Chapter 8: Formal considerations

This chapter discusses practical applications of the models put forward so far and suggests a more precise rendering of these models in a formal setting. The reason for addressing these two subjects in the same chapter stems from my belief that the applications to which the networks are put help to further elucidate the exact nature of the proposals, given that formalization is relative to one's goals (cf. Quine (1972:453): "logical analysis itself -- better, logical paraphrase -- may go one way or another depending on one's specific logical purpose").

Section 8.1 discusses possible implementations and the practical utility of the networks suggested and used in the previous chapters. Section 8.2 addresses some questions relevant to any formalization of the models, and discusses briefly some possible paths. Finally, Section 8.3 proposes, within a particular formal framework, a deeper explication of the concepts used and handles some particular examples in detail.

8.1 On the implementable content of the present thesis

This section, as a complement to the general remarks in Section 1.3 about the interest of the present thesis for NLP in general, is concerned with particular applications and practical systems. Especially, it is concerned with the properties of such systems which follow from the theoretical points put forward in the preceding chapters.

8.1.1 Overview of contrastive computational systems

I start by providing a very brief critical look at recent translation-related NLP efforts in the literature. In my view, the focus of work has moved from automatic translation to human translation. This move took place basically in two different directions, namely:[1]

1. the development of aids for the human translator -- or even for the bilingual lexicographer: Isabelle et al. (1993), Picchi et al. (1992);

2. the use of existing human translations as (semantic or other) data: Church & Gale (1991). For example, it has been claimed that a translated text put into correspondence with the original would constitute a sense-disambiguated corpus, i.e., the target language text can be used to disambiguate the source language text, and "[this] would be a valuable resource for all kinds of natural language applications" (Gale & Church, 1991:153).

More marginally, but not less interestingly, two other directions have also been suggested:

3. the use of parallel (not translated) corpora for monolingual studies: Dagan & Itai (1994);

4. the use of existing (human) translations for machine translation: Sato & Nagao (1990).

This is a sign of what I claimed in Section 1.3 to be the adequate trend for language engineering: the focus on simple applications with a complex raw material.

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[1] The references provided are not meant as an exhaustive, but merely indicative, overview of current research.

The way I am going to proceed here is by introducing the concept of a translation browser in Section 8.1.2, and then project several larger applications of which the translation browser would be (one of) the major building block(s), in Section 8.1.3. I am convinced that the main difficulty will not actually lie in the implementation of these external applications, but rather in the translation browser itself. Be it as it may, I will only turn to the latter in some detail, the others having here the status of simply possible future extensions for further work.

It should also be clearly stated that I have not attempted to implement the translation browser which I describe here. Hence I do not make any claims about ease of implementation, nor do I provide a full specification of it. If anyone wishes to engage in such work after reading this thesis, I can just hope that, although hard, it will prove rewarding in the end. I am of course fully aware that many interesting problems will only turn up during the building process.

8.1.2 The notion of a translation browser

The notion of a translation browser is not new. In fact, several such systems have been presented in the literature; cf. e.g. Church and Gale (1991), Marinai et al. (1991), Isabelle (1992) or Johansson and Ebeling (1994).

Very sketchily, a translation browser is a system that draws on a large body of translation data previously put into (some) correspondence, and allows the user to browse through it displaying the translations in context. Typically, keys for browsing can be source expressions, or source-target pairs. A more detailed description will be given in Section 8.1.2.3 below.

8.2.2.1 General problems with existing systems

From the content of the preceding chapters, it should be clear that I have identified two general problems with the existing translation browsers -- but these problems are crucially dependent on what is claimed and on what application they are put to.

The first problem is the assumption of translation equivalence. This is reflected e.g. in the mention in Sadler and Vendelman (1990:451) of "cross-references between equivalent expressions in the two languages" and in Marinai et al.'s (1991) apparently evident creation of bidirectional links: "when one of the translation equivalent forms is found (...) a link will be created between the form and its equivalent in the L1 text, <u>and vice versa</u>" (Marinai et al., 1991:66, my emphasis). I have already presented enough criticism of such views: What should be mentioned is translation relatednesss, not equivalence; and translation is not symmetrical.

