphor, as in:

- (37) When *she_i* returned home, *Sue_i* was surprised to find her dog gone.

In such a case, the pronoun is often called 'cataphor'.

Sometimes it is difficult to decide which is an anaphor and which is its antecedent, as especially in appositive cases (*Seoul_i*, {*the capital of South Korea*}_j, where *i* and *j* corefer.). In such cases, we simply have to state that they correspond to or corefer with each other.

The antecedent-anaphor relation is normally a one-to-one relation, but there are cases in which the antecedent of an anaphor is split into many. Besides this case of split coreference, [70] lists *subCoreference* as another type of coreference:

- (38) I have {two cars}_i, but one_j of them_i broke down.

Here *one_j* is a member of the set of *two cars_i*.

4 Formal Description

4.1 Overview

[7] provides a formal description of the annotation structure, consisting of two levels of syntax:

- (39) a. One is an abstract level of an annotation, called 'abstract syntax';
 b. Another level, a concrete level of representing annotations, called 'concrete syntax'.

Every abstract syntax for semantic annotations must be supported by an explicit (formal) semantics, as sketched in section 6. An XML-serialization of an abstract syntax is an instance of a concrete syntax. The semantics of a concrete syntax is defined as the semantics of the abstract syntax for which it defines a concrete representation. (Different representations of the same abstract syntax thus have the same semantics.)

Following [7], we first sketch a general view of 'abstract syntax' in 4.2. We then follow a modified version of [55] to present a general abstract syntax *ASyn* in 4.3 and an abstract syntax for anaphoric links *ASyn_{ana}* as a particular instantiation of the general abstract syntax *ASyn* in 4.4.

4.2 A Sketch of Abstract Syntax

According to [7] and two of his subsequent works, [8] and [10], the abstract syntax of an annotation scheme consists of two parts:

- (40) a. A conceptual inventory that specifies the basic concepts from which annotation structures are built up;
- b. A specification of the possible ways of combining elements of the conceptual inventory into annotation structures.

An annotation structure is a set, consisting of two kinds of elements: **entity structures** and **link structures**. Entity structures provide linguistic information about a region of primary data; link structures provide information about the semantic relation between regions of primary data.

In the case of annotating coreference and other anaphoric link types, entity structures correspond to the entities that are related by anaphoric links, and link structures to the linkings of anaphoric expressions to their antecedents.

An entity structure is a pair $\langle m, a \rangle$ where m is a markable that identifies a region of primary data, and a is the specification of the semantic information that the annotation provides about that region of primary data. In the abstract syntax $ASyn_{ana}$ for anaphoric annotation, the a component of an entity structure is an n -tuple, $3 \leq n \leq 6$ consisting maximally of a semantic type t , a definiteness d , a morphosyntactic form f , a natural gender g , a plurality p , and a collectiveness c (more about these elements below). The fact that the length n of these n -tuples may vary reflects the optionality of some of the elements.

A link structure is a triplet $\langle \varepsilon, \eta, \rho \rangle$, where

- (41) a. ε is an entity structure and η , a set of entity structures, corresponding to an ‘anaphor’ and a set of its ‘antecedents’, respectively;¹⁷
- b. ρ is a relation between a pair of entity structures or between an entity structure and a set of entity structures.

For the abstract syntax $ASyn_{ana}$ for anaphoric annotation, the conceptual inventory is a 9-tuple $\langle M, T, D, F, G, P, C, Q, R \rangle$, where

- (42) a. M is a non-empty set of markables;
- b. T is a set of semantic types;
- c. D is a set of definiteness values;
- d. F is a set of morphosyntactic forms;
- e. G is a set of natural genders;
- f. P is a set of singular/plural values;
- g. C is a set of ‘collectivity values’;

h. Q is a set of generalized quantifiers and

- i. R is a set of binary relations over the set of entity structures, corresponding to the various types of anaphoric links.

The annotation structures are defined by an assignment $@$ that specifies the semantic components of entity structures. For each markable m in M , $@(m)$, an n -tuple, $3 \leq n \leq 7$, of elements from $T \times D \times F \times G \times P \times C \times Q$.¹⁸

We do, however, follow [52, 53], and his more recent work [55] in formalizing an abstract syntax in algebraic terms that are often used in defining formal grammars. We also use [37] extended BNF as a meta-language to specify various features of data types because BNF is expressively more powerful than simple set-theoretic listing.

4.3 General Abstract Syntax

Given a fragment L_i of a language as primary data for annotation, the general structure of an abstract syntax $ASyn$ for an annotation structure can be formally defined as a triple:

(43) $\langle M, T, @ \rangle$, where

1. M is a set of (possibly null or non-contiguous) strings of character segments, called ‘markables’, in L_i , delimited by E_i ;
2. T is a finite set of semantic types, consisting of E_t and L_t , where E_t is a finite set of ‘entity types’ and L_t is a finite set of the types of link over E_t ,
3. $@$ is a set of assignment functions from T to linguistic features.

For semantic annotation, its markables in M are strings of character segments which are identified as tokens, words or phrases in a fragment of a language, given as its primary data.¹⁹ This is so because semantic annotation normally presupposes that its input data has been preprocessed by word segmentation or morpho-syntactic analysis.

Empty strings are allowed as markables in M . They represent so-called *non-consuming tags* with their use licensed in [35].²⁰ Consider example (44),

- (44) a. John_i got up late and $\emptyset_i$ had to skip breakfast.
- b. We camped $\emptyset_{pl1}$ near the river.

The missing subject in the right conjunct of example (44a) can be represented as a non-consuming empty tag, if necessary. The $\emptyset_{pl1}$ in (44b) refers to some place_{pl1} near the river and the event of camping is anchored to that place_{pl1}.

¹⁸The specification of morphosyntactic forms, and several of the other elements may refer to other levels of annotation.

¹⁹Here we are assuming that the media type of markables is textual. The media type of markables can, however, be extended to other types than the textual type, such as visual objects (pictures and videos).

²⁰See Definition 3.11 “Terms and definitions” and Annex A.3.4 “Special section: Non-consuming tags”, pp.29-30.

¹⁷Split coreference has more than one antecedent.

T is a very small set, consisting of a very small number of entity types E_t and link types L_t . As will be shown in 4.4, the sets M , E_t , and L_t are interrelated by the set $@$ of feature assignment functions associated with those sets.²¹ A particular function $@_i$ in $@$ assigns an entity type t in E_t and other associated features F_i to each markable m in M , generating an annotation structure $\langle m, @_i \rangle$ such that $@_i(m) = t \oplus F_i$.

For each link type in L_t , $@$ also defines a set of (binary) relations ρ over the set $\langle M, E_t \rangle$ of entity structures. Each of the specifications can be represented in extended BNF [37] as a function $@_i$ over T that assigns a value type such as CDATA (character data) or IDREF (identifier reference) associated with XML to each of the features associated with each markable m in M . The particular names of features and their value types mentioned in the specifications are not fixed, but may vary for each concrete syntax or dialect.

