IDHS, MLDS: TOWARDS DICTIONARY HELP SYSTEMS FOR HUMAN USERS

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1. Introduction.

The systems here presented are both conceived as Computer Dictionary Systems for human use. IDHS supports reasoning mechanisms analogous to those used by humans when consulting a monolingual dictionary. MLDS has been thought as an on-line computational help system for human translators.

The starting point of IDHS is a Dictionary Database (DDB) built from an ordinary monolingual (explanatory) French dictionary. Meaning definitions have been analysed using linguistic information from the DDB itself and interpreted in order to be structured as a Dictionary Knowledge Base (DKB). The intelligent exploitation of the dictionary is supported by the resulting DKB, that is based on the representation of the dictionary as a semantic network of frames, where each frame represents one concept. Frames are interrelated by attributes representing lexical-semantic relations such as taxonomy, synonymy, meronymy, and specific relations derived from the lexicographic metalanguage used in definitions. MLDS extends and adapts to its needs the DKB mechanism developed in IDHS. Two monolingual dictionaries (French and Basque) constitute its knowledge base along with a bilingual dictionary that establishes equivalence links among concepts of the monolingual ones.

Following is given a general motivation of these dictionary systems. Section 3 presents the dictionary used as source in IDHS and gives a summary description of the construction of the Dictionary Knowledge Base (DKB). The knowledge representation model designed for the DKB is described in section 4. Section 5 presents an overview of MLDS. The functionality of IDHS and MLDS is shown in Section 6. Some conclusions will be presented in the last section.

2. General motivation.

In these projects, the dictionary is seen as a vast reference handbook of the lexicon of a language. The user of a dictionary looks up words in order to know their meanings, find synonyms or similar words, confirm intuitions about different aspects of the words, looks up for equivalents when translating, etc. The main objective of a dictionary is to help the user in language comprehension (reading) and language production (writing) tasks.

The importance of the lexicon in natural language processing is increasing. There is a need to make the process of construction of lexical components in NLP systems automatic, using for that actual dictionaries (Machine Readable Dictionaries, MRD).

The main objectives followed in the design and implementation of these systems are the followings:

- To extract lexical-semantic knowledge from conventional monolingual and bilingual dictionaries.
- To make a proposal for dictionary knowledge representation and validate it in different types of dictionary help systems.
- To design the exploitation mechanisms needed to make explicit the knowledge implicit in dictionary structures.
- To specify a basic functionality set taking into account a wide variety of users.
- To integrate the system in a help context.

3. Building the Dictionary Knowledge Base.

The knowledge represented in IDHS has been acquired from a conventional dictionary by means of parsing dictionary definitions using NLP techniques. Two different phases were distinguished to build the DKB. First the extraction of the information from the dictionary and its recording into a relational database: the Dictionary Database (DDB). This DDB was the starting point in order to create, in phase 2 (see figure 1), the object oriented Dictionary Knowledge Base; in fact, the support of our deduction system.

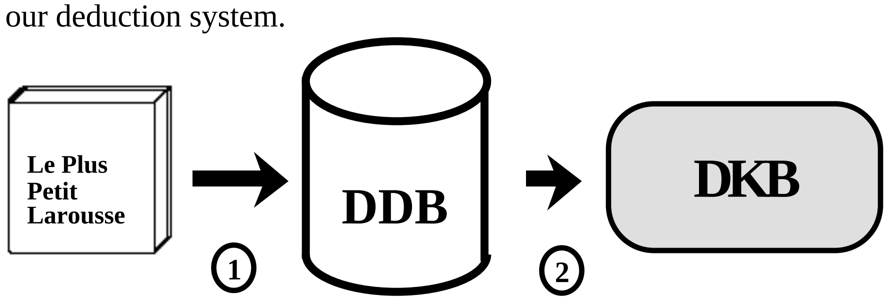

Fig. 1.- The process of building the DKB.

The dictionary used as first source has been *Le Plus Petit Larousse* (Paris: Librairie Larousse, 1980), a French explanatory dictionary that contains the following fields for each entry: orthography, phonetics, part of speech, usage label, definition of the different senses, examples and others.

Definitions are quite short in this small dictionary. The average length of them is 3.27 words, 74.57% of definitions containing less than 5 words. There are 15953 entries, 70.09% of them with a unique sense and 21.29% with two senses, giving a total amount of 22899 senses. That is, the average number of senses per entry is 1.44. Besides, 1980 inflected forms are presented as entries.

As there was no MRD version, the dictionary was recorded directly into a relational database: the DDB.

