American Journal of Computational Linguistics *Microfiche 54*

MULTIPLE ENVIRONMENTS

APPROACH TO NATURAL LANGUAGE

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Summary

The paper describes a preliminary stage of author's inquiry aimed at integrating the "possible world" approach with the idea of treating utterances as programs. It is claimed that providing sophisticated facilities for manipulating possible world" descriptions should be one of the main concerns in designing a natural language understanding system. The logical notion of "possible world" has a close counterpart in the computer science notion of the environment of expression evaluation. The idea of treating utterances as programs is generalized by allowing environment switching during the evaluation of an utterance. A model of natural language, based on multiple environments in the sense just mentioned, is outlined in terms of computer science. A rough classification of environment types is given. One structure of environments is devoted to keeping track of the direct and indirect speech recursive quotations. Another structure is assigned to every person involved in a discourse or mentioned in it; it is used to handle belief-sentences, lies and promises. A third type of environment is used to represent the structure of topics in a discourse. Advantages of the advocated approach, called the multiple environment model of natural language" are demonstrated in the discussion of well-known problems of reference and presuppositions.

CONTENTS

1. Introduction.

The paper presents several ideas on how to describe natural languages for a language understanding system. Some of them are similar to those advocated by Lakoff (1968) and Morgan (1969). They have been derived by the author independently (Bien 1975) while exploring the Davies and Isard(1972) approach of treating utterances as programs.

The subject examined in the paper is itself broad and encompasses many controversies;however, it is not the author s intent to make a case for the ideas presented. Firstly, the limits of the paper do not permit a proper discussion of the pros and cons for each solution proposed; and furthermore most of these problems have a tradition dating as far back as the Middle Ages, in some cases. And secondly, the author has not yet developed all of his own concepts fully enough to warrent a detailed presentation. Instead,the paper seeks to present the simplicity and generality of the proposed approach

The paper is an enlarged and modified version of a talk delivered at the Fourth International Joint Conference on Artificial Intelligence in Tbilisi. The modifications envolve mainly the terminology and the form of presentation; the only essential change of some importance is the different treatment of the first and second person pronouns.

Most of the examples in the paper are direct quotations from

the referenced literature; herein, some are employed somewhat differently than was their original intent.

2. Discourses as programs.

2.1. Utterances as programs.

It is now obvious that the human ability to use language is related closely to intelligence itself. Nevertheless, the complexity of natural language is still rather underestimated by linguists, which results usually in using relatively primitive tools for a formal description of language. Although such formalisms like e. g. transformational grammar may be theoretically adequate, from a practical point of view they are too cumbersome; (in my opinion writing a transformational grammar may be only compared with programming a sophisticated system exclusively in an assembly language). The main merit of Artificial Intelligence for the development of computational linguistics lies in suggesting a quite new way of thinking about language. It consists in shifting the attention of research from linguistic competence to linguistic perfomance and treating the latter as an operation of a real or imagined language processor, which in turn can be discussed in terms of computer science. Winograd (1972:2) claims even that the best test of a complex model of natural language is to implement it as language understanding system. Although he is basically correct, in the present state of

art, the objection posed by Charniak is often valid. Charniak (1972:2) noticed that most programs in Artificial Intelligence handle only a few kinds of selected test examples. Deciding that a program can be extended in some easily imaginable way to handle more examples or more sophisticated cases reguires practically the same procedure as verifying a non-programmed theory. Therefore, I treat Winograd's postulate as a long-term aim, and at this moment I advocate a less ambitious strategy: to use as much possible of the computer science intuitions in natural language description. This is in fact also the approach of Longuet-Higgins (1972) who states that natural language utterances are just programs to be run in our brains.

Some interesting analogies between language understanding and running a POP-2 program have been shown e. g. in (Davies, Isard 1972). I pursue this approach in another direction, characterised by an intensive use of the notion of environment. In the earlier stage of the inquiry, represented by (Bien 1975), I thought that all the environment manipulations which were necessary for the feasibility of my approach could be realised by means of the Bobrow and Wegbreit multipl environments primitives (1972); therefore, I have introduced the term "multiple environments model of natural language". Now I am not sure of it, because I see reasons to use e. g. cross-world bindings , whose relation to the Bobrow-Wegbreit primitives is not yet clear to me. Anyway, I still use the term multiple en-

vironments model of natural languages because it characterises well my approach even if it is to be understood only metaphorically.

It should be noted that considering all utterances as a kind of imperative is not a new idea for linguists; it can be found e. g. in (Wierzbicka 1969), but to my knowledge such ideas had no practical impact on linguistic research.

2.2. The notion of discourse.

The notion of <u>discourse</u> (called also <u>coherent text</u>) is a rather vague one. I will try to clarify my use of the term by discussing several aspects of coherency.

First, there is a type of coherency which I shall call <u>textual</u>. It is realised by these inter-sentence and inter-phrase links which are visible in the text surface as some lexical items or syntactical features. Surface realisations of these links I shall call <u>pointers</u>. A simple but very important class of pointers consists of <u>pronouns</u> understood in a broad sense, including pro-adverbs etc. There are also pointers peculiar to given languages; e. g. after McCawley (1971) and Isard (1974) it is reasonable for English to treat the Past tense as a pointer, because (Isard 1974) it acts as a form of definite reference to a past situation on which the attention of the conversants has recently been focussed The <u>presupposttions</u>

often function similarly to pointers, but I think that presuppositions are essentially different from pointers and I prefer to account for them in another way.