4.4 Abstract Syntax for Anaphoric Annotation

4.4.1 General

The abstract syntax $ASyn_{ana}$ for anaphoric annotation is a particular instantiation of the general abstract syntax $ASyn$ which is introduced in (4.3) General Abstract Syntax, $\langle M, T, @ \rangle$.

(45) $ASyn_{ana}$ consists of:

1. M is a set of (possibly null or non-contiguous) sequences of tokens or words that refer to objects of the entity types specified in E_t ;
2. T is a set of semantic types, consisting of two types: a single basic **entity** type and a single **anaphoric link** such that each link type is associated with a triple $\langle \varepsilon, \eta, \rho \rangle$; and
3. $@$ is a set of feature assignments to be specified for each of the types in T in extended BNF separately.

Among the elements of the 9-tuple $\langle M, T, D, F, G, P, C, Q, R \rangle$ introduced in (42), the first two elements M and T exactly correspond to the M and T in $ASyn_{ana}$. The other six elements, D, F, G, P, C, Q , and R , are treated by the feature assignment function $@$ which is associated with each of the types in T .

4.5 Feature Assignments @

Associated with $ASyn_{ana}$, the feature assignment $@_{entity}$ assigns to each entity, which is referred to by a markable, a value for each of the attributes specified by D, F, G, P, C, Q , and R , as shown (46):

(46) **Feature Assignment** $@_{entity}$:
attributes = identifier, target, type,

```
form, [definite], [natural
    Gender], [plural], [collective],
[quantified], [comment];
{*The attributes in square brackets
are optional attributes.*}
identifier = unique ID;
target = IDREF|NULL;
{*A non-consuming tag is allowed by
the NULL value.*}
type = CDATA;
form = CDATA;
definite = BOOLEAN;
naturalGender = CDATA;
plural = BOOLEAN;
collective = BOOLEAN;
quantified = CDATA;
comment = CDATA;
```

The feature assignment function associated with the type **link** is specified as in (47):

(47) **Feature Assignment** $@_{link}$:
attributes = identifier, anaphor,
 antecedents, relType;
identifier = unique ID;
anaphor = IDREF;
antecedents = IDREFS;
relType = CDATA;

The feature assignments (46) and (47) specify only the data type of a value for each attribute, which is either required or implied, without providing any specific values. Specific values are given by concrete syntaxes based on the abstract syntax for anaphoric annotation.

4.6 XML-based Concrete Syntax

We introduce an XML-based concrete syntax $CSyn_{anaX}$, corresponding to the abstract syntax $ASyn_{ana}$ for anaphoric annotation. First, the annotation of each of the entity or link structures is represented as an XML element. $CSyn_{anaX}$ introduces two elements $\langle entity \rangle$ and $\langle anaLink \rangle$ ²² that correspond to each of the entity structures and also to each of the link structures, respectively, as defined in $ASyn_{ana}$. Both of these XML elements have an $@identifier$ attribute in order to allow references from within the representation of a certain link structure to the representations of specific entity structures or other link structures. Moreover, $\langle entity \rangle$ structures have a $@target$ attribute for representing the markables that they associate linguistic information with.

Second, the assignment $@$ for M can be transduced into $CSyn_{anaX}$ as specified in (48):

(48) **Attributes and Values for the element** $\langle entity \rangle$: $@_{\langle entity \rangle}$ **attributes** =
 identifier, target, type, form,
 [definite], [naturalGender] ;

²¹The term 'feature' is used here loosely and interchangeably with the term 'property'.

²²The element $\langle anaLink \rangle$ may be understood as standing for $\langle link \text{ type}="anaphoric"/ \rangle$.

```

[plural], [collective] ;
[quant], [comment] ;
identifier = IDprefix="x" followed by
INTEGER;23
target = IDREF|CDATA;24
type = "person"|"organization"|CDATA;25
form = "name"|"nom"|"pro"|"quant";26
definite = "yes";27
naturalGender = "male"|"female"|CDATA;28
plural = "yes";
collective = "yes";
quant = "universal"|CDATA;29
comment = CDATA;

```

By allowing the value `quant` as a possible value for the attribute `form`, *CSyn_{anaX}* treats the anaphoric link between a quantifier and a bound anaphor (e.g., pronoun). As defined as in (48), *CSyn_{anaX}* may treat reciprocals (e.g., *each other*, *one another*).

The feature assignment function for `<anaLink>` is specified as in (49):

(49) Attributes and Values for the element `<anaLink>`

```

attributes = identifier, figurer, ground,
relType, [comment];
identifier = idPrefix="anaL" followed by an
INTEGER";
figure = IDREF;
{* Standing for the entity type anaphor.
*}
ground = IDREFS;
{* Standing for the entity type antecedent. With its value being IDREFS, the
attribute @ground may have more than one
antecedent as its value.
The indexical use of a pronoun may
not have an antecedent in the element
<entity>.*}
relType = "ident", "partIdent",
"splitIdent",30 "qBound", "recip" ;
comment = CDATA;

```

The attribute name `@figure` stands for an anaphor, while the attribute name `@ground` stands for the entity type **antecedent**.³¹ The attribute `@relType` introduces values other than `ident` for referential identity. These values allow

²³The identifier is tagged `xml:id` for XML documents, otherwise `id`. Examples of ID values are: "x3", "x20".

²⁴The attribute `@target` has an extent ID in a tokenized source text or the extent itself as its value. This value can be a (possibly null or non-contiguous) sequence of tokens or their IDs.

²⁵See [57] for the list of entity types.

²⁶Verbal forms including sentential or adjectival forms are excluded.

²⁷Optional attributes have a value "unspecified" as default.

²⁸CDATA allows any other values.

²⁹The "universal" quant is a logical quantifier, while CDATA allows other generalized quantifiers that include a variety of existential quantifiers.

³⁰"splitIdent" is the inverse of "partIdent".

³¹The MATE annotation scheme names it "anchor".

the types of the anaphoric link other than the type of coreference proper. The use of each of the values of the attribute `@relType` is illustrated as in (50):

- (50) a. `ident`: referential identity either at an individual level or at a set or group level;
John_{x1} loves Jane_{x2}, but she_{x2} dislikes him_{x1}.
{The whole army}_{x3} surrendered themselves_{x3}. (reflexive) *They_{x3} got totally exhausted.*
- b. `partIdent`: referential partial identity or sub-coreference;
John owns {two cars}_i. One_{i1} of them_i broke down.
- c. `splitIdent`: antecedents are split into more than one;
I_i met {a farmer}_j and {his_j dog}_k and we_{i,j,k} all walked together.
- d. `qBound`: case of bound anaphors;³²
{Every farmer}_x owns a donkey_y. They_x beat it_y.
Every_x farmer loves his_x wife.
- e. `recip`
We_{x5} love [one another]_{x5}. (reciprocal)

We introduce an XML-element `<anaX>` with its ID prefix `ax` as the root element for XML documents in the concrete XML annotation scheme *CSyn_{anaX}* for coreference and other types of anaphoric link. Every annotation based on *CSyn_{anaX}* is enclosed by a pair of the root element `<anaX>` and its closing element `</anaX>`.