The second problem, which is still more practically relevant, is that of translation quality. In Landsbergen's (1987) terms, actual translations are <u>possible</u> translations, but not necessarily the <u>best</u> ones. In Chapter 3, I have criticized Isabelle's claim that existing translations provide more solutions to more translation problems, since 1) existing translations may display possible solutions but not the best; and 2) they may at worst even contain errors. In fact, in Section 3.4.2, I have described several kinds of translation relations observable in real translations. This relation, furthermore, applies to any part of the source text whose meaning can be construed independently, i.e., a particular translation of a given sentence may be exact in terms of its subject, involve addition in terms of its verbal meaning, and failure in terms of one adjunct. This makes it highly improbable that a screening procedure retaining only the exact translations could be feasible.

In systems like the ones I am criticizing, all translation relations, provided they are identified, are taken equally. This, I claim, makes their usefulness debatable for many applications.

Now, some of the systems that neglect quality are paradoxically used for translation checking: Isabelle (1992), for example, describes two methods of checking translation automatically. The first one relies on the failure of the program to align -- and some consideration shows that it identifies translation quality with translation literalness. The second one is geared to a particular kind of mistake, i.e., assumes one model of translation errors (namely deceptive cognates), and explicitly looks for them using the translation browser. Des Tombe and Warwick's (1993) use of function words to measure translation quality has the same problem as Isabelle's first method: they simply measure how literal the translation is. The good results they report must be due to the specific language pair, English-French. In my opinion, these treatments of translation quality are very limited, if not totally inadequate.

Finally, there is another wrong assumption lurking in the background of many such systems, which is not harmful to the application in itself, but which may produce unwise expectations: the belief that putting existing translations into correspondence with their originals is a task simpler than, and related to, machine translation. In Chapter 3, I have claimed that such a task is not necessarily simpler; and, even worse, that the phenomena relevant for performing it may not be of value for machine translation in the end.

8.1.2.2 Discussion of the system proposed

My suggestion is to drop the wrong assumptions, and proceed, rather, with a complex translation model in the first place.

Specifically, instead of aligning phrases, I will propose to align categories. These categories are obtained through aspectual networks for each language, as proposed in Section 5.3 and illustrated in Chapter 7. I.e., the "alignment" I propose should proceed through the indications of a translation network.

But let me first consider the question of getting categories from real sentences.

In other words, can real text be parsed neatly by my aspectual networks? This is not what I am claiming. The aspectual networks provided so far cannot be expected to exhaust all possible language phenomena in either language. But they are presumably adequate for many phenomena, due to their strong empirical basis. Their coverage is, in fact, an empirical question -- and only the application and consequent test of the models will give an answer, and above all, serve as the basis for further extension.

Given that the best computational grammar for English in the 80ies would have a coverage lower than 40% of running text as far as parsing a full sentence was concerned, it should not discourage a language engineer that the models are not exhaustive. Rather, a system that could make sense of 40% of the translations pairs in any aligned corpus would be a remarkable achievement.

A system with such a performance would then be applicable -- with some care -- not only to the investigation of plausible extensions (by analysing the quantitatively salient cases where the aspectual network model got blocked), but also to the reinforcement of the model as suggested by Richardson (1994) to make computational grammars more robust (bootstrapping) or in the automatic improvement of the tagger suggested by Brill (1992) and taken up by Roche & Schabes (1995). In sum, not only traditional methods of error debugging but also semiautomatic processes could be applied in a bootstrapping mode.

Now, is it possible to parse any sentence at all, given an aspectual network? Is not additional information, like lexical aspectual class, needed? On the one hand, it should be noted that only surface (grammatical) clues are considered as valid labels for the arcs. Clearly, if the labels read "attempt", "specified quantity" or "presence of human agent", it would be more difficult to specify objective verification criteria to be performed by the computer. Choosing objective linguistic clues -- whose interpretation is not immediately relevant from an implementation point of view -- one can expect to parse (producing possibly multiple parses) sentences carrying those markers.

