REPRESENTATION AND INTERPRETATION OF DETERMINERS IN NATURAL LANGUAGE

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ABSTRACT.

Following the principles of locality and compositionality during semantic interpretation, we propose a semantic representation formalism which manages to deal with reference problems, i.e. with the interpretation of NPs (in particular, of those beginning with an article): the addressed problems are generic / specific / class readings, and collective / distributive interpretations.
The formalism follows the semantic net approach, and uses different representation plans (semantic, content and reference) and particular structures, called ambiguity spaces, that hide the ambiguities from the other parts of the sentence and remain neutral with respect to the various interpretations until certain disambiguation clues are found.
Besides presenting the formalism, the paper discusses which clues may be used to disambiguate among the various interpretations and shows the way this representation is used to update the hearer's knowledge base *.

I INTRODUCTION

The interpretation of natural language is a process aimed at converting a linear sequence of word forms (a "text") into a semantic representation that can be worked on in order to perform inferences, produce answers, and, more generally, to modify the knowledge base of the hearer **. Many knowledge sources cooperate in a more or less synchronized way to perform the task: they include lexicon, syntax, knowledge about the way utterances are connected to each other, and knowledge on how the structured representation of a sentence can be converted into the corresponding semantic representation ***. The present paper is concerned with the last of them, and in particular with what is usually called "semantic interpretation process".

One of the most common assumptions about the way this process is carried on is the principle of compositionality, stating that the meaning of a given constituent can be obtained by combining in some way the meaning of its components, where by "constituent" it is usually intended a suitably defined portion of the syntactic representation. This principle establishes a clear and effective relationship between the syntactic structures and their semantic counterparts (of course the overall context has to be taken into account to solve, for instance, anaphoric references), but it still allows a semantic theory to model the interpretation process in an apparently unnatural way. An example is provided by first order predicate calculus:

> "The sentence *Floyd broke a glass* translates into
> 3 *x (glass (x)* A *break (Floyd, x))*
> or, in the notation of restricted quantification
> *( ] x : glass) (break (Floyd, x)).*
> In either case, the syntactic constituent *a glass* does not correspond to any semantic constituent; rather, its interpretation forms several discontinuous parts of the logical expression." [Jackendoff 84, p.52).

A principle that should guide the search for a perspi-:uous semantic theory is the Grammatical Constraint:

> "The Grammatical Constraint says that one should prefer a semantic theory that explains otherwise arbitrary generalizations about the syntax and the lexicon" [Jackendoff 84, p.51]

The first aim of the representation presented in this paper is to respect the Grammatical Constraint, in order to increase further the naturalness of the interpretation process, [n fact, it will be shown that the analysis can be carried on in a deterministic way. The features of the representation will be described by discussing its suitability to handling a difficult problem in NL analysis, i.e. the interpretation of determiners. The analysis of determiners is strictly confined with the relationships between sense and reference, intension and extension, concept and class. It is not possible to analyze here in detail the aistinction among the different terms *, but we will try to make clear wnich kinds of linguistic phenomena have to be modelled.

The purpose of a natural language utterance is to make some assertion or to ask for information about something. This something must be specified by the speaker in some way. To do that in an understandable way, the speaker must make some assumptions about the knowledge available to the hearer. In order to be as informative as possible, and if s/he assumes that the involved entity is known to the hearer, the speaker must try to enable him/her to identify that entity; otherwise, s/he can leave it (more or less) unspecified (see [Appelt 85J). The same identification issues arise if the predication does not concern an individual entity, but applies to each entity of a given set. A very different :ase is the one where the predication does not refer to the elements of the set, but to trie set as a collective entity: here, the fundamental process known as "inheritance" does not apply, so we need some way to keep apart the two kinds of 'set' statements.

Still another different case is the one where there is no specific entity (or set) involved in the predication, but the assertion is "generic", in the sense that it applies to all possible entities satisfying the description. In principle, nothing nore than context-dependence seems implied by this distinetion; for instance, Ex1: "The girls are very nice" expresses i fact about a well-defined set, both in case it is understood

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•* We will use the terms "speaker" and "hearer" to refer to the producer and the receiver of the message, without any commitment about the fact that the message is written or spoken

*** We assume that such a structured representation exists The debate on this assumption is exemplified by [Schank, Birnbaum 84] [Marcus 84] [Tanenhaus et al 85]

* The most thorough discussion is, to our knowledge, [Lyons 77, chapt.7]. See also [Woods 75] (in particular, the fourth section) and [Castelfranchi, Stock 86]

as a reference to a subset (contextually determinable) of girls, and in case it is intended to state a generic property of the (context-independent) set of all girls. On the other hand, specific and generic expressions are worth being represented in different ways for two reasons. The first is mainly semantic: in definite references the set is fixed (i.e. it does not change over time), whilst in generic expressions the property applies to any member of the set, even in case some current members were not in the set when the proposition was issued. The second reason is linguistic: genenc statements can also be expressed in the singular (intuitively, without reference to a set} as in Ex2: "A bear hibernates in winter" or Ex3: "The dog is a friendly animal"*. This is one of the main sources of problems in the design of an effective interpreter of NL expressions.