5 Illustrations

Here we introduce the first part of the dataset about a retired professor to show how it is annotated. The proposed *CSyn_{anaX}* can annotate it, as shown below:

- (51) a. **Step 1: Identification of Markables**
Not long ago {a retired professor_{x1} of a small university_{x2} in Essex_{x3}}_{x4} lost {his_{x5} wealthy wife_{x6}}_{x7}, who_{x8} had been ill for {over ten years}_{x9}. After {her_{x10} death_{x11}}_{x12}, {the professor}_{x13} and {their_{x14} only daughter_{x15}}_{x16} found {a large sum of money}_{x17} left for them_{x18} to share.
- b. **Step 2a: Identification of Possible Anaphors and Step 2b: Links**
`<anaX xml:id="ax1">`
`<entity xml:id="x1">`

³²The "qBound" may be treated as a case of "setIdent" with the assumption that the denotation of an anaphor is a set and also that that set is also the denotation of its antecedent so that they are identical as sets. For example, the denotation $[[every\ farmer]]^M$ of *every farmer* with respect to a model *M* is understood to be a set $\{X | [[farmer]]^M \subseteq X\}$ of supersets of the set of farmers.

```

target="professor" type="person"
  form="name" definite="no"
naturalGender="male"/>
<entity xml:id="x5" target="his"
  type="person"
  form="pro"
naturalGender="male"/>
<entity xml:id="x6" target="wife"
  type="person"
  form="nom" definite="yes"
naturalGender="female"/>
<entity xml:id="x8" target="who"
  type="person"
  form="pro"/>
<entity xml:id="x10" target="her"
  type="person"
  form="pro"
naturalGender="female"/>
<entity xml:id="x13"
  target="professor" type="person"
  form="name" definite="yes"
naturalGender="male"/>
<entity xml:id="x14"
  target="their" type="person"
  form="pro" plural="yes"/>
<entity xml:id="x15"
  target="daughter" type="person"
  form="nom" definite="yes"
naturalGender="female"/>
<entity xml:id="x17" target="a
  large sum of money"
  type="impersonal"
  form="quant"/>
<entity xml:id="x18" target="them"
  type="personal"
  form="pro" plural="yes"/>
</anaX>

```

Various types of links between the anaphors, colored blue, and their red-colored antecedents can be represented by Figure 1:

Not long ago [a retired **professor**_{x1} of a small university_{x2} in Essex_{x3}]_{x4} lost [his_{x5} wealthy **wife**_{x6}]_{x7}, **who**_{x8} had been ill for [over ten years]_{x9}. After [her_{x10} death_{x11}]_{x12}, the **professor**_{x13} and [their_{x14} only **daughter**_{x15}]_{x16} found [a large sum of **money**]_{x17} left for **them**_{x18} to share.

Figure 1. Anaphoric Links

Except for those two links listed in (52), all of the links, represented in Figure 1, are of the *ident* type which represents the coreferential relation between an anaphor and its antecedent at an individual level:

```

(52) <anaX xml:id="ax2">
  <anaLink xml:id="anaL1"
    figure="#x14" ground="{#x1, #x6}"

```

```

    type="splitIdent"/>
  <anaLink xml:id="anaL2"
    figure="#x18" ground="#x13, #x15"
    type="splitIdent"/>
</anaX>

```

The pronoun *their*_{x14} is grounded on or anchored to the two antecedents, *professor*_{x1} and *wife*_{x6}, whereas the pronoun *them*_{x18} is also grounded on the two antecedents, *professor*_{x13} and *daughter*_{x15}. Note that *professor*_{x13} is grounded on the earlier occurrence of *professor* with an ID x1.

Consider one more fragment:

(53) a. Step 1: Identification of Markables:

b. Text:

Billy Jones_{x25} took {his_{x26} family_{x27}}_{x28} to {a manor }_{x29} in {the country}_{x30} near Edinburgh_{x31}. There_{x32} they_{x33} spent most of {a year}_{x34}, but stayed in {Cannes, France}_{x35}, in the winter season_{x36}.

The antecedent of the pronoun *they*_{x33} is split into *Billy Jones*_{x25} and *family*_{x16}. The antecedent of the locative pronoun *There*_{x32} is ambiguous: it can be either *a manor*_{x29} or *the country*_{x30}. This can be represented as in 54, for both of the situations hold:

```

(54) <anaLink xml:id="anaL3"
  figure="#x32" ground="#x29"
  relType="ident"/>
  <anaLink xml:id="anaL3"
  figure="#x32" ground="#x30"
  relType="ident"/>

```

Consider how well-known donkey sentences are annotated. Two classical types are illustrated in (55):

(55) a. Every farmer who owns a donkey beats it.³³
 b. If Pedro owns a donkey, he beats it.

Example (55a) can be annotated as below:

```

(56) a. Every farmerx1 who owns {a donkey}x2 beats itx4.
  b. <anaX xml:id="ax3">
    <entity xml:id="x1" target="Every
      farmer" form="quant"
      type="farmer" quant="universal"/>
    <entity xml:id="x2" target="a donkey"
      form="quant"
      type="donkey"/>
    <entity xml:id="x4" target="it"
      form="pro"
      type="donkey" def="yes"/>
    <anaLink xml:id="anaL2" figure="#x4"
      ground="#x2"
      type="qBound"/>
  </anaX>

```

³³Originally, from [22].

Example (55b) can be annotated as below:

- (57) a. If Pedro_{x1} owns $\{\text{a donkey}\}_{x2}$, he_{x3} beats it_{x4} .
- b.

```
<anaX xml:id="ax4">
  <entity xml:id="x1" target="Pedro"
    type="person" form="name" />
  <entity xml:id="x2" target="a donkey"
    type="donkey" form="nom"/>
  <entity xml:id="x3" target="he"
    type="person" form="pro"/>
  <entity xml:id="x4" target="it"
    type="person" form="pro"
    def="yes"/>
  <anaLink xml:id="anaL1" figure="#x3"
    ground="#x1"
    type="ident"/>
  <anaLink xml:id="anaL2" figure="#x4"
    ground="#x2"
    type="ident"/>
</anaX>
```

Here both of the anaphor-antecedent or figure-ground pairs, $\langle \text{he}, \text{Pedro} \rangle$ and $\langle \text{it}, \text{a donkey} \rangle$ are treated as corefering. Note that indefinite descriptions are treated as referential terms, not existential quantifiers (see [38].)

6 Semantic Interpretations: A Sketch

As stated earlier in the introductory section, every semantic annotation must be supported by an explicitly defined semantics. It is not something interesting or optional to do. Possibly unlike POS-tagging or syntactic parsing, the construction of a semantics for the abstract syntax of semantic annotation is a task required for any valid semantic annotation scheme as explicitly stipulated in [36]. An abstract syntax or a concrete syntax based on it alone cannot be justified without a supporting semantics.