A shallow syntactic parser is presupposed to apply prior to this whole process, identifying *for*-phrases, the progressive, tenses, etc. Such a system is obviously not trivial, but neither is it practically impossible. Even though there is none for Portuguese,[2] there are some for English, as documented e.g. in Jensen et al. (1992) and Dagan & Itai (1990), or in Hindle & Rooth (1993).[3] On this subject I will not have anything to say in the present dissertation.

As far as lexical information is concerned, and even though it would be very helpful to have access to it,[4] it is strictly not presupposed: In fact, the aspectual network itself could be used as a tool for massive aspectual classification of lexical items, as will be described below.

Let me now discuss the actual production of the translation relations. The translation mappings, as already noted, are obtained with the aid of the corresponding translation networks. This is, in principle, a computationally simpler task, since what is at stake here is only the comparison of two (or possibly more) finite paths.

Again, a prior sentence alignment system is required (as in any of the translation browsers in the literature). This is a sensible thing to ask for, since, in fact, most of the systems currently in use are probably adequate for the pair English and Portuguese as well, since they are based

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[2] And this is my main excuse for not even attempting an implementation of the aspectual or translation networks.

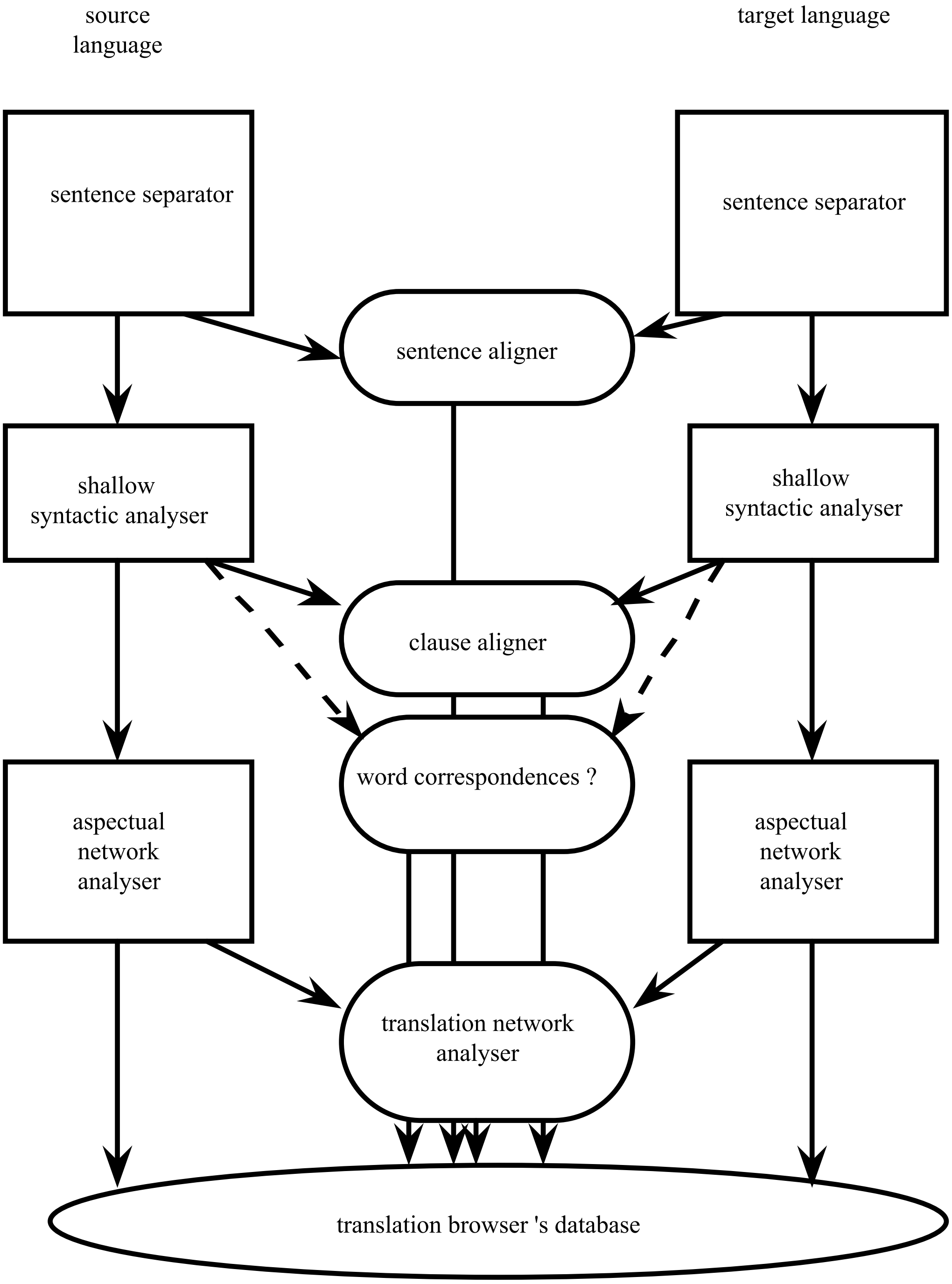
[3] In addition, there are several parsed corpora of English, like the Penn Treebank (Marcus et al., 1993), the Lancaster Parsed Corpus (Garside et al., 1987) or Sadler and Vendelman's (1990) BKB, which depended (to a larger or lesser extent) on (machine-assisted) human coding.