The method to parse dictionary definitions is based on pattern hierarchies as defined by (Alshawi, 89). The DDB itself has played the role of lexicon when parsing the definition sentences. Special attention has been paid to the method used to build the patterns. The main objective of this method is the semantic characterisation of each different type of dictionary definition in order to represent them in the DKB. As intuition may not be reliable enough, it has been done systematically.

The method to characterise and parse dictionary definitions follows these steps:

1) POS tagging and lexical disambiguation of words in definitions.
2) Statistical analysis of words in definitions.
3) Compilation of frequency lists of POS sequences in definition sentences.
4) Compilation of frequency lists of phrasal structure sequences in definition sentences.
5) Empirical research of stereotyped definition formulae. Finding specific relators such as "type of", "act of" or "kind of" (Vossen et al., 89).
6) Taken as basis the data obtained in steps 2 to 5, the hierarchy of patterns was built and the definitions parsed. The results of the parsing were added to the DDB.
7) After assigning to each pattern a semantic structure construction rule, the DKB was generated automatically.

4. Structure of knowledge in IDHS.

The knowledge representation scheme chosen for the DKB of IDHS is composed of three elements (see figure 2), each of them structured as a distinct knowledge base:

- THESAURUS, a concept network where word senses are linked by means of lexical-semantic relationships.
- DICTIONARY allows access from dictionary word entries to their corresponding senses in THESAURUS.

- STRUCTURES contains meta-knowledge about concepts and relations in DICTIONARY and THESAURUS: the different structures in the whole knowledge base are defined here hierarchically, specifying the corresponding slots and describing them by means of facets that specify their value ranges, inheritance roles, etc.

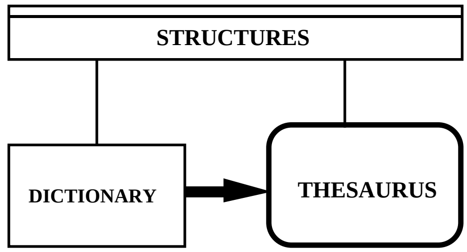

Fig. 2.- General schema of the DKB

4.1 THESAURUS knowledge base.

THESAURUS represents the dictionary as a semantic network of frames, where each frame identifies a one-word concept (word-sense) or a phrasal-concept (phrase structures associated to the occurrence of concepts in meaning definitions). Frames —or units— are interrelated by slots representing lexical-semantic relations such as synonymy, taxonomic relations (hypernymy, hyponymy, and taxonomy itself), meronymic relations (part-of, element-of, set-of, member-of), specific relations expressed by means of meta-linguistic relators, casuals, etc. Those relations have been implemented by means of reference attributes which point to concepts. Hypernymy and hyponymy have been made explicit (establishing a concept taxonomy) and represented using the hierarchical relationship of the programming environment in order to get inheritance. Other slots contain phrasal, meta-linguistic, and general information.

4.2 DICTIONARY knowledge base.

This knowledge base is the link between each dictionary entry and its senses. The following example illustrates the link between the word *plante* and its corresponding senses.

|plante|
SENS: |plante I 1|, |plante I 2|

4.3 STRUCTURES knowledge base.

Four are the main object classes in the DKB: ATTRIBUTES, DEMONS, INFERENCE-RULES and DICTIONARY-STRUCTURES. The last one defines the data types as a taxonomy of units that belong to DICTIONARY and THESAURUS knowledge bases. The main dictionary data types are: ENTRIES (dictionary entries), DEFINITIONS (senses classified according to part of speech), REFERENCES (concepts created in THESAURUS due to their occurrence in definitions of other concepts), and CONCEPTS (dictionary senses and other conceptual units).

Three different classes of conceptual units are distinguished:

- TYPE-CONCEPTS. They are similar to Quillian´s "type nodes" (Quillian, 68). TYPE-CONCEPTS is the superclass under which every concept of THESAURUS is placed. It is subdivided into ENTITIES, ACTIONS/EVENTS, QUALITIES and STATES.
- PHRASAL-CONCEPTS. They correspond to Quillian´s "tokens", that is, occurrences of type concepts in definition sentences. They represent phrasal structures which are composed by several concepts with semantic content, e.g. |plante I 1#3| represents the noun phrase *une plante d'ornement*.
- AMBIGUOUS-CONCEPTS. They correspond to not completely disambiguated concepts.

There are two kinds of ATTRIBUTES:

- *Representational attributes*, that reflect the surface (definitory) level representation of the definition of each sense (morphosyntax features like determination, verb mode, time, etc. are represented by means of facets).
- *Relational attributes*, that are used to give the relational view of the lexicon. They support the deductive behaviour of the system.