The use of the lambda calculus in the line of [60] or that of the discourse representation structures (DRSs), proposed by [38] and [39], can, for instance, be linked to the abstract syntax to provide such a semantics for semantic annotations. Attempts have been made by [41], [68], [6, 8, 9], and [51] to develop an annotation-based semantics with the use of lambda calculus or by [7] with the use of DRSs. The use of lambda abstraction has run into the problem of complexity especially in dealing with multiple quantification and embedded adjunct structures. This should be the case with the treatment of various anaphoric phenomena. There are at least two interesting works to overcome this complexity problem: One is an earlier work by [62] which proposed a way of combining Montague semantics with DRSs and another is the most recent work by [9] which directly addresses to the treatment of anaphoric phenomena by combining underspecified representation (USR) that arises because of the presence of context-dependent expressions such as pronouns with annotation information representation (AIR). In constructing these representation structure, [9] shows how

useful and necessary it is to combine the introduction of discourse referents in DRSs with markables in the annotation into USR and AIR, especially when there are multiple occurrences of identical anaphoric expressions, that is, pronouns, in a text.

Here is a very simple illustration showing how a list of annotations is converted into a semantic representation:

- (58) a. Text: John hates himself.
- b. Annotation:
- ```
<anaX xml:id="ax1">
 <entity xml:id="x1" target="John"
 type="name" form="name"/>
 <event xml:id="e1" target="hates"
 type="hate"/>
 <entity xml:id="x2"
 target="himself" type="person"
 form="pro"
 naturalGender="male"/>
 <anaLink xml:id="anaL1"
 figure="#x2" ground="#x1"
 relType="ident"/>
</anaX>
```

### (59) Semantic Values

- a.  $\sigma_{x1} := \lambda x[\text{named}(x, \text{John})]$   
 b.  $\sigma_{x2} := \lambda y[\text{person}(y) \wedge \text{male}(y)]$   
 c.  $\sigma_{e1} := \lambda e[\text{hates}'(e, x, y)]$   
 d.  $\sigma_{\text{anaL1}} := \lambda y(x = y)$   
 e.  $\sigma_{\text{anaX1}} := [\sigma_{x1} \oplus \sigma_{x2} \oplus \sigma_{e1} \oplus \sigma_{\text{anaL1}}]$   
 $:= [\text{named}(x, \text{John}) \wedge \text{person}(y) \wedge \text{male}(y) \wedge \text{hates}'(e, x, y) \wedge x = y]$

Or equivalently:

### (60) Semantic Values in DRT:

$x, y, e$
$\text{named}(x, \text{John})$
$\text{person}(y)$
$\text{male}(y)$
$\text{hates}'(e, x, y)$
$x = y$

We leave detailed discussion of ways of interpreting anaphoric links as a work item for the future. Here are some remarks on the interpretation of various anaphoric expressions. First, names and definite descriptions are referential terms, both referring to some unique entities in the domain of discourse referents. Indefinite descriptions are also treated as referential terms, as mentioned earlier.

Second, as proposed and discussed in formal model-theoretic semantics (see [60], [3], [58], and [45]), proper names, definite descriptions, indefinite singular (*a dog*) or bare plural (*donkeys*) noun phrases as well as quantified noun phrases (*three students*, *every man*) are also interpreted as referring to sets of sets or properties, in the world. In our treatment, universally quantified expressions are differentiated from other types of generalized, but existentially quantified expressions.

Third, pronouns, on the other hand, do not refer directly to any entities in the world, but only through being coreferential with some other terms in the text (anaphoric use) or by referring to some entities that are provided contextually in a discourse situation (indexical use) (see [44]). Nevertheless, pronouns are also marked up as referring expressions or mentions in coreference annotation (see [16], [19], [20].)

There have been two trends in formal semantics that allow both of them to be treated as the same type of binding phenomena. One trend was initiated by [60] and further developed by [3], [58], [45], and a host of others. According to this trend, all nouns phrases that include proper names (e.g., *George Washington*) and definite descriptions (e.g., *the king of France*) are treated as (generalized) quantifiers just like the universal and the existential quantifiers in logic and interpret them all as denoting sets of sets, as illustrated below:

- (61) a.  $[[John]]^M = \{X \mid j \in X \wedge |X| = 1\}$   
 b.  $[[the\ dog]]^M = \{X \mid [[dog]]^M \cap X \neq \emptyset\}$   
 c.  $[[all\ men]]^M = \{X \mid [man]^M \subseteq X\}$

Here,  $[[\alpha]]^M$  stands for the denotation of an expression  $\alpha$  with respect to a model  $M$ .

Possibly initiated by [40] among the linguists, another trend has been to treat pronouns as bound variables. As a variable, a pronoun  $x$  has its semantic  $\sigma(x)$  determined not by a model  $M$ , but an assignment  $g$  that ranges over the domain  $D$  of a model  $M$  such that  $\sigma(x) = g(x)$ , or written  $[[x]]^g$ . Since [40] there have been discussions, either in the framework of formal semantics or the binding theory of the generative grammar, on the status of pronouns among linguists and logicians such as [16], [29], [19], [20], [38], and [78]. As a result, various types of pronouns have come to be known, including pronouns, called ‘presumptive’, ‘intrusive’<sup>34</sup>, or ‘lazy/paycheck’ pronouns. Here are some examples:<sup>35</sup>

- (62) Presumptive or intrusive pronoun:  
 a. This is *the girl<sub>i</sub>* that whenever it rains *she<sub>i</sub>* cries.  
 b. This is *the camel<sub>i</sub>* that I think *he<sub>i</sub>* likes Oscar.
- (63) Lazy/paycheck pronoun:  
 c. John spent *his paycheck<sub>i</sub>* on beer. Everyone else put *it<sub>i</sub>* in the bank.

Another question has to do with the extension of markable mentions. Linguists such as [40], [29], [28], [42], [43], [88], [89] and too many others have discussed presumptive and lazy pronouns, while [74], [46], and other have discussed the occurrences of pronouns in modal contexts. Hence, to produce semantically adequate ASs, it may be necessary to accommodate all their ideas into a unified AS for anaphoric links.

<sup>34</sup> [80] claims that English has no genuine presumptive pronouns, but they should be ‘intrusive’ pronouns.

<sup>35</sup> Examples (a) and (b) were copied from Wikipedia, the free encyclopedia, and see also [?], cited in Wikipedia. Example (c) was recopied from [88].

The interpretation of indexical pronouns such as *I*, *we* and *you* is more complex than their surface phenomena. It requires a clear understanding of dialog or discourse situations in which these indexicals interact with each other, especially in a language like Korean that has a complex honorific system. Little attention has, however, been given to the hearer-speaker mode exchange phenomena in communication except for [27] and many of his earlier works [25, 26]. [27] introduces the notion of **anchoring** that grounds the content of indexicals to real communication situations. In section 7, we introduce the elements such as <metadata> and <metaLink> to deal with the speaker and the hearer references that are often omitted in a pro-drop languages like Korean, but in a sketchy way to be able to understand such utterances:

- (64) a. from [27], 11.2.2  
 John told Mary: *I* love *you*. Mary told John: *I* love *you*.  
 b. John to Mary: 사랑해. salang-hay. (I) love (you).  
 Mary to John: 사랑해. salang-hay. (I) love (you).