A second type of coherency I shall call <u>situational</u>. The situation of a conversation can influence the coherence of the message in two ways. First, it can supply values for these pointers which are not assigned by the text itself. It is the case of e. g. (Isard 1974a)

(1) Be careful, he might bite you.

said while the adressee is near a dangerous animal. Such an utterance can be easily transformed into a textually coherent one by introducing a narrator. The second type of situational coherency is more subtle,it consists of applying the addresse's knowledge to fill up some relations omitted in the sender s message. This is needed e. g. in the text (Bellert 1972:79)

(2) Ann's eldest son has left Warsaw for a scholarship study in the Sorbonne.

(3) France is an interesting country to study in.

where the knowledge that the Sorbonne is a French university has to supply the missing link. In general, a text is situationally coherent only relative to a given domain of knowledge. In practice we often communicate our ideas by means of non-coherent texts; the communication succeeds only because the addressee modifies his beliefs for the purpose of making the text coherent relative to this updated domain of his

beliefs. Because he does it only if he decides more or less arbitrarily, that the message has a meaning, such texts I shall call volitionarily coherent. A typical example is a text with a sentence which carries brand new information by means of presuppositions. The existence of such sentences has been pointed out by Wierzbicka (1969), Bellert (1972:79), recently by Karttunen (1974:191) who gave the following examples:

(4) I would like to introduce you to my wife.

(5) We regret that children cannot accompany their parents to commencement exercises.

where (4) presupposes the existence of the wife and (5) that its complement is true but both sentences are used in situations which do not satisfy these presuppositions.

For the sake of completeness it is necessary to mention the situations, where the text contain pointers without values, but they are considered by the addressee as not relevant to the matter at hand. This situation seems to happen only in literary texts.

2.3. Discourse processing.

I will discuss below the main levels of discourse analysis. I ignore discourse generation for two reasons. First is a theoretical one: I feel strongly that it is the analysis which is the primary activity and that the generation is driven by

the evaluation of the re-analysis of a generated text. Second reason is a practical one: at the present state of art we have much better insight into the analysis processes than into the synthesis problems.

According to the present views I take for granted that the analysis consists of a set of cooperating processes performing different task, in particular the syntactic, semantic and pragmatic analysis. By a level mentioned above I mean a set of such processes which manipulate the notions of similar type, in the intuitive sense of the same degree of abstractness relative to the physical message.

I distinguish four levels.

The level responsible for extracting relevant information from acoustic signal or a visual image I call the sorbtion. I mention it here only for the sake of completeness as I have nothing to say on this subject.

The second level, which is the only point of interest of the present paper, I call the interpretation. I mean by it the process taking as data the results of sorbtion (of course, it does not mean that the sorbtion is to be executed before the interpretation; the sorbtion should supply partial results on the request of the interpretation) and yielding some value in the formalism used in the system under consideration for the representation of knowledge. For simplicity I assume here that the knowledge is represented in labelled graphs stored in a

classical way in a PLANNER-like associative data base (Hewit 1971), e.g. the value of the sentence (Charniak 1972:83)

(6) Bill got the ball before he went to the park.

may be something like

(7) (N1 BEFORE N2 N3)
(N2 GET BILL1 BILL3)
(N3 GO BILL1 PARK1)
.....

It is often assumed that text processing by a language understanding system consists only of those two levels or their equivalence. I insist on the necessity of two additional levels. First of them I call judgement. This is the level responsible for keeping the beliefs of the system consistent. As long as trivial worlds are considered, this level can be integrated into some systematically performed data base bookkeeping When we start to model more complicated worlds, we will face the problem of theoretical or practical undecidability of bookkeeping problems and therefore this level is to be thoroughly controlled by the system supervisor. Such a solution agrees with the intuition of Marciszewski (1972:180) that "most beliefs are spontaneous and that it is the entertaining of a belief with the awareness of non-accepting that requires a special act of giving up; the suspension of judgement is therefore an act more sophisticated than spontaneous belief"

The fourth level, which I call the integration, should be de-

signed to memorize the facts marked by the judgement level as important enough to be stored. As far as I know, the investigation of the problems related to this level has been neglected, the only exceptions being the works of Chafe, in particular (Chafe 1973).

2.4. Ambiguities.

All the recent works on speech understanding as well as on discourse analysis show that the result of interpretation is as a rule ambiguous. For particular domains of discourse we often find some particular rules to disambiguate sentences, but the final solution consists, in my opinion, in formalizing and implementing general pragmatic rules, which I shall sketch below.

The highest priority rule should be the rule of coherency. It says that this interpretation of a discourse is better which yields as the value the more dense graph. The density of a graph can be computed as e.g. the ratio of graph arrows to the number of nodes; if our graphs are frame structures in the sense of Winograd (1974), we can compute the ratio of the important elements filled up to the important element slots left unassigned. I feel it is just the rule which chooses properly the referent of the last sentence "she" in the examples (Charniak 1972:56):

(8) Penny wanted to go to Bill's party.

Mother had to tell her that she had not been invited.

(9) When Penny heard about the costume ball she started thinking about what Mother could wear.

Mother had to tell her that she had not been invited.

In general, the net effect of the coherence rule will be that sometimes the referents of different noun phrases (and in general, the linguistic means which I call designators) are collapsed to form one object for the sake of the higher density of the result. Therefore the rule will also help us to handle presuppositions properly. We may treat every presupposition as carrying brand new information and leave for the coherency rule the task of collapsing eventually the presupposed facts with the facts already known by the system.

Second rule I call the consistency rule. I mean by it the simple but important rule:if one interpretation of an utterance is inconsistent, look for another interpretation. It explains why for the utterance (Russel 1905):

(10) I thought your yacht was larger than it is.

one should not react by saying

(11) No, my yacht is not larger than it is;

or why we treat the sentence (McCawley 1967):

(12) Boris said that he didn't kiss the girl who he kissed.

as the information that Boris lied and not that he uttered a non-consisted utterance.