4.4 Examples.

In order to represent the following definition two new conceptual units have to be created in the THESAURUS KB

géranium I 1: une plante d'ornement

One of the units created corresponds to the definiendum and the other one to the phrasal concept representing the noun phrase of the definition, as well as the units which represent *plante* and *ornement* (if they have not been previously created). Let us suppose that three new units are created: *|géranium I 1|*, *|plante I 1#3|* and *|ornement I 1|*. Their definitory level of representation is the following (slots are in capitals, facets or properties of slots are in smaller italics):

|géranium I 1|
MEMBER.OF: NOMS
GROUPE-CATEGORIEL: NOM
CLASSE-ATTRIBUT: INFO-GENERALE
TEXTE-DEFINITION: "une plante d'ornement"
CLASSE-ATTRIBUT: INFO-GENERALE
DEF-CLASSIQUE: |plante I 1#3|
CLASSE-ATTRIBUT: DEFINITOIRES
DETERMINATION: UN
GENRE: F
RELATIONNELS-CORRESPONDANTS: DEFINI-PAR

|plante I 1#3|
SUBCLASS.OF: |plante I 1|
MEMBER.OF: NOMINALES
TEXTE: "plante d'ornement"
CLASSE-ATTRIBUT: INFO-GENERALE
DE: |ornement I 1|
CLASSE-ATTRIBUT: SYNTAGMATIQUES
RELATIONNELS-CORRESPONDANTS: ORIGINE, POSSESSEUR, MATIERE, OBJECTIF
OBJECTIF: 0.9

|ornement I 1|
MEMBER.OF: REFERENCES

Once the units created, some enrichment processes, based on the execution of some deductive procedures (e.g. inverse relationships and taxonomy formation), produce the knowledge structure shown in figure 3. Note that, at this level, an OBJECTIF/OBJECTIF-INV relation has been deduced between |*géranium I 1*| and |*ornement I 1*|, on the basis (see above slot DE of unit |*plante I 1#3*|) that the preposition "de" was deemed to mean the relation "objectif" with certainty 0.9.

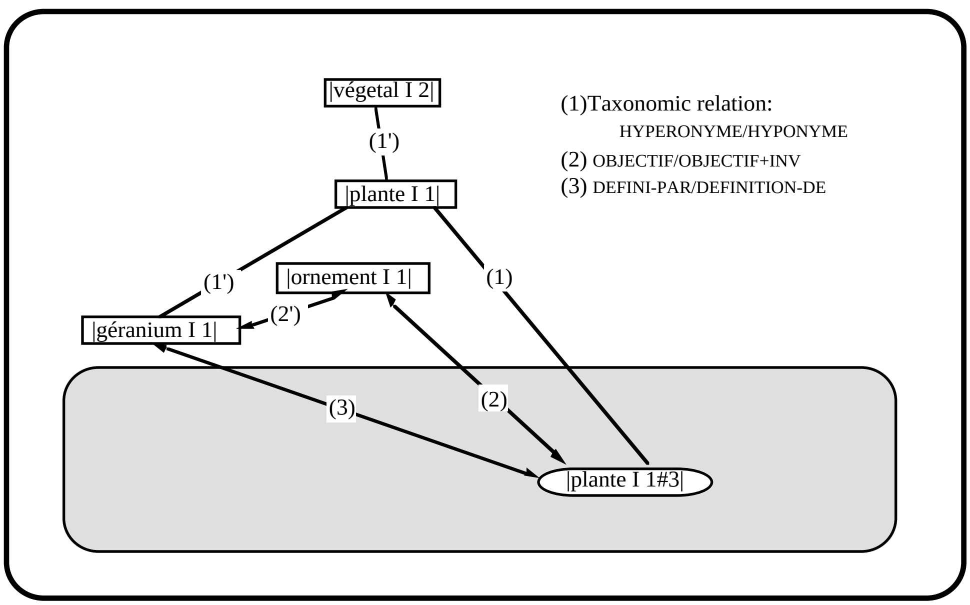

Figure.3.- Relational view of the concept |*géranium I 1*| (in the THESAURUS network). Phrasal concepts are inside the shaded box, type concepts outside.

Figure 4 shows the links among the three knowledge bases and the relations among the units created or referenced during the construction of the DKB corresponding to the following definition:

pansement I 1: *action de panser une plaie*

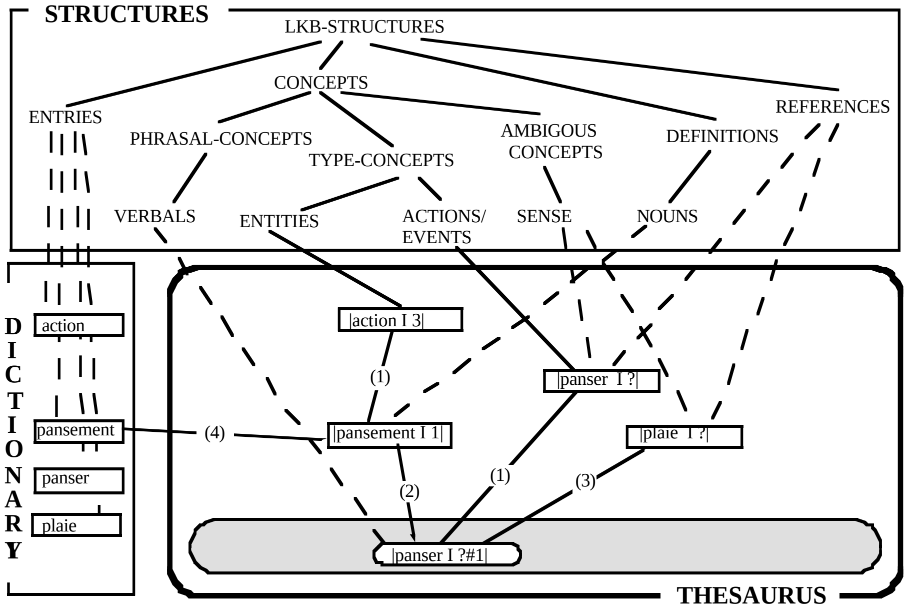

Fig. 4.- Links among the three knowledge bases

(1) Taxonomic relation: HYPERNYM/HYPONYM
(2) DEF-ACTIOND ("Act of" definition mode)
(3) OBJET (Object)
(4) SENS (Sense)
———— CLASS/SUBCLASS link
- - - - - - MEMBER.OF link

5. MLDS. Multilingual Dictionary System.

In order to describe the functionality of the system, MLDS will be presented. Its functionality is, in fact, a superset of the functionality of the monolingual system (IDHS). MLDS has been designed as a help system for human translators and its aim is to make easier the use of dictionaries.

In this context the dictionary is considered as a necessary tool in the process of translation not only among no experts in the subject but even among experienced translators. The difficulty lies in knowing the way in which a dictionary is used, which are the more efficient access ways, what are the strategies used when consulting it, and so on.

The knowledge base in MLDS is built from dictionaries of different languages. The nature of the dictionaries is heterogeneous. Different monolingual explicative dictionaries are connected with those of synonyms and espezialized ones (mainly technical).

Definitions of the knowledge base of IDHS are the starting point for MLDS. Acquisition, representation and exploitation techniques developed in IDHS have been enriched and adequated to the needs of translators. The connection among different dictionaries permits the exploitation not only of intradictionary relations but also of interdictionary ones. The inference system allows the extraction of not explicit dictionary knowledge by means of different operations; these operations have been defined on the basis of the observation of the translation process itself.

The specification of its functional environment was the first phase in the design of MLDS. The methodology followed has been based on direct observation of human translation work and also on personal experience obtained from professional translators by means of interviews. The analysis of this material has led us to the characterisation of typical uses of dictionaries in translation focusing on qualitative aspects.

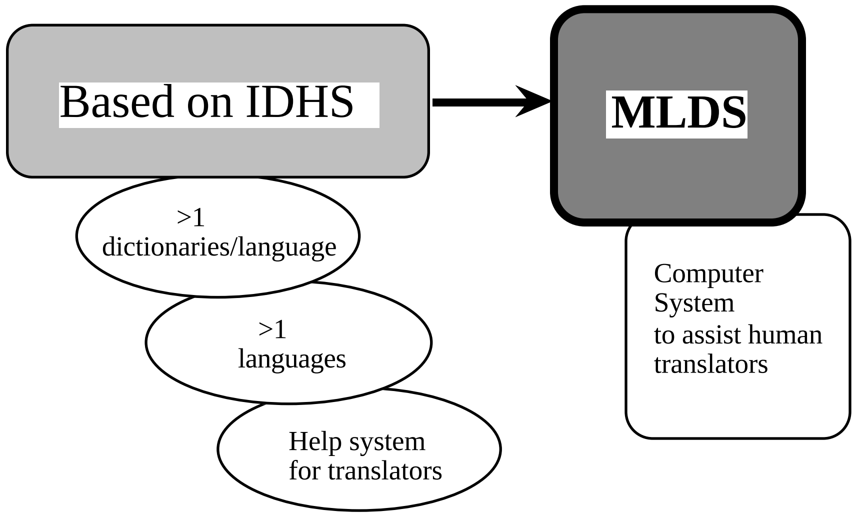

Fig. 5.- Relations between IDHS and MLDS help systems.