In the Korean examples, both the first-person pronoun and the second-person pronouns are deleted.

## 7 Application to Korean

### 7.1 Datasets

Our discussion of pronominalization in Korean starts with the following two versions of the Lord’s Prayer in Korean:

#### (65) Lord’s Prayer: Protestant Version

하늘에 계신 우리 아버지여,  
 이름이 거룩히 여김을 받으시오며  
 나라이 임하옵시며  
 뜻이 하늘에서 이룬 것 같이 땅에서도 이루어지이다.

Hanul-ey keysin wuli *apeci*,  
 ilum-i keluk.hi yekim-ul patusimye  
 nala-i imhaopsimye ttus-i hanul-eyse-wa kath-i ttang-eyse-to  
 ilwu.e.ci.ita.<sup>36</sup>

‘Our Father, who art in Heaven,  
 hallowed be *Thy* name,  
*Thy* Kingdom come,  
*Thy* will be done on earth as it is in Heaven.’

#### (66) Lord’s Prayer: Catholic New Version

하늘에 계신 우리 아버지,  
 아버지의 이름이 거룩히 빛나시며  
 아버지의 나라가 오시며  
 아버지의 뜻이 하늘에서와 같이 땅에서도 이루어지소서.

Hanul ey keysin wuli *apeci*,

<sup>36</sup> We have adopted the Yale Romanization for Hangul characters, following the general practice of Korean linguists.

*apeci-ui ilum-i keluk.hi picnasimye*  
*apeci-ui nala-ka osimye*  
*apeci-ui ttus-i hanul-eyse-wa kath-i ttang-eyse-to*  
*ilwu.e.cisose.*

Both (65) and (66) show the rare use of pronouns in Korean: neither of them has any other pronoun than 우리 (*wuli*) corresponding to the pronoun *our*. The Protestant version of the Lord's prayer has no word corresponding to *thy* or *your*, while the Catholic version has 아버지(*apeci*) 'father' for the addressee, *thy* in English. These datasets show the characteristics of Korean as a typical **pro-drop language** that allows the dropping not only of subject pronouns, but also of any other contextually recoverable pronouns. (67) are common examples of daily familiar greetings:

- (67) a. 사랑해요. (*salang.hay.yo*) '(I) love (you).'  
 b. 고마워. 잘 먹을께. (*komawue. cal mek.ul.kkey*) '(I) thank (you). (I) will eat (it) well'

The pro-dropping is often compensated by the repetition of the nouns referred to, as shown by (83) and a newly proposed Protestant version of the Lord's prayer (68):

- (68) 하늘에 계신 우리 아버지,  
 아버지의 이름을 거룩하게 하시며  
 아버지의 나라가 오게 하시며,  
 아버지의 뜻이 하늘에서와 같이 땅에서도 이루어지게 하소서.

Here are a couple of examples from [56]<sup>37</sup> that show how noun phrases are repeated:

- (69) 나는 감자가 많이 나는 고장에서 태어나서 감자를 무척 좋아한다. 그리고 감자를 좋아 하는 사람을 만나면 해마다 감자를 선물로 보내고 싶어진다.

*na-nun kamca-ka manh.i nanun kocang eyse thaye nase kamca-lul muchek coh.a hanta. kuliko kamca-lul coh.a hanun salam-ul mannamyen hay-mata kamca-lul senmul-lo ponayko siphecitna.*

'Since I was born in a place where they grow a lot *potatoes*, I really like *them*. Moreover, whenever I meet someone who likes *potatoes*, I want to send them *some* as a present every year.'

- (70) 나는 어머니를 사랑한다. 어머니가 없는 세상은 상상조차 할 수 없다. 어머니들은 정말 대지와도 같다.

*na-nun emeni-lul salang-hanta. emeni-ka epsnun seysang-un sangsang-cocha hal swu epsta. emeni.tul-un ceng-mal tayci-wato kathhta.*

'I love (my) mother. I can't even imagine a world without *her*. *Mothers* are really like the earth to me.'

<sup>37</sup>Examples (12) and (13), page 94. The second example (70) is slightly modified by changing 어머니 (*emeni*) to a plural form 어머니들 (*emeni.tul*) 'mothers'.

## 7.2 Production of Pronouns in Korean

[56] claim that there are no third-person pronouns in Korean. As an agglutinating language, Korean can, however, produce a host of third-person pronominal expressions, based on the three basic demonstrative pronouns, as listed in (71):

- (71) a. 이 (*i*) 'this': pointing to some entity in close proximity  
 b. 그 (*ku*) 'that': simply referring to some entity that has been mentioned or pointing to some entity in near proximity  
 c. 저 (*ce*) 'that (over there)': pointing to some entity at a distance

[14] calls 이 (*i*) 'this' **proximal**, 그 (*ku*) 'that' **medial**, and 저 (*ce*) 'that over there' **distal**.

To these demonstrative pronouns, bound morphemes such as 분 (*pun*) 'person', 것 (*kes*) 'thing', or 놈 (*nom*) 'fellow, guy' can be affixed to form pronouns. Here are examples:

- (72) a. 이분이 제 선생님이시다.  
*Ipun-i cey sensayingnim.i.sita*  
 This is my teacher.  
 b. 내가 좋아하는 과일은 사과인데 매일 그것을 하나씩 먹는다.  
*nay-ka coh.a-hanun kwail-un sakwa.inte mayil kukes ul hanassik mek.nunta.*  
 'My favorite fruit is an apple and I eat it one a day.'  
 c. 저놈은 도둑놈이다.  
*cenom-un totwuknom.it*  
 'That fellow over there is a thief.'

Bound nouns such as 때 (*ttay*) 'time' and 곳 (*kos*) 'place' can be affixed to those demonstratives:

- (73) a. 내가 즐기던 그때, 내가 살던 그곳을 영영 못 잊겠다.  
*nay-ka culkiten kuttay, nay-ka salten kukos-ul yengyeng mos ic.keyssta*  
 '(I) can never forget the time I used to enjoy and the place where I used to live.'

## 7.3 Pragmatic Features Associated with Pronouns in Korean

The first and second person pronouns are seldom used in spoken language. If they are used, then their use is much constrained by pragmatic principles involving the speaker, the addressee(s), and the persons or things referred to in an utterance.

**Table 1.** Constraints on the Use of First and Second Person Pronouns

pronouns	speechRole	plurality	speechStyle
나	speaker	no	plain
저	speaker	no	humble
우리	speaker	yes	plain
저희	speaker	yes	humble
너, 자네	addressee	no	plain
당신	addressee	no	plain, honorific
너희	addressee	no	plain
여러분	addressee	yes	plain

나 (na), 저 (ce), 우리 (wuli), and 저희 (cehui) are first-person pronouns, each referring to a speaker or speakers. 나 (na) is a **plain** speech style form, while 저 (ce) is called a **humble** or **self-lowering** speech style form, meaning that the speaker is considered as paying due respect to the addressee(s). 우리 (wuli) and 저희 (cehui) are plural forms, corresponding to the singular forms 나 and 저, respectively.<sup>38</sup> 저희 (cehui) is a humble form.