The third and most subtle rule which has the lowest priority I call the efficiency rule. A similar regulation attributed to Quine, can be found in Ajdukiewicz (56:126). This rule states that if we have to choose between two interpretations of a sentence, and one interpretation is also the value of a simple sentence, we choose the other interpretation. Our choice is based on the assumption that the sender was aware of all relevant possibilities and consciously used the more complicated sentence to transmit the message expressible only by this sentence. For example, although I agree with Ajdukiewicz (1967:32) that the sentence

(13) Caesar knew that the capital of the Popes lies on the Tiber.

may be interpreted as equivalent to

(14) Caesar knew that Rome lies on the Tiber.

on the basis of the efficiency rule I prefer this interpretation of (13) which is equivalent to

(15) Caesar knew that Rome lies on the Tiber and that Rome is the capital of the Popes.

Incidentally, in some situations the efficiency rule may suggest for the sentences similar to (13) an interpretation analogical to (14). Let us assume for example that Stanley is solving a crossword puzzle and has to fill in a pattern specified by the clue "the river on which lies the capital of the Popes"; Stanley knows that Rome is the capital of the Popes but he does not

know that Rome lies on the Tiber. He may ask John about the name of the river and receive the proper answer. Now, when Stanley is asked by somebody

(16) Have you properly filled in this pattern?

there is a quite natural answer

(17) Yes, John said that the capital of the Popes lies on the Tiber

To summarize,I think the only solution to the ambiguity problem is the breadth first search in the sense of Charniak (1972:75) with the above-mentioned rules used to evaluate the interpretations. It does not mean that I neglect the need for the rules peculiar for particular discourse domains. They are necessary for efficiency of the interpretation process and they should drive the search,but they may not be allowed to override any interpretation, as is the case in the Wilks preference grammar. For the sentence (Wilks 1974:32)

(18) The hunter licked his gun all over, and the stock tasted especially good.

the real world knowledge would probably cause the interpretation with the "soup" sense of stock to be found first,but the coherency rule would properly choose the interpretation where "stock" is understood as a part of the gun.

3. Multiple environments.

3.1. The notion of environment.

In actual language understanding systems the facts stored in the system memory are classified according to their ontological status in a very rough way. Usually they are split into the classes: past versus present and reality versus possible future ; the only exceptions are the system for playing tic-tac-toe of Isard (1974), Joshi and Weischedel (1973). In the linguistic literature one can easily find the ideas of possible worlds used to handle the modal concepts,but more subtle possible worlds classifications was discussed, to the best of my knowledge, only by Lakoff (1968) and Morgan (1969). My claim is that we need a very sophisticated classification schemae for the possible worlds features.

A set of facts to which I assign the same ontological status I will call environment. The term is borrowed from computer science, where it means all variables accessible from a given program point together with their values. My use of the term is justified by the fact that the access to the system memory is ussually performed by matching a pattern against an associative data base, resulting in binding the free variables of the pattern to some values found in the memory; access to different environments in the sense defined above may result in different binding of the variables, which is also the case with the

environments understood in the computer science sense.

For the purpose of the present paper environments can be thought of as subsets of a PLANNER-like data base with contens specified by some filters in goal statements. In reality such an implementation would probably be inefficient and therefore it is necessary to look for another solution, starting with the notion of context in Conniver (Sussman, McDermot 1972) and QA4 (Rulifson et al 1972).

The crucial point of the presented approach consists in allowing quite complicated access environment structures, to stress this fact I use the term "multiple environments".

3.2. Person environments.

A sophisticated language understanding system has to take into account the fact that some other beings also have the ability to use natural language, to remember events, to make inferences etc. For the sake of simplicity any real or fictious being capable of using a natural language will be called a person. Practically, persons will be either humans, engaged in a discourse with the system or humans mentioned in such a discourse, but we can mean by persons also another language understanding systems and robots, persofinications of animals from children tales, etc. In the lack of arguments to the contrary, the system will assume that the language using abilities of other

persons are identical with those of itself. Therefore it can easily simulate relevant aspect of other persons mental processes by running recursively its own language processing routine in a suitable environment. For example, if the system perceives the sentence (19) said by Fred to Stanley:

(19) I like your book.

it should be interpreted in the environment where the pronouns "I" and "you" are respectively bound to Fred and Stanley; such a treatment allows it to obtain the correct value of the sentence, which may be represented as:

(20) Fred likes Stanley's book.

In the text:

(21.1) Frank said:

(21.2) "When I came back, John was already waiting for me and asked:

(21.3) 'How are you'?"

the clause (21.1) may be evaluated in the environment of the system itself. The mention of Frank causes the environment of Frank to be created or recovered with the prounon "I" preset to Frank; the interpretation of (21.2) is done by the recursive call to the language processing routine in the environment of Frank. The mention of John yields the environment of John, which is embedded in the environment of Frank; therefore from the point of view of the system, it is the environment of John as described by Frank. This person environment has the pronoun

I" preset as usual to the respective person and the pronoun you" is set to his current interlocutor, i. e. Frank. The sentence (21.3) and other sentences reported by Frank as said by John are interpreted in this environment.

Multiple person environments allow the system to keep track of differences in person's knowledge, which has importance for many reasons. For example, it is difficult to account for the use of the indefinite noun phrase in (22.5) in the text (Charniak 1972:185):

(22.1) Jack and Bill were outside flying a kite.

(22.2) A strong wind came by and the string broke.