5.1 From IDHS to MLDS. The knowledge base of MLDS.

The knowledge base of MLDS has been built considering the information included in two dictionaries of Basque and French but it is supposed to offer a general framework for different languages. In the present version, the system is composed by three main knowledge bases (SDMOL1, SDMOL2, and SBL1/2). SDMOL1 and SDMOL2 contain information concerning the source and object languages respectively, whereas SBL1/2 links concepts from SDMOL1 with concepts included in SDMOL2. The general structure of MLDS is shown in figure 6.

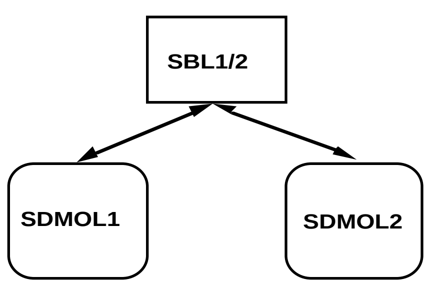

Fig. 6.- Knowledge bases in the MLDS help system.

SDMOL1 and SDMOL2 adapt and extend the knowledge bases defined in IDHS [Agirre et al., 93] introducing new aspects in the definition of the global knowledge base as shown in Figure 7.

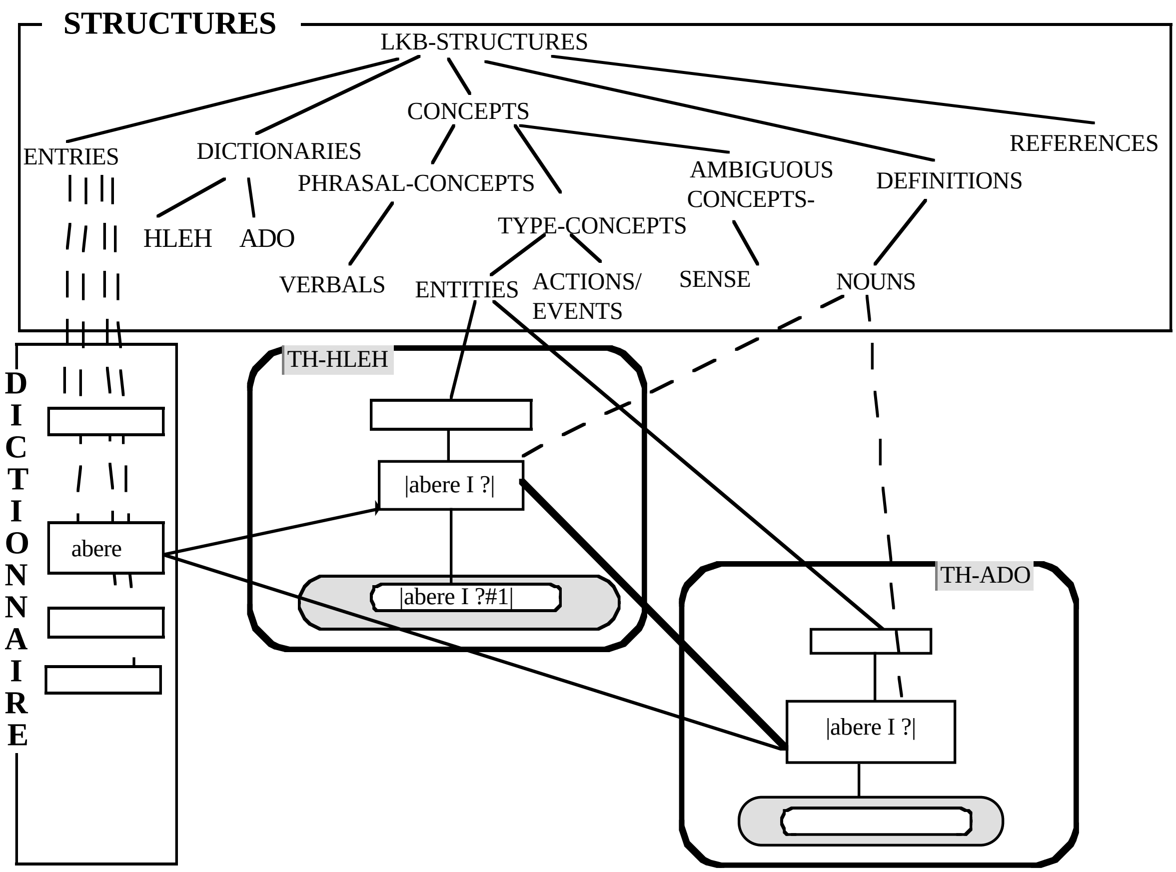

Figure 7.- Monolingual multidictionary environment

MLDS knowledge bases.

We have one THESAURUS per dictionary (TH-HLEH and TH-ADO coresponding to the "Hauta-lanerako Euskal Hiztegia" -Sarasola, 91- and "Euskararako Hiztegia" -Aurrekoetxea, 86- in figure 7). The definitions of the units have been extended by means of a relation of ***intralingual equivalence*** (links among equivalent concepts defined in different dictionaries within the same language). New attributes have been defined in the units in order to represent examples contained in dictionary entries.