A. Interpretation problems for determiners

As" seen above, the same article may indicate different types of referents. For instance, in case of a definite article, there are three alternatives: a single individual (or a specific group of individuals), as in Ex4: "The bear is eating meat"; the generic element of a set, as in Ex5: "The bear eats meat" or Ex6: "The bears eat meat" (this sentence is likeky to sound unnnatural to English speakers, because they would say "Bears eat meat"; on the other hand, in Italian we seldom have bare plurals); the class corresponding to a particular concept, as in Ex7: "The bear is dying out" [Di Eugenio et al. 86]. The choice of the correct interpretation is not easy and, although some clues may be provided by syntactic, semantic and/or pragmatic knowledge, this choice is sometimes impossible without taking into account the discourse history.

Another point from which ambiguity arises is the possibility of having distributive readings, like in Ex8: "The soldiers who hit Hannibal have been praised", or collective ones, like in Ex9: "The soldiers who defeated Hannibal have been praised"**. In both cases, the initial representation we give to the NP must be neutral, in order to be specified, if this is possible, during the further processing of the sentence.

Notice that the neutrality required of the initial semantic representation as regards the two problems of generic vs. specific or collective vs. distributive reading is different: in the former case, the ambiguity concerns the interpretation of the NP itself, i.e. what kind of reference is made; in the latter one, it concerns its links with the other parts of the sentence. In fact, a plural NP defines a set through its members, and the set and its individual members must be both present in the representation ***, as either of them may be referred again in the sentence: disambiguating a reading as distributive or collective, then, does not mean to furtherly specify some elements of the representation, but to individuate which element - set or individual member - must be linked to the other parts of the sentence.

Some of the representation formalisms that have been proposed in the literature seem to have a strong expressive power, because they manage to represent the different readings we talked about above (at least some of them), but they lack to explain, or do not stress enough, the way in which this representation is built.

For example, Webber's logical formalism, which resorts to restricted quantification (Webber 831, is able to represent definite and indefinite NPs, collective and distributive readings, generic sets; on the other hand, her aim is to derive entity descriptions that allow her to solve subsequent anaphoras, so that she generates those descriptions from sentences that have already been translated into a logical formalism, but the way she represents the NPs appearing in the sentence while the sentence itself is processed is not clear.

Hobbs's approach [Hobbs 83] is based on a flat logical formalism where the predicate SET and the so-called 'typical element' of a set nicely account for distributive and collective readings. The drawback of this representation is that it does not seem to allow the most natural treatment of generic assertions: in fact, the deduction that the individual about which the predication is made is the typical element of a set is left to the discourse interpretation process; in our opinion, as the generic reading of an NP is sometimes clearly pointed out by clues present in the sentence itself, it is not the case to systematically demand this task to the discourse interpretation process; on the contrary, there must exist a distinct way to represent generic sentences.

Another flaw of trie approaches previously adopted is their inability to model the NPs of type 'class'; e.g. in Hobbs' representation they could be solved by using an entity for which the predicate SET holds, but this would fail to distinguish between set and class. Notice that assertions on classes are not to be confused with collective readings of sentences, although they are very similar: first of all, 'class' readings are generic assertions, collective ones not necessarily; moreover, collective readings usually express a parti-:ipation (not necessarily active) in some event, something that is true of every member of the set, while no particination of the single individual to an event * is asserted in class assertions.

A last case, which deserves particular attention, since it is substantially different from all others, occurs in the so-called *Opaque Contexts:* no individual is involved, but neither inheritance applies, nor the class is referred. It is exemplified by sentences as ExIO: "John wants to marry a Norwegian", Exll: "Mary is looking for a knife". In these cases (though these examples are ambiguous) there is a reading where the meaning of the indefinite noun phrase can be roughly characterized as "some entity which has the characteristic properties denoted by the term used". Opaque contexts are very strictly correlated with the concept of "intension". What is peculiar is that the 3 quantifier that is usually associated with indefinite singular NPs (denoting the "existence" in the universe of discourse of an entity satisfying the predicates that apply to the quantified variable) is loosing now its power. In fact, in Exlz: "Every boy needs a dog no existing dog is involved, neither a single one that every boy needs, nor a specific one associated with each different boy (perhaps via a suitable Skolem function). Instead, what is said is that for each boy there *should* be *at least one* entity to which the "dog" intension applies and which is needed by that boy. Note that it is by no means said that any dog can satisfy the needs of a particular boy, so that the inheritance mechanism cannot apply to dogs, thus inhibiting an interpretation as "a property ofeach dog is that it is needed by the boys". It is clear that opaque contexts require a very special treatment.