너 (ne), 자네 (caney), 당신 (tangsin), 너희 (nehui), and 여러분 (yelepun) are second-person pronouns, referring to an addressee or a group of addressees. The first two forms, 너 (ne) and 자네 (caney), and the two plural forms 너희 (nehui) and 여러분 (yelepun) are of the plain speech style form, whereas the other three 당신 (tangsin) is an addressee-honoring form or plain form. The use of these three forms is very much restricted, too. In prayers or some writings, 당신 (tangsin) is accepted as a humble form, but in ordinary dialog situations is often misunderstood as failing to convey respect to the addressee. There are many other addressee-referring forms such as 어르신 (elusin) 'elder', 부인 (puin) 'lady', 선생님 (seonsayingnim) 'teacher', 사모님 (samonim) 'teacher's wife', 강아지 (kang.aci) 'puppy', 삼촌 (samchwun) 'uncle', 이모 (imo) 'aunt', 오빠 (oppa) 'brother', 자기 (caki) 'self', but their use is very much pragmatically constrained, reflecting various social-level relations between the speaker and the addressee. 어르신 (elusin) is used only when an elderly person is addressed to, but older people may not want to be called as such. 자기 (caki) is a third-person reflexive pronoun, but is often used among young married couples, addressing to each other.

By suffixing a plural marker 들 (tul), we can have the plural forms, 저희들 (cehui-tul) and 너희들 (nehui-tul). Other such plural forms are: 당신들 (tangsin-tul) and 여러분들 (yelepun-tul).

When followed by a nominative (subject) marker, 나 (na), 저 (ce), and 너(ne) undergo a vowel-raising process, thus changing their forms to 내(nay), 제 (cey), and 네 (ney), respectively. These forms are also used as genitive case forms.

- (74) a. 저를 용서하여 주십시오. 제가 잘못 했습니다.  
ce-lul yongse-haye cwusipsiyo. cey ka calpos haysswup-nita.  
'Pardon me. I did wrong.'

<sup>38</sup> 우리 (wuli) may be used in a singular sense, especially when it is used with a family member or home: e.g., 우리 마누라 (wuli manwura) 'my wife', 우리 집안 (uli cipan) 'my family'.

- b. 내가 너를 보니 네 언니 생각이 난다. 네가 언니를 꼭 닮았다.  
nay-ka ne-lul poni ney enni sayinggak-i nan.ta. ney-ka enni-lul kkok talm.assta  
When I see you, I am reminded of your sister. You really resemble her.

## 7.4 Reflexives, Reciprocals, and Quantifiers

Korean has reflexives as listed in (75):

- (75) a. 자기 (caki) 'self'  
b. 자신 (casin) 'self'  
c. 당신 (tangsin) 'self'

The use of 자기 (caki) is restricted. It cannot be used with the first person pronoun, although 자신 (casin) is acceptable.

- (76) a. 내 자신 그것을 몰랐다.  
nay casin ku.kes-ul moll.assta.  
'I myself didn't know it.  
b. 미아가 자기 자식들을 자랑했다.  
mia-ka caki casik.tul-ul calang.hayssta  
'Mia boasted about her own children.'

The second person noun 당신 (tangsin) can be used as a third person reflexive, as in (77):

- (77) 할아버지가 당신 손주들을 무척 아끼신다.  
halapeci-ka tangsin soncwu.tul-ul mwuchek akki.sinta  
'Grand is very fond of his own grandchildren.'

Here are examples of reciprocals in Korean:

- (78) a. 서로 (selo) 'each other, one another'  
너희들은 서로 사랑하여라.  
nehui.tul-un seolo salang.hayela  
'You love each other.'  
b. 서로서로 (seloselo) 'each other, one another'  
우리들은 서로서로 손을 맞잡고 노래 부르자.  
wuli.tul-un seloselo son-ul mac.cap.ko nolay pwulu.ca  
'Let's hold hands with each other and sing a song.'

There are two forms of quantifiers: one is an adnominal form and the other an adverbial form, as shown in (79):

- (79) a. Adnominal Form:  
모든 (motun) 'all', 각 (kak) 'each'  
  
모든 사람이 모였다. 각각 손에 태극기를 들고  
motun salam-i moye.ssta kakca son-ey thaykuk.ki-lul tul.ko  
'All people gathered, each holding a Korean flag in their hand.'  
b. Adverbial Form:  
모두 (motwu) 'all', 각각 (kak.kak) 'each'  
  
사람들이 모두 모였다. 그들은 각각 손에 태극기를 들고서  
salam.tul-i motwu moy.essta. ku.tul-un kakkak son-ey thaykukki-lul tul.ko.se  
'People all gathered, each holding a Korean flag in their hand.'



## 7.5 Extension of $ASyn_{ana}$ to Korean

### 7.5.1 General

As in English and other languages, the reference of first-person and the second-person pronouns is determined by each discourse situation. First-person pronouns refer to the speaker, sender or creator of a piece of information, while second-person pronouns refer to the addressee or recipient of that information.

- (80) 내가 너를 사랑하는데 너도 나를 사랑하느냐? 우리가 서로 사랑하느니?  
 nay-ka ne-lul salang.ha.nunte ne-to na-lul salang.ha.nunya  
 wuli-ka selo salang.ha.nunci?  
 'I<sub>i</sub> love you<sub>j</sub>. Do you<sub>j</sub> also love me<sub>i</sub>? Do we<sub>i,j</sub> love each other<sub>i,j</sub>?'

Just like any other indexical expressions such as *now* and *here*, the first-person and the second-person pronouns are also indexical expressions, depending the situation in which a discourse is carried out or the circumstance where a particular text is created. It is necessary to devise a way of constructing such a situation or circumstance.

### 7.5.2 Discourse Situation as Part of Metadata

To construct a **discourse situation**, we introduce at least four entity types that constitute it.

- (81) a. **speaker**: <speaker>  
 b. **addressee**: <addressee>  
 c. **time of utterance**: <uTime>  
 d. **place of utterance**: <uPlace>

To capture any pragmatically relevant relationship between the speaker and the addressee, we also introduce the type of a link, tagged <metaLink>. We then introduce <metaData> as a root element that encloses all the information carried by these four entity types.