[4] And it should be emphasized that there are other possible information sources for broad-coverage aspectual information, like human dictionaries, as described e.g. by Alonge (1992).

mostly on non-linguistic (or rather, non-language dependent) factors, like sentence length in characters and in words (with the possible addition of clues like numbers, or words which are formally similar -- proper names, or cognates), or else they are based on a list of pairs of (fairly frequent) items which are good indicators of translatability (cf. Johansson & Hofland (1994)).

Figure 8.1 displays a block diagram of the system envisaged, which, despite its symmetry is conceived as directional.

Figure 8.1



This is, in fact, a particular instantiation of Isabelle et al.'s (1993) tripartite model for translation analysis. Where it differs (and, I would hold, it differs considerably) from Isabelle et al.'s systems is in the internal complexity of the modules it embodies.

8.1.2.3 The system from the user's point of view

From the point of view of the user, I will characterize a translation browser as the one envisaged above as regards the kind of queries, and the kind of information displayed.

Display of translation pairs

I start from the desired format of presenting a translation pair, indexed by source word. There are several possibilities, displayed in the literature, in addition to the ideal one which I claim would result in the system suggested. One example:

Figure 8.2: Three ways of displaying concordance for English *near*

instep and continued on its way, and Kino left his foot there and watched them move over it. The sun arose hotly. They were not **near** the Gulf now, and the air was dry and hot so that the brush cricked
pés de Kino e continuous o seu caminho. Então Kino não se mexeu mais e ficou a observar o movimento das formigas. O Sol nasceu escaldante. Já estavam longe do Golfo. O ar era tão seco e quente que os arbustos estalavam com o calor

[They were not **near** the Gulf now]
[Já estavam longe do Golfo]

The sun arose hotly. [They were not **near** the Gulf now], and the air was dry and hot so that the brush cricked with heat and a good resinous smell came from it.
O Sol nasceu escaldante. [Já estavam longe do Golfo]. O ar era tão seco e quente que os arbustos estalavam com o calor e emanavam um belo cheiro a resina.

The first method resorts to a simple *n*-word sized window for the display (in the example, 25 words to the left and 15 to the right). There is no linguistic motivation for the choice of the particular linguistic chunks that are displayed. Some heuristics are applied to the target language side in order to make relatively sure that the translation lies in the window, but there is no linguistic processing of any sort.