We have also one STRUCTURES per language containing meta-information about dictionaries and grammar concepts in order to cover the defined functionality.

And, finally, the access from the word to the associated concepts (senses) in all the dictionaries is allowed by one DICTIONARY KB per language.

SBL1/2 is composed by two bilingual knowledge bases (INTERLINGUA BASQUE-FRENCH and INTERLINGUA FRENCH-BASQUE). Each of them relates a concept of the source language to a concept of the target language. These relations are complemented with information about types of equivalence, equivalence levels, etc.

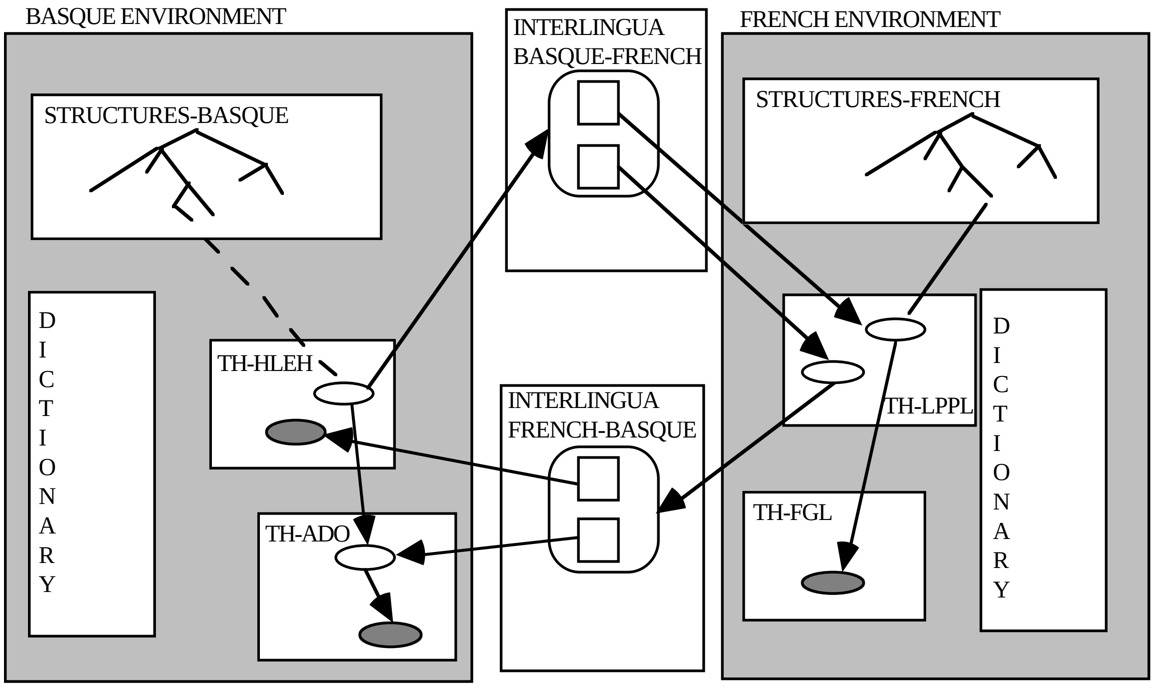

Figure 8.- Multilingual Environment.

6. Functionality. Analysis of dictionary use.

Although the use of dictionaries is considered as a "common" activity, there are important questions without an answer. During the last years it has been investigated from different perspectives and using several methodologies. Different authors based their studies on the analysis of questionnaires (Clarence Barnhart, 1962; Randolph Quirk, 1973; Béjoint, 1981; Baxter, 1980). Others prefer the direct observation (Zelko Bujas, 1975; Kurt Opitz, 1979; Karl Müller, 1983; Tomaszczyk, 1979). Some of them have filmed the activity of persons involved in their translation work (Josh Ard, 1982; Marsha Bensoussan et al., 1983) or have investigated by means of written protocols (Hatherall, 1984; Wiegand, 1985)

Some conclusions arise. Bilingual dictionaries are more used in the comprehension and translation process of texts while looking for other type of information as use, orthography, grammar, and so on, implies the use of monolingual ones.

Traditionally three different methods have been used in the analysis of dictionary use: a) free invention that relies only on intuition, b) questionnaires posed to human users where it is difficult to distinguish between what the user answers and what he really does when using dictionaries–, and finally, c) direct observation, currently the most used method.