The feature assignment @ for each of the four entity types is specified in (82):

- (82) a. Feature Assignment @<sub>speaker</sub>:  
**attributes** = identifier, target,  
 [plural], [speechStyle], [comment];  
**identifier** = idPrefix="sp" followed  
 by a positive integer;  
**target** = IDREF|CDATA;  
**plural** = "yes";  
 {\*If not plural, unspecified and  
 the value is assumed  
 to be singular.\*}  
**speechStyle** = "humble"; {\*If not  
 humble, it is a plain style.\*}  
**comment** = CDATA;

- b. Feature Assignment @<sub>addressee</sub>:  
**attributes** = identifier, target, type,  
 plurality, [speechStyle],  
 [comment];  
**identifier** = idPrefix="ad" followed  
 by a positive integer;  
**target** = IDREF|CDATA;  
**speechStyle** = "humble"; {\*If not  
 humble, it is a plain style.\*}  
**comment** = CDATA;
- c. Feature Assignment @<sub>uTime</sub>:  
**attributes** = identifier, target,  
 value, comment;  
**identifier** = idPrefix="ut" followed  
 by a positive integer;  
**target** = IDREF|CDATA;  
**value** = CDATA; {\*follows [32].\*}  
**comment** = CDATA;
- d. Feature Assignment @<sub>uPlace</sub>:  
**attributes** = identifier, target,  
 value, comment;  
**identifier** = idPrefix="up" followed  
 by a positive integer;  
**target** = IDREF|CDATA;  
**value** = CDATA; {\* may follow  
 [35].\*}  
**comment** = CDATA;
- e. Feature Assignment @<sub>metaLink</sub>:  
**attributes** = identifier, figure, ground,  
 relType, [trigger], comment;  
**identifier** = idPrefix="metaL"  
 followed by a positive integer;  
**figure** = IDREF;  
**ground** = IDREFS;  
 {\*The value of the attribute  
 @ground is either a speaker  
 or an addressee. It can also have  
 more than one value.\*}  
**relType** = CDATA;  
**trigger** = IDREF  
**comment** = CDATA;

The attribute names @figure and ground are the terms borrowed from Gestalt psychology, as used extensively for the annotation of spatial relations in [35]. The **figure** is a perceptually prominent object against some background which constitutes its **ground**. The attribute speechStyle is relevant only for those languages like Korean and Japanese that have a honorific system of discourses.

In order to incorporate the metadata information on discourse situations into the anaphoric annotation scheme, specified with  $ASyn_{ana}$  and  $CSyn_{anaX}$ , we need to instantiate  $ASyn_{semAnn}$  with an XML-based  $CSyn_{semAnnX}$  from the general annotation scheme specified with  $ASyn$ . The concrete syntax thus extended will have <semAnn> with an ID prefix sa as its root element under which the two elements <metaData> and <anaX> are embedded.

### 7.5.3 Illustrations

Consider the Catholic new version of the Lord's prayer. :

#### (83) Lord's Prayer: Catholic New Version

하늘에 계신 우리 아버지,  
아버지의 이름이 거룩히 빛나시며  
아버지의 나라가 오시며  
아버지의 뜻이 하늘에서와 같이 땅에서도 이루어지소서.

This is the prayer that Jesus taught his disciples.<sup>39</sup> The annotation of this prayer undergoes two annotation processes: (a) word segmentation, (b) metadata, (c) identification of markables and (d) the annotation of links.

#### (84) a. Word Segmentation:

하늘에 계신 우리<sub>w3</sub> 아버지<sub>w4</sub>,  
아버지<sub>w5</sub>의 이름이 거룩히 빛나시며  
아버지<sub>w9</sub>의 나라가 오시며  
아버지<sub>w12</sub>의 뜻이 하늘에서와 같이 땅에서도 이루어지  
소서.

#### b. <semAnn xml:id="sa1">

```
<metaData xml:id="metaD1">
<speaker xml:id="sp1" target="#w3"
type="human"
plurality="yes"/>
<addressee xml:id="ad1" target="#w4"
type="divine"/>
<metaLink xml:id="metaL1"
figure="#ad1" ground="#sp1"
relType="fatherOf"/>
</metaData>

<anaX xml:id="ax1">
<entity xml:id="x1" target="#w5"
form="nom"
type="divine" definite="yes"/>
<entity xml:id="x2" target="#w9"
form="nom"/>
type="divine" definite="yes"/>
<entity xml:id="x3" target="#w12"
form="nom"/>
type="divine" definite="yes"/>
<anaLink xml:id="anaL1" figure="#x1"
ground="#ad1"
relType="ident"/>
<anaLink xml:id="anaL2" figure="#x2"
ground="#ad1"
relType="ident"/>
<anaLink xml:id="anaL3" figure="#x3"
ground="#ad1"
relType="ident"/>
</anaX>
</semAnn>
```

Here are four occurrences of the markable 아버지 (apeci) and they all refer to one and identical entity, the addressee, identified as ad1. <anaX xml:id="ax1"/> captures such a fact.

Consider example (85), which is identical with (70):

(85) 나는 어머니를 사랑한다. 어머니가 없는 세상은 상상조차 할 수 없다. 어머니들은 정말 대지와도 같다.

na-nun emeni_{x1}-lul salang-hanta. emeni_{x2}-ka eps.nun seysang-un sangsang-cocha hal swu epsta. emeni.tul_{x3}-un ceng-mal tayci-wato kaththa.

'I love (my) mother. I can't even imagine a world without her. Mothers are really like the earth to me.'

There are three occurrences of 어머니 (emeni) 'mother', but the third one 어머니들 (emeni.tul) 'mothers' is a plural indefinite form.

(86) shows how (85) is annotated. Note that the fragment has undergone word segmentation as a preprocessing step:

(86) a. 나_{w1}는 어머니_{w2}를 사랑한다. 어머니_{w4}가 없는 세상은 상상조차 할 수 없다. 어머니들_{w11}은 정말 대지와도 같다

b. <semAnn xml:id="sa2">

```
<metaData xml:id="metaD2">
<speaker xml:id="sp1" target="#w1"
type="human"
plurality="yes"/>
<metaLink xml:id="metaL2"
figure="#x2" ground="#sp1"
relType="motherOf"/>
</metaData>

<anaX xml:id="ax2">
<entity xml:id="x1" target="#w1"
form="nom" type="person"
definite="yes"/>
<entity xml:id="x2" target="#w2"
form="nom" type="mother"
definite="yes"/>
<entity xml:id="x3" target="#w4"
form="nom" type="mother"
definite="yes"/>
<entity xml:id="x4" target="#w11"
form="nom" type="mother"
definite="no" plurality="yes"/>
<anaLink xml:id="anaL1" figure="#x1"
ground="#sp1"
relType="ident"/>
<anaLink xml:id="anaL2" figure="#x3"
ground="#x2"
relType="ident"/>
<anaLink xml:id="anaL3" figure="#x2"
ground="#x4"
relType="partIdent"/>
<anaLink xml:id="anaL4" figure="#x3"
ground="#x4"
relType="partIdent"/>
</anaX>
</semAnn>
```

As a final example, consider example (ex70):

(87) 내가 너를 사랑하는데 너도 나를 사랑하느냐? 우리가 서로 사랑하는지?

nay-ka ne-lul salang.ha.nunte ne-to na-lul salang.ha.nunya wuli-ka selo salang.ha.nunci?

³⁹See Matthew 6, 9–13 and Luke 11,2–4.

'I_i love you_j. Do you_j also love me_i? Do we_{i,j} love each other_{i,j}?'