The second method is linguistically safe, but little informative: it consists in presenting exactly the sentences of the translation pair, and nothing else. The practicality of this method depends, in fact, crucially on the actual sentence size of the languages involved.[5] Another variant of the method could be supplying further adjacent sentences (possibly depending on the size of the main translation pair), as is displayed in the third example of Figure 8.2.

The ideal would, however, be to pin-point exactly what the translation part of the source probe was, or, at least, the minimal translation correspondence involving it, and this irrespective

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[5] For example, in a Norwegian-English parallel corpus a user can get along with whole sentences as context and be able to immediately spot the translation relation in most of the cases. In contrast, systems that involve German or Portuguese as source languages may prove to put too much of a burden on the part of the user, if displaying whole sentences and respective translations, because the stylistic conventions of those languages encourage native writers to use long sentences. This may, in fact, be the reason why the Italian-English system of Marinai et al. is the only one which does not use sentences but contexts defined by number of words.

of the amount of context also supplied. Additionally, and contrary to the first method, all and only the target parts corresponding to the source text would be displayed.

Figure 8.3 displays other examples where such functionalities would be better perceived:

Figure 8.3

And the baby was weary and petulant, and he **cried** softly until Juana gave him her breast, and then he gurgled and clucked against her.
A criança estava fatigada e agitada, e só deixou de chorar quando ela lhe mostrou o seio, a que se lançou com avidez.

And, since early Mass was over and business was slow, they followed the procession, these endless searchers after perfect knowledge of their fellow men, to see what the fat lazy doctor would do about an indigent baby with a scorpion bite.
e, como a missa da manhã estava acabada e aquilo já pouco **rendia**, juntaram-se à procissão como incansáveis pesquisadores do perfeito conhecimento do próximo, para verem o que aquele gordo e preguiçoso médico faria por uma criança pobre picada por um lacrau.

Note that Marinai et al.'s (1991) system comes close to my suggestion here, in that they display a smaller frame inside which the translation, whatever it is, is supposed to be. However, their highlighting, in my opinion, not only turns out to be counterproductive (because the user's attention is called to the limits of the interval and not to the translation) but it is also based on a complex lexical process (bilingual dictionary based) which would not be required in the system I suggest here.[6]

Figure 8.4 reproduces some of Marinai et al.'s (1991) and Picchi et al.'s (1992) own (successful) examples and my alternative suggestion to render them.

Figure 8.4

I-HEN.34: un re di Spagna che si diceva "cattolicissimo". Mostruosamente egoista, ed amante all'eccesso dell'adulazione, non **mancò** per questo di accattivarsi l'amore del popolo. Non furono pochi suoi errori in politica.
E-HEN.35: Monstrously egotistical and excessively fond of flattery, yet he managed to endear himself to the people. Politically he made many mistakes but, in spite of them, he nearly always managed to emerge victorious. (Marinai et al., 1991:69)

> Mostruosamente egoista, ed amante all'eccesso dell'adulazione, [non **mancò** per questo di
> accattivarsi l'amore del popolo].
> Monstrously egotistical and excessively fond of flattery, [yet he managed to endear

[6] Furthermore, it is not irrelevant to note that one (out of 5) of their examples does not actually succeed in getting the translation inside the calculation frame. It is true that Marinai et al. only assert, about the frame they display, that "the two matched (linked) forms which are closest to (immediately preceding and immediately following) the point calculated as the middle of the L2 context are underlined" (Marinai et al., 1991:69), but what is the point of displaying a frame if the translation is not included in it in the first place?

This, in fact, raises the question of the actual performance of the systems presented in the literature. Unfortunately, there have to my knowledge not even been proposed any evaluation measures, let alone used. This, however, is a problem in much work in natural language processing.

himself > to the people].

{I} estremo del campo. L'osservai con indolenza masticando uno di quei fili d'erba coi quali le ragazze predicono il futuro. Camminava **pian pianino** lungo la scarpata. Teneva una mano sul fianco e nell' altra aveva un bastone col quale saggiava il terreno erboso. I-Dublin2.197

{E} I watched him lazily as I chewed one of those green stems on which girls tell fortunes. He came along by the bank slowly. He walked with one hand upon his hip and in the other hand he held a stick E-Dublin2.211 (Picchi et al., 1992:975)

> Camminava **pian pianino** lungo la scarpata.