* This is probably one of the reasons that led many researchers lo postulate the existence of "prototypes" Their use and their import have been widely discussed in the literature (sec, for instance, IBrachman 85]); although prototypes are not part of the representation that we propose herein, this representation is amenable to the same discussion. However, this is not a paper on knowledge representation, at least in its usual sense, but on semantic interpretauon; this simply means that we will not consider problems about inheritance, cancellation, classifiers and so on, but only the internal structure of the molecular entities which the representation is composed of.

** Actually, as Webber points out |Webber 83], a plural NP may have another reading, the conjunctive one "Three boys bought five roses" may mean "Three boys bought five roses (each)", "Three boys bought five roses (together)", or "The total of rose-buying boys is three and the total number of roses is live, without any commitment to the relation between each boy and each rose" We will not address this problem, since it seems to be more related to the treatment of quantifiers than to the one of determiners.

*** A similar point is made by Hobbs [Hobbs 83], who states that "the logical form for a plural NP will include reference lo a set and its typical element".

* The word 'event' here does not mean single occurrence of a particular fact, but it is used in the broader sense of situation, state or action, possibly generic, expressed by a verb phrase

II TRI-CONCEPTS AND AMBIGUITY SPACES

The solution we propose for the problems outlined in the introduction involves new representation tools that we called Tri-Concepts (TCs) and Ambiguity Spaces (ASs). We introduce them by means of an example.

Fig. 1 shows the final representation relative to Ex13: "ILorso che vive nella gabbia sta mangiando" (The bear which lives in the cage is eating) *. The representation involves three different plans:

- the semantic plan (SP), which contains the semantic knowledge of *the* system (i.e. the - more or less - static knowledge about the world);
- the content plan (CP), on which the representation of the content conveyed by the sentence is built;
- the reference plan (RP), on which the possible referents of the NPs are built.

The reference plan, whose existence is limited to the single sentence orocessing, stores the initially ambiguous representations of the NPs <ind not the entities previously mentioned in the discourse; the RP allows to take apart the problems of the referential interpretation of an NP and the semantic role that the object that the NP denotes plays in the sentence. In fact, what seems important is to maintain distinct those features of the representation that concern the semantic roles that constituents play with respect to each other and those regarding the ambiguities mentioned above. We solved this problem by means of the reference and content plans and by means of what we call 'ambiguity spaces' **: they are structures that embody the ambiguities internally, ana, in a certain sense, hide them from the other components of the representation. If the ambiguity can be solved at the syntactic and semantic level, the contents of these spaces are modified to convey this information without affecting the other parts of the sentence; otherwise, the still ambiguous (or partially ambiguous) spaces will be passed to the processes that access the pragmatic knowledge and/or the discourse context.

There are two types of Ambiguity Spaces: the *reference ambiguity spaces* (RASs), regarding the genenc / specific / class readings, and the *aistributivity ambiguity spaces* (DASs), that concern the collective / distributive readings.

Before talking about the ASs, we must explain the KB representation that corresponds to a noun: it is not merely a node, but a ternary structure, called a TriConcept, that includes three atomic nodes: the concept, the extension and the class.

The concept node will be used in the usual way: it will take part in taxonomies and will accumulate assertions, but only those inheritable by every individual corresponding to that concept.

The class node will accumulate the generic assertions that are not inheritable by individuals (like those contained in Ex7).

The extensional node will not accumulate any assertion, but it will make it possible to have the specific readings of plural NPs linkea to the correct set referent and to express membership to a set.

A. Reference ambiguity spaces

When an NP head is met, a new node on the content plan (*i in fig.l) and a RAS on the reference plan are created; the initial content of the RAS depends on the type of the NP determiner: while the definite determiner may be involved in a generic, specific or class reading (sec Ex4, Ex5, Ex6, and 6x7, in section LA), the indefinite determiner is not used in class assertions: you cannot say "A bear is dying out" or "A bear is studied by naturalists" ***. Therefore, the RAS initially associated to a definite NP will contain a complete copy of the TC, the one associated to an indefinite one only the concept and the extensional nodes; besides, the arc connecting the node on the content plan and the RAS will be labelled by SAME for definite NPs, by I-OF (INSTANCE-OF) for indefinite ones: in the former case the NP refers to a precise individual (or set), concept or class, while in the latter nothing can be said on the individual denoted by the indefinite NP besides its belonging to a certain set or its being a random exemplar of the concept (in case of the generic reading of the indefinite article). In fig. 2 we can see the situation occurring after an NP head has been met (the other parts of the representation are omitted).