(22.3) Janet and Alice were outside the house.

(22.4) Janet looked up and said:

(22.5) Look Alice, there is a kite flying away.

without separating the knowledge of the narrator and the addressee from the knowledge of Janet.

By keeping track of the knowledge and beliefs for every person in the discourse, we are able to give an obvious explanation for the difference between factual and non-factual sentences, e. g. (Kiparsky 1971:345):

(23) John regrets that it is raining.

(24) John thinks that it is raining.

In the first case it is the environment of the addressee which is affected by an evaluation of the phrase "it is raining". According to our treatment of presupposition, the value of that

phrase is added to the environment of the addressee, where eventually may be collapsed with another mention of the rain An analogical process is independently performed in the environment of John. In the second case it is exclusively the environment of John which is affected by the evaluation of the phrase "it is raining", while the addressee's environment remains unchanged. As has been pointed out by Morgan (1969) it is not true that non-factual sentences have no presuppositions. It can be easily seen in the following text:

(25.1) John thought the door is open.

(25.2) He thought he should open it

which is inconsistent in the same way as the text

(26.1) The door was open.

(26.2) John went to open it.

The difference between (25) and (26) consists in the environment to which the presupposition refers: the real world or the mind of John.

It should be noted that the class of non-factual sentences and phrase is much larger than is usually assumed. For example, in the text (Charniak 1972:191)

(27.1) Jack and Bill were outside flying a kite.

(27.2) A strong wind came by and the string broke.

(27.3) Janet and Alice were outside the house.

(27.4) When Janet looked up she saw a kite.

a kite of (27.1) and (27.4) in reality refers to the same ob-

ject, but in (27.4) it is referred again by means of the indefinite noun phrase to mark Janet's ignorance about it. We may easily account for it by evaluating this noun phrase only in the environment of Janet.

Some cases involving non-factual interpretations of phrases and sentences have been discussed by logicians and philosophers under the name of intentional (spelled with 't') or intensional (spelled with 's') verbs, e. g. (Montague 1973):

(28) John looks for a unicorn.

intensional sentences, e. g. (Ajdukiewicz 1959):

(29) Caesar knew that the capital of the Republic lies on the Tiber.

or belief-sentences, e. g. (Partee 1973:31):

(30) Tom believes that you an I are sisters.

All these cases can be easily handled by means of multiple environments.

3.3 Impression environments.

In the above discussion of persons we have assumed that exactly one environment is assigned to every person. There are several arguments for splitting this environment into at least three environments, which I call the environments of <u>behaviour</u>, <u>pretense</u> and <u>knowledge</u>.

Distinguishing the pretense environment from the knowledge one

is necessary to handle the cases of lying, e. g.

(31) Fred is lying when he says he likes Stanley's book.

we interprete as meaning

(32) Fred likes Stanley's book.

in the Fred's pretense and as

(33) Fred does not like Stanley's book.

in the Fred's belief.

This distinction allows us also to handle the performatives along the lines of Isard (1974a), i. e. the sentence

(34) I bet you 2.5 p that it will rain tomorrow.

is taken to be true, because uttering it changes the respective pretense (which is equivalent to the notion of point of reference used by Isard) and the judgement during the comparison of the value of (34) with the content of respective person environment founds them compatible.

The distinction between behaviour and pretense is more discutable, as it yields subtlety not needed in most applications. It is useful to handle e. g. slips of tongue and to distinguish different aspects of "what is said" (Ziff 1972).

To account for such linguistic facts like e. g. the acceptability of

(35) John wants to catch a fish and he intends to eat it.

and the non-acceptability of

(36) John intends to catch a fish and he wants to eat it.

it is necessary, following Lakoff (68:7) to introduce additional

environments,namely the environment of desires and the environment of intentions.
The word "knowledge" in the term "knowledge environment" is not to be understood literally. In fact it describes the knowledge attributed to somebody on the evidence of its behaviour, statements etc. This justifies using the term impression environments to cover all the environments assigned to a person.

3.4. Choosing an environment.

From the preceeding paragrapn it follows that during discourse analysis we have usually several environments at hand. Every phrase is to be interpreted in at least one environment. This poses the problem of choosing the proper environments for the interpretation of a given phrase. We will see that there exist several strategies to handle the problem, which differ in the amount of computational resources (time and memory) used this fact may be considered to be the analogue of the human ability to change the amount of attention devoted to discourse undrestanding.
Let us imagine a highly sophisticated computer-aided instruction system. During a teaching session with a student the system models its interlocutor by means of a person environment, composed of the behaviour environment (used e.g. to measure the student response time), the pretense and the knowledge

environments. The knowledge environment is preset to some general knowledge and it is systematically updated by the analysis of student utterances. If we do not exclude the possibility that the student lies, we should interprete them directly in his knowledge environment. In any case, the pretense is useful to store the results of such performatives as student's definitions of symbols etc. If the student quotes a manual or a lecturer, it is necessary to create a new person environment and to evaluate the whole quoted passage in it When the system is going to say something to the student, it should verify whether the utterance [illegible] for the student. The verification is made by running its utterance in the student's environment, which allows it to compare the real intention of its utterance with the intention probably assigned to it by student. To be more strict, in the student's environment the environment of the system as imagined by the student should be created, and the utterance run in the pretense of it; the results should be compared with the results of running the utterances in the proper pretense of the system.

Obviously, this is a complicated and resource consuming process, difficult to carry on with reasonable efficiency. Newertheless, I think that processes performed in the mind of a talented teacher working at full capabilities must be similar.