> He came along by the bank slowly.

Condensed information on translation patterns

One sensible requirement of a translation browser is that it produces more condensed information on translation relations, such as, for example, the ten most frequent translations (and associated frequency) for a given source word, as displayed by Church & Gale (1991) for the English word *house* in the Hansards (the bilingual proceedings of the Canadian parliament).

To do this, a word correspondence module (dictionary-based like the one used in Marinai et al.'s system, or statistically derived as in Gale & Church (1991)) is required; the scope of such a module, however, is severely restricted to content words like nouns, and those verbs which happen to fall in relatively similar aspectual classes across translation. This is by no means a standard situation, as shown in Chapter 7.

In any case, nouns or aspectually similar verbs are definitely the cases least in need of a translation model such as the one developed in this dissertation. Probably, an ideal translation browser would allow a combination of both the translation network method and of a lexical-based word correspondence module (which is marked with a question mark in the diagram of Figure 8.1).

But I should emphasize that a lexically based system is not the whole story. A dictionary-based system will not be able to cope alone with most (let alone all) translation cases. This can be easily appreciated noting that many of the examples presented in Chapter 7 did not correspond to standard translations of the kind to be expected in a bilingual dictionary. Klavans & Tzoukermann (1995) have suggested that a robust word correspondence method would have to combine statistical (like that in Church & Gale) and dictionary-based information (like that in Marinai et al.).[7] As I have shown throughout the present dissertation, grammatical context has a lot of weight, too, and so a good translation browser would also have to embody specifically non-trivial contrastive information of the translation network kind.

Kinds of queries allowed

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[7] This is not mainly a theoretical question. Rather, it is related to such down-to-earth considerations as simple availability. In particular, Church and Gale's (1991) statistical word correspondence module requires a huge amount of parallel corpus for training purposes. For the pair of languages English and Portuguese-- and, indeed, for most language pairs --, there is no corpus of comparable size.

In any case, a reasonable kind of query would be to look for pairs. Up to the present, these pairs have been mostly related to lexical items, either looking for the presence of lexical items or for their absence. So, Church & Gale's (1991), Isabelle et al.'s (1993) and Johansson & Ebeling's (1994) translation browsers allow for the search of translations of word A involving the word B, or else not involving the word B (or a list of words).

The translation browser architecture presented in Figure 8.1 allows one to considerably extend the range of pairs to be considered. For one thing, one can surely look for category pairs in addition to lexical items, like Obra to accomplishment. More interesting still, one can look for grammatical markers as well. I.e., it is possible to ask for translations of the word *hang* involving a passive in Portuguese, or translations of relative clauses in Imperfeito in Portuguese involving the progressive in English.

In addition, and this is a crucial advantage, some measure of quality can be provided with each translation pair, based on the number of individual pairings, ambiguity preservation, same relative typicality in the two languages, and so on.

Some selected examples of the query power would be:

- get all examples of phrase to word translation involving the word *be* in the source phrase
- get all examples of *fazer* in Perfeito involving the English perfect
- get whatever is translated by *again* and does not include the expression *outra vez*
- get examples of Mais que perfeito rendered by the English passive
- get the distribution of the translations of the word *evitar*: how many to a lexical item, to a phrase, or even involving a whole clause

Finally, one could look for the cases above displaying quality as measured by the translation network as well as those which seem to fail. The interest of this last query will be best grasped when I turn to further applications of a translation browser, in the next section.

8.1.3 Applications of the translation browser

Which other applications does a translation browser have, apart from being an aid for the translator and/or the contrastive linguist? I answer this question while responding to a plausible objection: A translation browser is no more than a tool intended for translators and linguists. What then is the real advantage of having such a sophisticated -- and computationally heavy -- system if a current translation browser, used by human experts, would allow the filtering of the right examples anyway?