This example contains first-person and second-person pronouns. Their reference is determined by a discourse situation, as shown in (88b) Metadata:

(88) a. Word Segmentation:

내_{w1}가 너_{w2}를 사랑하는데 너_{w4}도 나_{w5}를 사랑하느냐?
우리_{w7}가 서로_{w8} 사랑하는지?

b. Metadata:

```
<metadata xml:id="metaD3">
 <speaker xml:id="sp1" target="#w1"
 form="pro"/>
 <addressee xml:id="ad1" target="#w2"
 form="pro"/>
</metadata>
```

c. Anaphoric Annotation:

```
<anaX xml:id="ax3">
 <entity xml:id="x1" target="#w1"
 form="pro"/>
 <entity xml:id="x2" target="#w2"
 form="pro"/>
 <entity xml:id="x3" target="#w4"
 form="pro"/>
 <entity xml:id="x4" target="#w5"
 form="pro"/>
 <entity xml:id="x5" target="#w7"
 form="pro" plural="yes"/>
 <entity xml:id="x6" target="#w8"
 form="reciprocal"
 plural="yes"/>

 <anaLink xml:id="anaL1" figure="#x1"
 ground="#sp1"
 relType="ident"/>
 <anaLink xml:id="anaL2" figure="#x2"
 ground="#ad1"
 relType="ident"/>
 <anaLink xml:id="anaL3" figure="#x3"
 ground="#x2"
 relType="ident"/>
 <anaLink xml:id="anaL4" figure="#x4"
 ground="#x1"
 relType="ident"/>
 <anaLink xml:id="anaL5" figure="#x5"
 ground="#x1"
 relType="splitCoref"/>
 <anaLink xml:id="anaL6" figure="#x5"
 ground="#x2"
 relType="splitCoref"/>
 <anaLink xml:id="anaL6" figure="#x6"
 ground="#x5"
 relType="recip"/>
</anaX>
```

The last link `<anaLink xmlLid="anaL6">` in (88) can be interpreted as in (89):

$$(89) [speaker(x_1) \wedge addressee(x_2) \wedge A = \{x_1, x_2\} \wedge reciprocal(A, R)]$$

In order to interpret $reciprocal(A, R)$, we adopt the definition of Weak Reciprocity (WR), discussed by [50]:

(90) Definition of Weak Reciprocity⁴⁰:

Given a set A and a relation R , which is $A \times A$,
 $reciprocal(A, R)$ is true if and only $\forall x \in A \exists \{y, z\} \in A[x \neq y \wedge x \neq z \wedge xRy \wedge zRx]$

$reciprocal(A, R)$ in (89) is now interpreted as in (91):

$$(91) [speaker(x) \wedge addressee(y) \wedge love(e_1, x, y) \wedge love(e_2, y, x)]$$

The interpretation (91) is a case of symmetric reciprocity. It is a particular case of (90) in which the cardinality of A is 2, $|A| = 2$, such that $z = y$.

8 Concluding Remarks: A Summary

This paper is an extended and revised version of [54]. It mainly aimed at making some linguistic contributions as necessary ground work to an ISO initiative to produce an international standard on anaphoric annotation as part of a series of semantic annotation schemes. It has thus reviewed several existing annotation schemes for anaphoric links including TEI-based [5], [85], [30], [79] based on [61], [64], [65], and [70] in efforts to normalize them into an interoperable annotation scheme implementing common denominators as an ISO international standard on semantic annotation.

Section 4 through section 6 form the core of this paper. Following the initial proposal of [7] and his subsequent works including [10], a basic work for [36], this paper adopts a formal approach to the construction of a semantic annotation scheme for anaphoric annotation which consists of:

1. an *abstract syntax* $ASyn_{ana}$,
2. a set of possible *concrete syntaxes* $CSyn_{ana}$, and
3. a semantics supporting the abstract syntax.

As designed by [55], the proposed abstract syntax $ASyn_{ana}$ for anaphoric annotation is derivable from the general abstract syntax $ASyn$, providing an anaphoric annotation scheme *structured* with a two-level specification language in abstract terms:

1. the level of identifying *entities*, called ‘discourse entities’, as marakbles and
2. the level of *linking* each anaphor to one or more antecedents, called ‘anchors’ or ‘grounds’.

$ASyn_{ana}$ allows a variety of types of anaphoric linking for coreference and other types of anaphoric relations by simply specifying their data type only.

⁴⁰The Korean reciprocal 서로 (selo) is a one single word. It cannot be subject to the analysis of [21] and [18] that relates *each other* to *each the other* in terms of a distributive quantifier *each* and some other elements such as coordinating elements of distributive adverbs.

ASyn_{ana} allows the derivation of a class of concrete syntaxes *CSyn_{ana}* that are semantically equivalent, but each with a different representation format. The proposed concrete syntax *CSyn_{anaX}* is based on XML, providing an XML-based representation format. The basic entity type for discourse entities that are referred to by either referring or anaphoric expressions is tagged <entity> with its ID prefix being "x" which is followed by an integer for unique identification. The attribute-value specification associated with <entity> has a long list of optional or implied attributes such as @definite, @naturalGender and @plurality other than a small number of required attributes, @xml:id, @target, @type and @form, depending on the language to which the annotation scheme is applied.

The XML-based concrete syntax *CSyn_{anaX}* for English has a single linking tag <anaLink> for anaphoric relations. Besides its ID with its prefix "anaL", which is needed for doing semantics as a handle for combinatorial operations, the element <anaLink> has three required attributes: @figure, @ground,⁴¹ and @relType. The attribute @ground may have more than one antecedent as its value. The list of values for the attribute @relType includes: "ident" for coreference, "partIdent" for partial identity, "splitIdent",⁴² "qBound" for quantifier binding, and "recip" for reciprocals.

The formulation of a semantics for an abstract syntax is required if the abstract syntax is for semantic annotation. Section 6 thus showed how semantic forms can be derived from the list of annotations or XML-elements in *CSyn_{anaX}* in a compositional manner in order to validate the proposed *ASyn_{ana}* even partially. The task of constructing a model-theoretic semantics for *ASyn_{ana}* is left as a future agenda item.

By applying *ASyn_{ana}* to Korean, we have shown how adequately a concrete syntax *CSyn_{anaX}* can be modified and extended. One such an example is the treatment of the reciprocal expression 서로 (selo) 'each other' in Korean. Given an adequate semantics of reciprocity in language, reciprocal expressions in Korean as well as in English are shown to be adequately annotated and interpreted.

In treating Korean, we have also extended *ASyn_{ana}* to accommodate the notion of *discourse situations* as meta-data, tagged <metaData>, that specifies various discourse-involving entities such as the speaker, the addressee(s), the utterance time and the utterance place as well as a link that relates them with each other. These entities are then tagged in XML: <speaker>, <addressee>, <uTime>, and <uPlace> with the link being tagged <metaLink>. The element, tagged <metaData>, is the root element for the annotation of discourse situations.

The current versions of proposed *ASyn_{ana}* and *CSyn_{anaX}* both need to be evaluated against inter-annotator agreed annotations with large data, especially applied to Korean. Such task is, however, left as a future project.

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Notes

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⁴¹These attribute names stand for an anaphor and a set of antecedents.

⁴²"splitIdent" is the inverse of "partIdent".

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