This initial representation will be augmented during the processing of the sentence if the NP has specifications, e.g. a restrictive relative clause (see Ex 13), an adjective *(the white bear),* a relation with other objects *(Georee's bear):* these specifications are not directly linkea to tne content node that refers to that entity (x_1 in fig. 1), but to another node (x_2 in fig. 1) by means of a DEF-AS arc. The meaning of this connection is that the subset, subconcept or subclass that the NP refers to is defined as the portion of the content net indexed by the DEF-AS arc itself. The introduction of a pair of nodes (x_x and x_2) is justified by the need of keeping apart the entity that participates in the main predication and the way it is defined; this is impossible if x, and x_2 coincide.

B. Distributivity ambiguity spaces

To a plural definite NP a second AS, the DAS, is associated on the content plan, as we can see in fig. 2: it allows to represent both the set that a plural NP defines and the members of this set without any commitment to the role that each of them plays in the sentence. Another DAS will be created on the content plan to express the specifications of the NP, in an analogous way to that described above for the specifications of a singular NP.

In fig.3 the final representation of complex NPs is shown: the RASs are internally transformed according to the particular reading. If the NP has no specifications, it will simply consist of the node, or DAS, connected to the RAS by the arc SAME or I-OF; the RAS will be linked to the TC on the semantic plan by an arc labelled by EQUAL, because no subset, subclass or subconcept has been defined. Note that there is no incompatibility between the representation of an entity on the content plan by means of a DAS, i.e. as a pair "set-member" and the possible class reading that to that pair can be given; in fact, we may have sentences like Ex14: 'Gli orsi cne vivono in Alaska si stanno estinguendo" (The bears which live in Alaska are dying out), where we have a set of bears, which in turn corresponds to a particular class of bears, upon which a predication is made.

As far as intensional context are concerned, they are simply represented by marking the RAS with "intensional" and by connecting the CP node with the concept node in the

ID DISAMBIGUATION RULES

Although the task of disambiguating among the different interpretations of an NP is not easy and cannot be fully dealt with without taking into account world knowledge and the discourse history, some useful syntactic and semantic criteria do exist, and they have been easily embodied in the framework constituted by the FIDO system (Flexible Interface for Database Operations) (see {Lesmo Torasso 83], [Lesmo Torasso 85], [Di Eugenio et al. 87]). The features that we have taken into account follow *.

A. The verb

One useful feature of the verb is its tense: verbal forms different from habitual past and habitual present (and

* From now on, the examples will be in Italian, because our FIDO system works on the Italian language.

•* Both the three plans and the ambiguity spaces are under some respect similar to spaces in partitioned networks fHendnx 79].

*** Perhaps the sentences above may be uttered if the meaning of 'a bear' is 'a [type of] bear', but we do not consider this case.

* We will only discuss the problem of generic / specific /class readings, as collective / distributive interpretations seem solvable by resorting to the semantics of the verb.

future, which needs distinct considerations) express a specific reading if the subject is indefinite, while for definite subjects the same is true, provided that the verb cannot be referred to a whole class (liKe "estinguersi", i.e. "to die out[M]). Notice that Italian and English differ, because in English there are two different forms expressing progressive and habitual present, while in Italian we have a unique present form (a progressive form does exist, but its use is not compulsory as it is in English); on the other hand, we have two different simple past forms to express a durative action or a specific event (although in English the form 'used to' exists). By resorting to trie verb tense and sometimes by taking into account its meaning, we can disambiguate sentences like ExI5 "II leone sta mangiando le muccne" (The lion is eating the cows), where we have the progressive form also in Italian, ExI6: "I leoni uccisero le mucche" (The lions killed the cows), ExI7: "II leone si sta estinguendo" (The lion is dying out). A sentence that remains ambiguous is ExI8: "II leone mangia le mucche", that, in Italian, may mean both "The lion is eating the cows" and "The lion eats the cows". The future tense gives some problems, as sentences like ExI9: "II leone mangera' le mucche" (The lion will eat the cows) can be disambiguated only resorting to world knowledge and the discourse context.