Let us now take an example from the other extreme, when the system works according to the reliability rule . It may be the

system from our first example during a session of knowledge acquisition when discussing a subject with a teacher. Now it is quite possible to introduce all the information directly to the knowledge environment of the system, which is the analogue of credously accepting everything what is said. It is evidently quite easy both for humans and computers; in practice humans apply this strategy mainly when they are forced to devote most of their computational power to other tasks of a higher priority.

Between these two extremes there exist many mixed strategies, where the system for every person of the discourse makes an independent decision, whether or not to create a new environment, based both on the reliability of the person and the availability of resources.

3.5. Topic environments.

The usual way of handling the reference problem is to compute for every noun phrase or pronoun a separate list of possible referents and to use some heuristics to choose one element from the list. Another approach, advocated here, consists in storing all possible referents permanently available into a special topic environments. The items stored in the topic environments may be the symbols of physical object as well as some relations and other semantic data structures, put there during the eval-

uation of respective linguistic constructs. In particular, the indefinite descriptions of the type (Bellert 1972:32)

(37) It is a foreigner who is delivering aspeech now.

(38) One young boy has flunked his matriculation exam.

are interpreted as declarations, used to create appropriate data structures to be put into the topic; therefore we do not need the Ref operator of Bellert (1972:3) introduced to handle such examples.

In every topic environment the items are ordered in some way; the access routine yields on request the subsequent elements of the topic in the very order; if the environment is exhausted and some new candidate for a referent is needed, the access routine switches to the respective super-environment.

Every succesful access to the topic causes its permutation, which results in making the accessed item the first element of the environment.

The essential difference between the traditional approach and that presented here lies in the possibility of structuring a topic environment.

For example (Isard 1974a), in the text:

(39.1) What did John say about Dick?

(39.2) He said that

(39.3) he looked like a drunken giraffe on ice skates.

there is no doubt that "he" of (39.3) refers to Dick. We account for it in the following way: every first use of a verb of the

"verbum dicendi" type causes a new topic environment to be created; the environment is initialised, in our case to Dick and then itself becomes an item of the current topic. The next mention of that act of communication causes the search in the current topic for the environment previously stored; when it is found, the reported clause is interpreted within it. In our case the first word of the reported clause is the pronoun "he" which calls the access routine for a possible referent. As the first and only possible referent of the current topic is Dick the pronoun is properly bound.

In the case of the text

(40.1) What did John say about Dick?

(40.2) He said that

(40.3) he doubted whether Dick would like it.

the pronoun will be also at first bound to Dick from the topic But when the proper name "Dick" will be evaluated, an attempt will be made to shift Dick to the first position in the topic where it already is located. This is a violation of the efficiency rule, and this interpretation will e rejected. Next possible refrent will then be obtain from the super-environment yielding the correct result.

There are some exceptions to the efficiency rule; in particular redundancy is desirable immediately after topic switching:

(41.1) What did John say about Dick?

(41.2) He said that

(41.3) Dick looked like a drunken giraffe on ice skates.

Another argument for topic structuring is the existence of sub-conversation, noticed e. g. by Charniak (1972:196):

(42) Janet, Bill and Bill's sister Helen were outside. Janet said:"I can't keep this kitten. Would you like to have it, Helen?". "Yes", said Helen. Bill said "I don't know. Remember how Mother objected to that robin. She would not let us keep it"."But Mother said it is not good to keep a robin indoors," said Helen. "It is not fair to the robin". "Look," said Janet, "Do you want it or not?".

At this stage the topic problem is the least elaborated part of my multiple environments approach;therefore I am not able to go into details here. Some additional argument in favour of the topic environment ideas will be found in the paragraph 4.2.

4. Running an utterance.

4.1. Designators.

By designators I understand the linguistic means used to refer to particular objects. Designators may be classified roughly into three classes: proper names, common names and descriptions. All three kinds of designators have been discussed for centuries by philosophers and logicians; our pragmatic approach to the designators is based mainly on the works of Kripke (1972) and

Donnellan (1971).

The characteristic feature of proper names is that their use must be preceded by the act of fixing thereference. Contrary to popular opinion, in practice proper names are much more ambiguous than common names , because proper names refer to individuals and common names to classes of individuals. For example, there are many men called John and if we are to understand e. g.

(43) John has come.

we need to have the referent of John already fixed. Different types of object have proper names of different stability. Countries, towns, mountains etc. have often unique names which are rarely changed.Most human full names are also rather stable from the practical point of view.Forenames are so ambiguous that their referents have to be reset again and again in every discourse, e.g. by quoting the full name of the person in question. Such proper names as <u>first and second person pronouns</u> may alternate their meaning even during one discourse. To sumarize, proper names in fact name some recognition routine supplied in the act of fixing the reference.

Common names do not refer directly to individuals, but they are names of characteristic functions of the respective sets of individuals;their meaning is so stable that they can be assumed to belong to the knowledge of the world; and therefore, fixing the reference, except in some peculiar cases, need not be

performed.

Descriptions are compound names constructed ad hoc by special linguistic means, like qualifying a common noun by an adjective etc. They name also respective compound characteristic functions.

All the designators are usually used in the referential way. That means that the respctive procedure is evaluated in a proper environment to yield the intended referent. Such treatment agrees in particular with Donnellan's intuition that a definite description does not in itself refer to anything but only its use points to a referent. Therefore, we may explain easily why the sentence (Donnellan 1971:110):

(44) Her husband is kind to her.

can be sometimes properly understood even if the man refered to is not the husband of the woman; such a sentence is just to be evaluated in the environment of false beliefs of the sender. Quite often the sender uses underspecified descriptions, i. e. the descriptions which refer to a much larger set of individuals than it is intended, e. g. in Charniak (1972:72):

(45.1) Mother made some cookies and left one on a plate.