Our method is based on:

a) Direct observations: given several texts to be translated (in our case texts written in French and Basque) and several dictionaries (with different characteristics), translator's problems, resolutions, and tasks have been recorded. These protocols can be considered as directed by the observer. The aim is to characterise the task of human translators by means of the observation of the translation of paragraphs (very rarely), words, expressions and context-dependent phrases. Each time the human translator looks up in a dictionary, the unit to be translated, the dictionaries used, the dictionary entry and the type of consultation are recorded.

b) Personal interviews with professional translators. These interviews allow us to consider different uses of the dictionary due to their experience in the subject. During the interviews with professional translators other type of questions were posed: the characteristics a dictionary should have in order to be useful when translating, the interest about having computerised dictionaries and their main functionalities, and so on.

The functions below result from our analysis of translators' needs. The monolingual version of the functions for text understanding and text generation were already included in IDHS. They have been classified according to three main activities: source text understanding, object text generation, and search for translation equivalents.

6.1 Source text understanding.

There are three main functions in this activity: definition request (DDEF), reformulating of a definition (RDEF) and property-value request for a concept (DPRO).

For instance, DDEF takes as input a concept, an explanatory-level, a dictionary and a language, giving as output a definition. The following examples are definition queries for the meaning of *guêpe(wasp)* in the LPPL French dictionary, but the requested explanatory levels are different: *textual* in the first example, *local* in the second one (its result is the "internal" representation of the textual definition), and *inherited* in the third one (its result is the internal representation of the textual definition plus other relations deduced from the concept hierarchy).

Translator.-
DDEF (|guêpe I 1|, textual, LPPL, French, ?D)
*Definition of **wasp** in French with "textual" as explanatory-level*
System.- D= **'insecte hyménoptère à aiguillon'**
T.- DDEF (|guêpe I 1|, local, LPPL, French, ?D)
*Definition of **wasp** in French with "local" as explanatory-level*
S.- D=

```
(and (|guêpe I 1| HYPERONYME |insecte I 1|)
     (|guêpe I 1| CARACTERISTIQUE|hyménoptère I 1|)
     (|guêpe I 1| POSSESSION |aiguillon I 1|))
```

Wasp is an **hymenopterous insect** with **sting**.

```
T.-  DDEF (|guêpe I 1|, inherited, LPPL, French, ?D)
     Definition of wasp in French with "inherited" as explanatory- level.
S.-  D=
     (and (|guêpe I 1| HYPERONYME |insecte I 1|)
          (|guêpe I 1| CARACTERISTIQUE |hyménoptère I 1|)
          (|guêpe I 1| CARACTERISTIQUE |articuler I 1#m|)
          (|guêpe I 1| POSSESSION |aiguillon I 1|)
          (|guêpe I 1| POSSESSION |patte I 1#n|)
          (|guêpe I 1| HYPONYME |frelon I 1|)
          (|guêpe I 1| POSSESSEUR |guêpier I 1|))
         Wasp is an articulated hymenopterous insect
     with sting and legs, a bumblebee is a wasp, and a
     wasp's nest has wasps.
```

6.2 Object text generation.

For this activity translators' needs are captured by the following functions: thesaurus-like search of concepts (RTHS), search of relations between two concepts (DRAP), request of differences between two concepts (DDIF), definition verification (VDEF), and property verification for a concept (VPRO).

For instance, DRAP gives the path relating two different concepts. RTHS takes as input a restriction expression, a dictionary, and a language, and returns the list of concepts that meet the restrictions stated. Examples follow:

```
T.-  RTHS((and (?X  HYPERONYME  |instrument I 1|)
               (?X  OBJECTIF    |mesurer I 1|)),
           LPPL, French, ?X, ?LC)
The user asks for nouns in French for tools used for measurement
S.LC=(|baromètre I 1||dynamomètre I 1||télémètre I 1|)
T.-  RTHS((and (?X  HYPERONYME  |consumer I 1|)
               (?X  AGENT |feu I 1|)),
            LPPL, Basque, ?X, ?LC)
The user asks for verbs in Basque for to consume with agent fire
S.-  LC=(|izeki I 1|, |kiskali I 1| )
     to burn, to blacken.
```

6.3 Search for translation equivalents.

There are some well known problems with lexical gaps when (a) there is no single word in the target language to express the source concept -which can be solved giving *equivalent phrasal concepts* - and when (b) the source concept does not appear as an entry in the bilingual dictionaries; in this case, in order to express that the concept in the result is *more general* or *more specific* than the source concept, set operators as $\subset$ and $\supset$ are used.