B. NP specifications

The features that we have taken into account are a) possessive adjectives and b) restrictive relative clauses.

a) It should not sound strange that possessive adjectives may help to disambiguate an NP with a determiner, because in Italian possessive adjectives are very often preceded by a determiner. In most cases, a possessive adjective, especially in the first or second person, makes a generic reading impossible. In Ex20: '11 tuo cane mangia sempre carne" (literally, *"The* your dog always eats meat"), the specific reading of the subject is forced by the presence of the possessive adjective; in fact, if we omit it, in Ex21: "II cane mangia sempre carne" (The dog always eats meat) the generic reading is preferred, if the sentence is taken in isolation.

b) Restrictive relative clauses point to a specific reading of the NP they refer to if they contain a reference to a specific individual; this holds both if the relative pronoun is not the subject of the clause, as in Ex22: "The castle that I visited yesterday ...", and if it is the subject and one of the other complements refers to a single individual, like in Ex23: "The dog which bit John is ferocious".

C. Mutual influence of NP interpretations

There seems to be a certain preference for a global generic or specific interpretation versus one where some NPs are specific and others generic. In particular, the NP head cannot be given one interpretation (specific / generic) and its specifications the other (generic / specific); the disambiguation can go in either direction, i.e. we may disambiguate an NP specification on the basis of the NP head, or the NP head on the basis of one of its specifications. For example, Ex24: "La donna con la gonna e' molto elegante" (literally, "The woman with the skirt is very elegant) may be generic or specific, while Ex25: "La donna con la tua gonna e' molto elegante" (literally, "The woman with the your skirt is very elegant") can only be specific. The same considerations hold for different complements of the same verb, although the disambiguation of one complement by means of another is not certain, because counterexamples do exist, like Ex26: "II cane di Giorgio mangia le aringhe" (literally, "The dog of Giorgio eats the herrings"), where, although "the dog of Giorgio" refers to a specific entity, the sentence does not refer to a specific event, but to a habit of that dog.

These disambiguation criteria have been inserted in the FIDO system, a system which accepts natural language sentences and addresses a relational DataBase. The disambiguation criteria have been implemented as condition-action rules; their activation is subordinate to some predefined event, like the analysis of a content word (implemented as a node filling process) or the completion of a constituent (implemented as a node closure operation). The rules are subdivided in packets, each of which concerns the definite or indefinite determiner and a particular situation of the parsing process. The condition parts of the rules test the already built tree; they examine the NP head, verify whether there are other disambiguated determiners, check the verbal form etc. The action part augments the internal structure of the RASs.

As an example, we report a rule relative to the disambiguation of a definite NP as a specific reference:

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CONDITION:
  (AND
    (OR ((CURRENT TENSE present_progressive)
         (CURRENTTENSE simple past))
    (NOT (CLASS VERB current_verb)))
ACTION:
  (CREATEJNDIV current_RAS newjndiv)
  (LINK current_RAS newjndiv extension m of)
  (DIRECT currentJRAS newjndiv contentlink)
```

The condition part verifies that the current verb does not require a class subject and that its tense is present progressive or simple past (remind that in Italian simple past has no duration meaning); in this case, the specific reading is accepted and the actions modify the current_RAS, i.e. the one connected to the NP under examination, in the following way:

CREATEJNDIV creates a new individual node - *newjndiv* - in the *current RAS;*

LINK links *newjndiv* to the extensional node - *extension* - of the TC contained in the *currentRAS* by means of an arc labelled *mof;*

DIRECT directs the arc *content Jink* coming from the content plan, whose head pointed to the RAS, onto *newjndiv.*

What is obtained is the structure shown in fig.3_al.

A last word on the certainty of these rules: while the one above is certain, other rules only give a preferential reading to a given NP (one of these rules concerns the mutual influence of two complements, like in Ex26 above). In case a rule is not certain, its action part is not executed, but it is delayed until other rules are activated that may confirm that interpretation. At the moment, we are studying a weighting mechanism to balance the interaction of the rules. If contradictions are detected, or if insufficient evidence in favour of an interpretation has been collected, RASs remain ambiguous.

IV HOW THE REPRESENTATION IS USED

The formalism previously described aims at representing the *information content* of a sentence *independently of the context* where it has been uttered. Of course, the way it is built is just the first phase of the interpretation process; although this paper is mainly concerned with it, it seems worth while giving an idea about how the resulting representation is used afterwards.

The described proposal tries to exploit the advantages of a description of the interpretation process called *Transient-Process Account* in [Woods 75] without being subject to the same criticism. In other words, the RP and the CP are transient, in the sense that they disappear at the very end, but they *are* an unambiguous representation of the sentence *. When this representation is made available, the hearer must access his/her contextual knowledge in order to find possible referents or to build structures to associate with newly introduced entities. But now all the information needed for guiding the search has been made explicit. This

* The discussion in [Woods 75] ia primarily addressed to relative clauses, but the distinction we made between "SAME" and "DEF-AS" links allows to keep apart the referred entity from its description, whatever the form of the latter is.

does not mean that what remains to do is an easy task (cfr. examples like Ex27: "Harry saw an hungry lion; the poor beast ..."), but the network representation makes it rather straightforward to verify that "lions" form a subset of "beasts" (this knowledge should be available on the SP) so that the rules of correct reference can be defined on well-known subsumption arcs *.

We can now introduce a preliminary version of the rules that govern the execution of the last phase, i.e. the mixing of previous (contextual) and new (RP-CP) information.

The updating of the knowledge base of the hearer can be done in two ways, depending on the contents of the Reference Plan (RP) and of the Content Plan (CP).