(45.2) She put the plate on the kitchen table and went into living room.

"the plate" of (45.2) by itself refers to every plate of the world.

The addressee has in such situations to restrict the respective

characteristic function to the object on his current topic; if it does not suffice, he need to eliminate the remaining ambiguities in the usual way, i. e. by means of the coherency, consistency and efficiency rules.

All designators except pronouns can also be use in an attributive way. In this case they mean just their characteristic functions. For example

(46) Mount Everst is Chomolungma.

means that in the sender's beliefs the characteristic function of Mount Everest has as well all relevant features of Chomolungma. In some other usage the respective characteristic function is to be adapted by the addressee to the circumstances of the context, e. g.

(47) He is a little Napoleon.

More common is attributive use of common names and descriptions, e. g.

(48) The Smith's murdered is insane.

in the sense of

(49) Whoever has murdered Smith, he is insane.

Attributive use of indefinite descriptions is also known as nonspecific setting , e. g. (Charniak 1972:178) "a kitten" in (50.):

(50.1) Jack wanted a kitten.

(50.2) Bill had a kitten and Jack offered to trade his ball for the kitten.

(50.3) Bill wanted to keep his kitten, so Jack went to look for George who also had a kitten.

(50.4) George was willing to trade so Jack got his kitten.

It is interesting that the SHRDLU program (Winograd, 1972) treat indefinite descriptions, which are used only attributively, e. g.

(51) pick up a big block

(52) find a block which is taller than the one you are holding and put it into the box

just along the lines given above, i. e. as programs with a free variable (Winograd 1972:130), although Winograd himself describes it, probably influenced by the logical tradition, by means of the variable bound by the existential quantifier (1972:126).

The characteristic feature of proper and common nouns is that they are always to be run in a single environment. It is not the case with descriptions which may require suitable splitting between several environments. It has been noted by Winograd (1972:147) with respct to the time reference, e. g.:

(53) Many rich men made their fortunes during the depression.

(54) Many rich men lost their fortunes during the depression.

(55) Many rich men worked in restaurants during the depression.

In these sentences the "rich men" phrase is to be evaluated in the present time environment for (53), in the past time envi-

ronment for (54), and the sentence (55) is ambiguous when taken out of a larger context.

There are other similar cases, e. g. the sentence

(56) Smith knows that the friend of Kowalski's brother is a writer.

is subject to several interpretations; some of them are

(57) Smith knows Kowalski, Kowalski's brother and the friend of Kowalski's brother and Smith knows that the friend of Kowalski's brother is a writer.

(58) Smith does not know Kowalski, but he knows Kowalski's brother and the friend of Kowalski's brother and Smith knows that the friend of Kowalski's brother is a writer.

Obviously, the interpretations (57) and (58) differ in the way the phrase "the friend of Kowalski's brother" is split between the environments of the knowledge of the sender and the knowledge of Smith.

Since we allow designators to switch environments, we have no problem with so called nouns with empty denotation ; they are to be evaluated in the respective fictitious worlds, e.g.

(59) I met him in the park by the sculpture of a faun.

4:2. Pointers.

In this paragraph we shall discuss the reference problem for the third person pronouns, the most important class of pointers.

We shall formulate a rule intended to substitute the "command rule" of the transformational grammar. The arguments in favour of our rule are simplicity, better adequacy and usage of the demon facility which should be present in the system for other reasons (Charniak 1972).

First, we shall remind that every access to the topic permutes it by advancing the accessed element to the very beginning of the topic; succesful evaluation of a designator introducing a new object puts the representation of the object also at the very beginning of the topic. Our rule states that the main clause pronouns immediately execute access to the topic, while the evaluation of subordinate clause pronouns may be suspnded if there is no suitable value for them in the topic; all the pronouns should be resolved before the end of the main clause processing.

Let us see how the rule works for examples from (McCawley 1971:226).

(60) After John left his apartment, he went to the pool hall.

The proper name "John" advances the John's representation at the beginning of the topic. The pronoun "his" is evaluated because there is at least one suitable value in the topic, i.e. John ; if bounding of "his" to John is rejected by some pragmatic rule, another possible referent is found, "he" is set to it and the referent is advanced at the beginning of the topic, getting ahead of John . When "he" is evaluated,

it is usually bound to the same referent as "his", which may be John or some other person.

(61) After he left his apartment, John went to the pool hall.

"After" introduces a subordinate clause, which may be suspended if there is no suitable value for "he" or "his" in the topic; if the clause is suspended, it can be resumed when evaluation of "John" puts its value to the topic.

(62) John went to the pool room after he left his apartment.

There is no problem with the sentence; "John" sets the topic supplying a possible value for "he" and "his".

(63) He went to the pool hall after John left his apartment.

The "he" is evaluated immediately; therefore the evaluation of "John" cannot influence its value. The strong feeling that the value of "he" should be different from John is explained as the violation of the efficiency rule: if you can refer to an object by a pointer and there is no possibility of misunderstanding, do not refer to it by a designator.

(64) A boy who saw her kissed a girl who knew him.

I am anxious to see a sentence of this type in an authentic English text, not as an example of areference problem, because I do not see any circumstances under which such a sentence can be uttered. None the less, we can handle the example easily. First, "a boy" is evaluated, yielding a person environment which is put into the topic. Next, " who saw her" is evaluated except

for the "her" because of the lack of a suitable value for it in the topic; therefore , the clause is suspended. Then the rest of the main clause is evaluated and the person environment for "a girl" is created, resulting in an updating of the topic. Now the suspended clause can be resumed and evaluated in parallel with the clause "who knew him"; all the pronouns will be properly bound.