In the first two examples below there is no problem when translating the concept |*accusatif I 1*| or |*coup_de_bec I 1*| from French into Basque. In the third and fourth examples |*pattar I 1*| and |*txakolin I 1*| are not in the bilingual dictionary, so the system gives the equivalent of the closest concept in the monolingual dictionary and indicates whether it is more or less specific. In the last example there is no single word to say *abere* (domestic animal) in French, therefore a phrasal concept is returned.

```
T.-   EQUIV ((|accusatif I 1|, , ), Basque, gram, ?LP)
S.-   LP = ( (|akusatibo I 1|, , ) )
T.-   EQUIV ((|coup_de_bec I 1|, , ),
             Basque, common, ?LP)
S.-   LP = ( (|mokokada I 1|, , ) )
T.-   EQUIV ((|pattar I 1|, , ), French, common, ?LP)
S.-   LP =  ( (⊃,|eau-de-vie I 1|, , ) )
T.-   EQUIV ((|txakolin I 1|, , ), French, common, ?LP)
S.-   LP =  ( (⊂,|vin I 1|, , ) )
T.-   EQUIV (|(abere I 1|, , ), French, common, ?LP)
S.-   LP =  ( (|animal I 1#n|, , ) )
      where |animal I 1#n| represents "domestic animal".
```

6.4 Other functions.

We explain here other functions extracted from the translation process analysis not included in the previous sections.

6.4.1 Grammar functionality

Morphological functions try to solve the problems due to the difference between the inflected lexical unit and the dictionary entry. The implementation of these functions needs to integrate morphological analysers. Among them we can distinguish the morphological analysis (ANALI), the lexical form production (PROD), and the lexical translation (TRAD-LEX). For instance, TRAD-LEX is carried out combining both lexical analysis and production.

T.- **TRAD-LEX ('goaz', French, ?U)**
S.- **U = 'allons'**

Allons *is the translation to French of the Basque verb form goaz (we go).*

Syntactic Functions try (a) to offer to the translator the possibility of finding syntactic patterns easily (PAT-SINT), (b) to determine the subcategorised grammar cases associated to the verbs (REG-VERB).

6.4.2 Semantic compatibility

This function determines whether two lexical units can be linked by means of a given relation and taking into account their selectional restrictions. This function tries to answer questions like: *Can two lexical units appear in a context being related according to a syntactic-semantic relationship?*

Example:
T.- **COMP-SEM (|poisson I 1|, |ruminer I 1|, AGENT)**
S.- **False**
*It doesn't hold that **fish** can be the **agent** of the verb **ruminate**.*

6.4.3 Lexical collocation

There is no doubt that lexical co-ocurrences have to be treated in order to produce correct texts. In our approach lexical functions devised by I. Mel'cuk (Mel'cuk, 82) are used to describe a certain type of lexical collocation.

Example:
T.- COLLOC (|beldur I ?|, Magn, ?LC)
S.- LC =('izugarria' 'hezurretarainokoa' '[beldurrak] aidean')
In order to ***magnify*** *the feeling of fear (****beldur*** *in Basque); that is, to express the notion of terrible fear, the adjective normally used in Basque is* ***izugarria****, or* ***hezurretarainokoa****.*

6.4.4 Request of examples.

As a conclusion from the study of the dictionary use we deduce that request of examples related with a concept is a very useful function that allows the user:

a) to prove that a word or a concept exists in a language and to see it in its real and cultural context.

b) to know deeper the meaning of the defined word.

c) to get illustrated its behaviour from the grammatical point of view.

d) to look for stylistic aspects.

e) to detect typical collocation cases.

7. Conclusion.

The starting point of this project has been the semantic characterisation of the different types of dictionary definitions that determine the sublanguage used in a conventional dictionary. This characterisation leads to the automatic parsing of definitions, and to their representation in a knowledge base that provides several knowledge accessing capabilities.

IDHS and MLDS have been presented as two different systems in the context of intelligent dictionary help systems, IDHS in a monolingual environment and MLDS in a multilingual one, with the following relevant aspects: extraction of knowledge from conventional dictionaries, a model for dictionary knowledge representation, deductive capabilities to make explicit the knowledge implicit in dictionary structures, and the specification of a basic functionality set. The methodology followed in the definition of the functionality of MLDS is based on direct observation of the tasks of human translators and on personal interviews to the experts trying to characterise the typical use of dictionaries in translation.

The integration of other tools in the dictionary environment has been seen as an interesting aspect in MLDS; for this reason, functions as ANALI, PROD, TRAD-LEX and PARAPHRASE have been considered. These functions deal with other types of information not directly included in the dictionaries which also need to be formalised.

A prototype of IDHS has been implemented on a Symbolics Lisp machine using KEE (Knowledge Engineering Environment). The knowledge base of the IDHS prototype built is composed by 6003 concepts, obtained from the definitions of the French dictionary treated. We are now working on the multilingual knowledge representation, analysing the different relations needed for the implementation of the described functionality.

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