The contents of the RP determine the mode of this updating:

a) if there is one or more I (individual) or S (set) nodes on the RP, then the corresponding nodes have to be looked for by the hearer in his knowledge base (to be more precise, in that part of his KB that regards the current situation of the world, analogous to the A-Box in a KRYPTON-like framework [Brachman et al. 851). The node to be found must satisfy the given description both in terms of the extension of the RP node, as given by the outgoing M-OF or SS arc (i.e., it must be of the right 'type'), and in terms of the possible DEF-AS arcs exiting from the RP node. Moreover, both in case it is an individual and a set, it must be unique, i.e. there must not be two different nodes satisfying the description **. When the relevant node has been found, the assertion about it expressed by the utterance ("ASSERT" entry point) has to be added to the knowledge base.

   In case no node satisfying these requirements is found, two possibilities arise: ir the nodes I and/or S are defined by means of a DEF-AS arc, new individuals or new sets are to be added to the KB; otherwise, i.e. if the reference is a bare NP without any specification ("the bear", "the woman"), as we do not consider situations where the referent is perceptually available, an inconsistency is found: either the speaker has used an inappropriate expression (but this can be disregarded, because we suppose the speaker follows the Conversational Postulates [Searle 69]), or the system has misinterpreted the reference, which is not specific, but either generic or class. At this point, a diagnostic process should be triggered; our provisional solution is to ask the user.

b) If the reference is definite (arc SAME between CP and RP), but generic or class, the general KB *** will be updated, according to two different modalities: if the NP has no specifications, the assertion will be made on the node (concept or class) in the TC corresponding to the NP head and contained in the KB; otherwise, as there is a DEF-AS arc coming out from the RAS, a new TC will be created, whose concept node will be a subconcept of the concept corresponding to the head of the NP (tnis corresponds to creating a new term in a T-Box) and the assertion will be stored there ****.

c) In case the reference to a single individual is indefinite (arc 1-OF pointing to an EXT node), then an individual node corresponding to the description (in the same sense explained above) must be created in the knowledge base.

d) In case an indefinite reference gives rise to a generic reading (arc I-OF pointing to a CONCEPT node in a RAS), this generic assertion is stored on the concept node; however, the problem is still under investigation, because this use of the indefinite article does not imply generic universality (an assertion of this kind can be considered 'defeasible' [Croft 85]).

e) The final point regards intensional contexts. The problem of their interpretation (i.e. what to do when the RAS is marked as "intensional") is still open. The solution we are currently implementing is to maintain nested spaces which block some kind of inferences. For instance, in the case of Ex 12 (Every boy needs a dog), we get something that correspond to a formula as:

$$\forall x\,(BOY(x) \rightarrow NEED(x, (\exists y\,(DOG(y) \wedge OWN(x,y)))))$$

where the higher order predicate NEED is opaque in the usual sense. As the paper is mainly concerned with the previous phase of the interpretation and the import of this solution is currently under study, we will not go in more details here