Although it should be obvious, it is better to state explicity that the value of his in (60)-(63) is finally fixed by the coherency rule.

Analogically as with subordinate clauses, we can treat parenthethical clauses and phrases, e. g.:

(65) In John's apartment, he smokes pot.

(66) In his apartment, John smokes pot.

and obtain the desired results.

4.3. Presuppositions.

It is hoped that the above discussion together with works of Isard, Davies and Longuet-Higgins has shown the advantage of treating discourses and utterances as programs. Below we give an additional argument in favour of this approach, based on an article by Karttunen (1974). He presented difficulties related to finding the presupposition for a compound sentence and suggested they be avoided by adopting the more dynamic approach

of a recursive verification of the satisfaction of presupposition" condition. This idea can be easily integrated in our model, as it is best illustrated from the examples

(67) If Dean told the truth, Nixon is guilty too.

(68) If Haldeman is guilty, Nixon is guilty too.

(69) If Miss Woods destroyed the missing tapes, Nixon is guilty too.

The consequent clause in all of these presupposes the guilt of someone else, but the presupposition of the whole sentences differ: (68) definitely does not presuppose the guilt of someone else while (67) and (69) may presuppose it or not,depending upon the circumstances of their use.In our model the antecedent clauses are run before the consequent clause; therefore in (68) the presupposition of the consequent clause is satisfied by the antecedent and in (67) and (69) it can also be the case, depending upon the other knowledge available in the environment of the evaluation.

5. Conclusions.

Even if some of the presented ideas may become obsolete throught further research,the usefulness of the sophisticated environment structures for natural language descriptions seems evident. The notion of environment deserves a place as a crucial notion in a fully adequate theory of natural language. It is important

that the environment structures postulated here involve quite complicated embedding of environments without any static restrictions on the depth of the embedding. At the present state of art, it is convenient to describe such structures in terms of computer science, because e. g. formal logic di cur.e. only much simpler relations between different possible worlds. This fact, together with some other advantages shown in the paper, makes a strong argument in favour of treating discourses and utterances as programs.

6. Refrences.

(A łukiewicz 1956). Kazimierz Ajdukiewicz. Okres warunkowy a implikacja materialna. Studia Logica IV, pp 117-153. Reprinted in (Ajdukiewicz 1965), pp 248-265.

(Ajdukiewicz 1965). Kazimierz Ajdukiewicz. Jezyk i poznanie, t.II. Warszawa: PWN.

(Ajdukiewicz 1967). Kazimierz Ajdukiewicz. Intensional Expressions (a lecture delivered in 1959, published posthumously) Studia Logica XX, pp 63-86.

(Bellert 1972). Irena Bellert. On the logico-semantic structure of utterances. Wrocław-Warszawa-Krakow-Gdansk: Ossolineum.

(Bennet 1975). Michael Ruisdael Bennet. Some extensions of a Montague fragment of English. Reproduced by the Indiana University Linguistic Club.

(Bien 1975). Janusz Stanisław Bien. Toward a Multipl Environments Model of Natural Language. Advance Papers of the Fourth International Joint Conference on Artificial Intelligence, Tbilisi, Georgia, USSR, pp 379-382.

(Bobrow, Wegbreit 1973). Daniel G.Bobrow, Ben Wegbreit. A Model and Stack Implementation of Multiple Environments.Communication of the ACM , Vol. 16, No. 10, pp 591-603.

(Chafe 1973). Wallace L. Chafe. Language and Memory. Language Vol. 49, No. 2, pp 261-281.

(Charniak 1972). Eugene Charniak. Toward a Model of Children's Story Comprehension. Massachussets Institute of Technology AI-TR-226.

(Davies, Isard 1972). J. M. Davies, S. D. Isard. Utterances as programs. In (Meltzer, Michie 1972), pp 325-340.

(Davidson, Harman 1972). Donald Davidson, Gilbert Harman (eds.). Semantic of Natural Language. D. Reidel.

(Donnellan 1971). Keith Donnellan. Reference and definite descriptions. In (Steinber, Jakobovits 1971), pp 100-114.

(Feigl, Sellars 1949). Herbert Feigl, Wilfrid Sellars (eds.). Reading in Philosophical Analysis. New York.

(Fillmore, Langendoen 1971). Charles J. Fillmore, D. Terence Langendon (eds.). Studies in Linguistics Semantics. Holt, Rinehart and Winston.

(Hintika et al. 1973). K. J. J. Hintika, J: M. E. Moravcsik, P. Supps (eds.). Approaches to Natural Language. D. Reidel.

(Hewitt 1971). Carl Hewitt.Description and theoretical analysis (using schemata) of PLANNER: A language for proving theorems and manipulating models in a robot. Massachussets Institute of Technology AI-TR-258.

(Isard 1974). S. D. Isard. What would you have done if ...? Theoretical Linguistics Vol. 1 No. 3.

(Isard 1974a). Stephen D. Isard. Changing the Context. Mimeographed.

(Joshi, Weischedel 1973). A. K. Joshi, R. M. Weischedel. Some Frills for the Model Tic-Tac-Toe of Davies and Isard: Semantics of Predicate Compliment Construction. Advance Papers of the Third International Joint Conference on Artificial Intelligence, Stanford, USA, pp. 352-355.

(Karttunen 1974).Lauri Karttunen.Presuppositions and Linguistic Context. Theoretical Linguistics Vol. 1 No. 1/2, pp 181-194.