A last word on the situation in which the RASs on the RP are ambiguous: the disambiguation task is dealt with by the processes that access world knowledge (however, they take into account the possible clues in favour of a certain interpretation found during the analysis of the sentence). These processes act as a filter that eliminates some interpretations; e.g. in Ex26: "L'uomo ha sofferto per molti secoli" (literally *'The* man has been suffering for many centuries") the maximum length of a single person's life forces the generic interpretation.

V CONCLUSIONS

This paper introduces a new formalism for representing the information contents of a NL utterance. The main advantages of this proposal are:

- the different readings of an NP can be represented in an unambiguous way. That is, distinct representations are obtained for specific, generic, class, collective, distributive, intensional readings;
- ambiguous expressions result in partially specified representations; in principle, other KSs could operate on them in order to solve ambiguities;
- the analysis can be carried on in a deterministic way, i.e. without reshaping temporary structures, but only adding new data.

The whole interpretation process is assumed to work in two steps that are currently applied sequentially, but could be interleaved in a subsequent version. The first step, with which this paper is more concerned, regards the construction of a context-independent representation of the sentence. The second one regards the actual update of the hearer's knowledge base on the basis of the representation that has been built. In this second step context-dependencies are taken into account.

We believe that the approach described in the paper is a first step towards a perspicuous treatment of quantifiers in natural language, which accounts both for the intrinsic complexity of the matter and for the apparent ease that seems to characterize human processing of quantified phrases. The paper does not treat generalized quantifiers but only determiners; the results obtained for them are encouraging and the studies on real quantifiers [Di Eugenio, Lesmo 86] seem to show that the formalism can be extended quite easily to cover them.

* Of course, if *Harry* was my dog and it was devoured by the lion, the reference assumed in the text is not the right one Moreover, it is clear that any mechanism for accessing the previous context should pay attention to more general problems of anaphoric references, and in particular to their relationship to the organization of discourse - on the problem of focussing see, for ex., [Sidner 831, IGrosz 81).

** This search process has not yet been implemented. Of course, it is not only a matter of efftciency, but also of taking into account the relevant data. For instance, the uniqueness condition must apply to a suitably specified current context, otherwise "the boy" or "John" could never be used

*** Its contents are similar to a T-Box's [Brachman et al. 851

**** Notice that we do not consider really definitional sentences like "The whale is a mammal".

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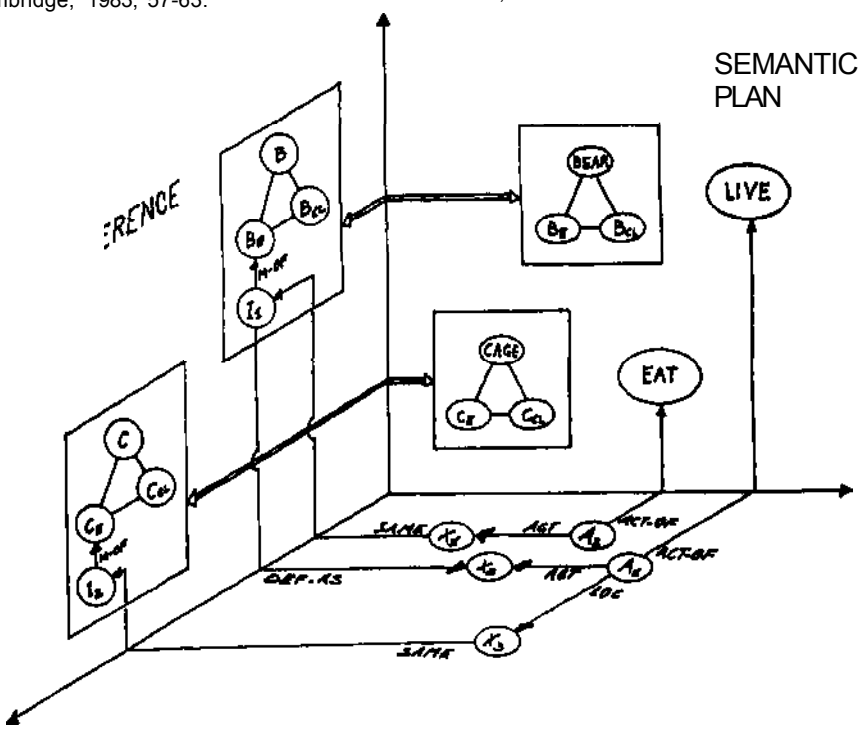

Fig. 1: final representation of Ex 13: "The bear which lives in the cage is eating".
(Unnecessary details, as the tense of the verb, are omitted)

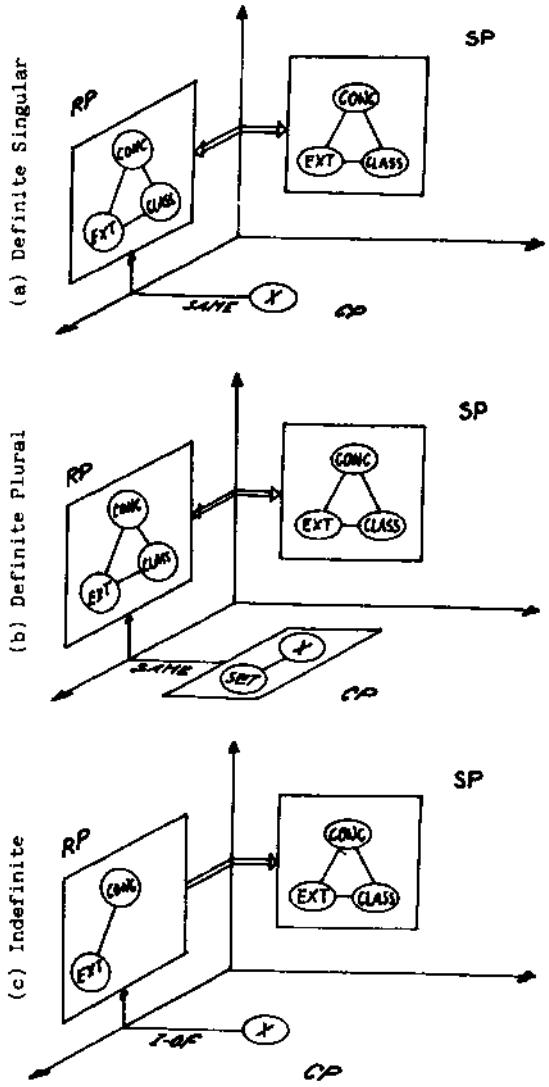

Fig.2 - Initial representation associated with different determiners

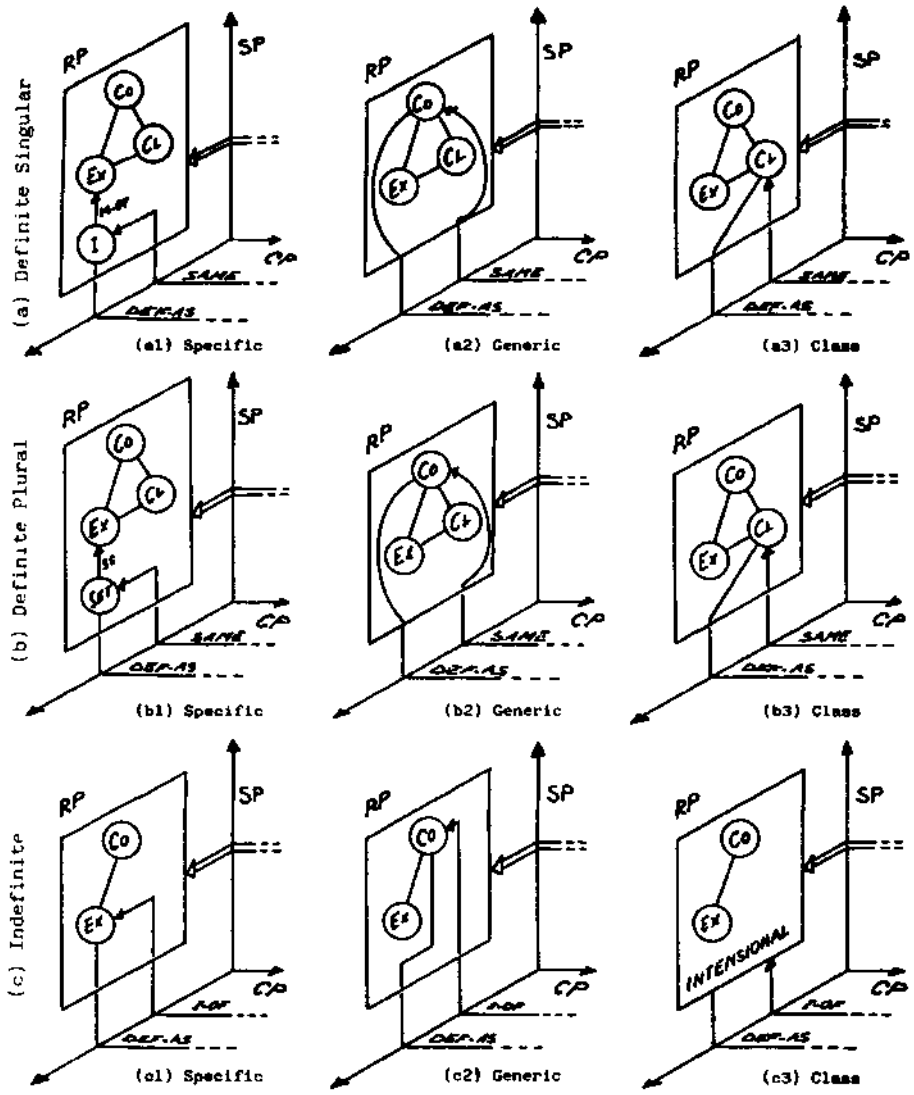

Fig.3 - Final Status of the Reference Plan after complete disambiguation of the determiner (in case this is possible)