(Kiparsky, Kiparsky). Paul Kiparsky, Carol Kiparsky. Fact. In (Steinberg, Jakobovits 1971), pp 345-369.

(Kripke 1972). Saul A. Kripke. Meaning and Necessity. In (Davidson, Harman 1972), pp 253-355.

(Lakoff 1968). George Lakoff. Counterparts, or the problem of reference in transformational grammar. Reproduced by the Indiana University Linguistic Club.

(Longuet-Higgins 1972). H. Christipher Longuet-Higgins. The algorithmic descriptionof natural language. Proceedings of the Royal Society London B. 182, pp 255-276.

(Marciszewski 1974). Witold Marciszewski. Podstawy logicznej teorii przekonan. Warszawa: PWN.

(Mc Cawley 1971). James D. Mc Cawley. Tense and Time Reference in English. In (Fillmore, Langendon 1971).

(Mc Cawley 1971). James D. Mc Cawley. Where do noun phrases come from? In (Steinberg, Jakobovits 1971), pp 217-231.

(Mc Dermott, Sussman 1972). Drew V. Mc Dermott. Sussman. The Conniver Reference Manual. Massachussets Institute of Technology AI Memo 259.

(Meltzer, Michie 1972). Bernard Meltzer, Donald Michie (eds.): Machine Intelligence 7. Edinburgh: University Press.

(Montague 1973). Richard Montague. The Proper Treatment of Quantification in Ordinary English. In (Hintikka et al. 1973), pp 221-242.

(Morgan 1969). Jerry L. Morgan. On the Treatment of Presuppositions in Transformational Grammar. Papers from the Fifth Regional Meeting Chicago Linguistic Society.

(Rulifson at al. 1973). J. F. Rulifson at al. QA4: A Procedural Calculus for Intuitive Reasoning. SRI AI Center Technical Note 73.

(Russel 1949). Bertrand Russel. On Denoting. Reprinted in (Feigl, Sellars 1949).

(Steinberg, Jakobovits 1971). Danny D. Steinberg, Leon A. Jakobovits (eds.). Semantics, An Interdisciplinary Reader in Philosophy Linguistics and Psychology.

(Wierzbicka 1969). Anna Wierzbicka. Dociekania semantyczne. Wrocław-Warszawa-Kraków: Ossolineum.

(Wilks 1974). Yorick Wilks. Natural Language Understanding Systems within the AI Paradigm. Stanford Artificial Intelligence Laboratory Memo AIM-273.

(Winograd 1972). Terry Winograd. Understanding Natural Language. Edinburgh: University Press.

(Winograd 1974). Terry Winograd. Five Lectures on Artificial Intelligence Laboratory Memo AIM No.246. Stanford University.

(Ziff 1972). Paul Ziff. What is said. In (Davidson, Harman 1972), pp 709-721.

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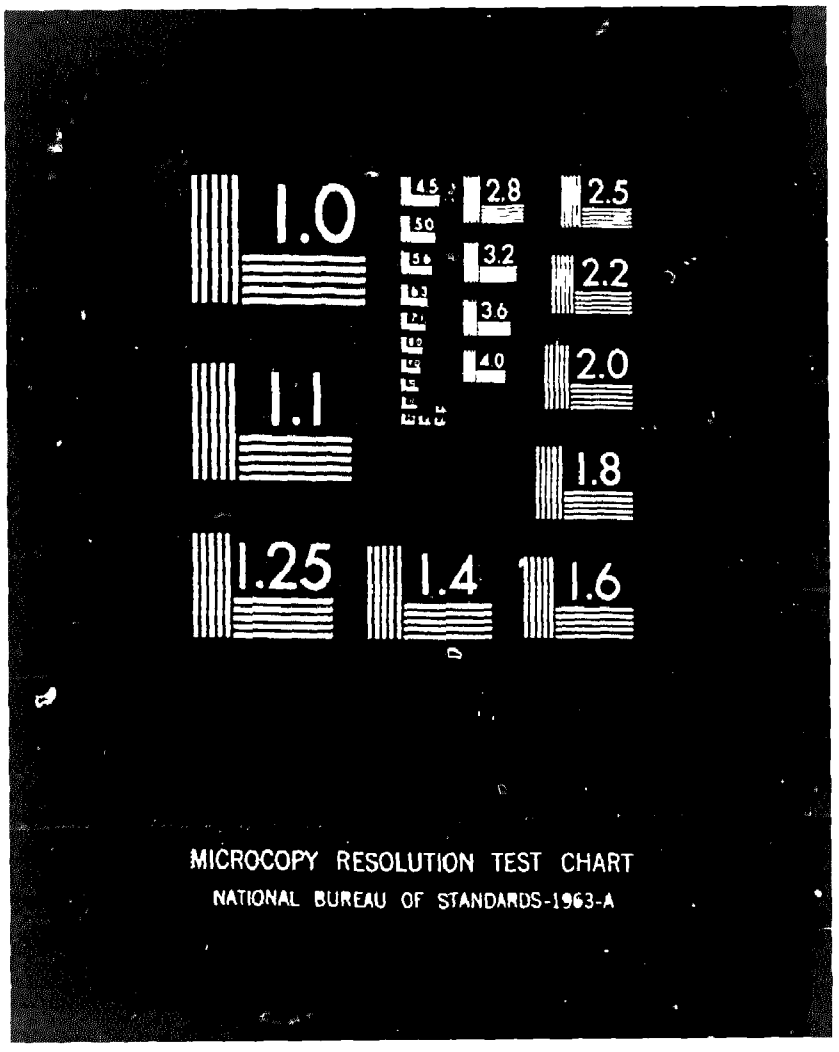
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