I will provide two answers. The first simply questions the word "anyway" in the above argument. If errors are made by human translators, there is absolutely no reason why they would not be made by human reviewers. And this seems to be especially so, if these reviewers were not professional translators, but linguists or lexicographers not particularly acquainted with translation delicacies, or apprentice translators. Also, even a professional translator who is re-using his work is not aware of his own systematic mistakes.

As to my second answer, let me assume, for the sake of the argument, that the choice of the right translations in face of ample evidence would indeed be unproblematic most of the time. My reply is that a system equipped with such capabilities provides a wide potential for more complex applications, contrary to the simple systems reviewed above. One obvious application, although still with a mainly theoretical import, is its use for informed language comparison along the lines of the methodology discussed in Section 3.8. What I have in mind are practical applications like a translation tutor, a translation evaluator, a translation checker, or a selective filter for translation memories, as will be shown presently. My point is that even if the increase in functionality of the translation browser in itself would not compensate for the increase of processing, these more powerful features would be required for further applications that could then be based on it.

Let me briefly describe a few such applications:

A translation tutor is an intelligent tutoring system whose aim is to help in teaching translation. By using previous translations, and, especially, problematic ones, it can provide considerable help to the student. In addition, the system can be made to evaluate possible translation suggestions made by the student in the course of the learning process.

A translation evaluator is a system that grades translations of the same original according to objective features (which could well be the ones mentioned above), while a translation checker is a system aimed at identifying problematic instances of translation. This latter task is actually a simple consequence of building a translation database and finding mismatches. The user then either helps the system to store them correctly, if he is concerned with the analysis of previous translations, or revises the translation if the aim is to create a correct translation.

A selective filter for translation memories is a device which prevents unwise addition of previous translations to a corporate memory. Instead of adding all translation pairs produced in a given text for future use, it would rather include only those obeying some standards of quality or exactness.

Finally, and as a more complex endeavour, one could envisage a semi-automatic translation system which would suggest translations based on the knowledge already stored. This was proposed by Sato & Nagao (1990), but the similarity measures they suggested did not embody any contrastive knowledge (they embodied fairly limited linguistic knowledge even as far as each language was concerned). My belief is that a system based on a translation browser (or better, on the database of the translation browser), as suggested here, might provide a considerably better starting point for a translation expert system.

In fact, the ideal automatic system for translation would embody all the previous capabilities, i.e., it would evaluate and filter previous translations to enrich its database, it would be able to suggest new translations, to criticize others, and to reason about translation, in the sense of being able to explain its choices.

Although such a system may be too complex to ever exist in practice, it is, I believe, a better engineering goal that the FAHQT of the sixties, especially because it is composed of several smaller pieces which are no doubt useful and even have present (commercial) applicability.

It is, furthermore, based on a basic tool, the translation browser, whose interest for contrastive research should be undeniable. This way, there would not be a physical separation between knowledge gathering and knowledge use, i.e., between research prototypes and end products.

8.1.4 Conclusion

Having a translation browser of the sort described here is certainly not the solution for all translation problems. It is not even a system that can free human beings from hard work. What it can do, if well used, is to improve significantly the work of its users, by giving them better tools, possibly a shorter training period, and access to previous results in their craft.

This can actually be compared to what the recent trends in information retrieval offer you. With the current networking capabilities, you can access almost any information at your terminal -- but that does not do the reading for you. What human beings gain is that they no longer have to go somewhere else during office hours to look in the shelves for something which actually may not be there. Likewise, what human translators gain is the possibility of accessing more information that would in principle be beneficial to their work -- but still no one is doing the translation for them.

Since the non-trivial parts of the whole system described are the networks, I will concentrate on their precise behaviour in the next sections.

8.2 Towards a more detailed specification

This section investigates, from a formal point of view, the two computational systems proposed in this thesis: the aspectual network for the description of each language's tense and aspect system, and the translation network to cast the translation relations between two different language systems.

Its main goal is to provide insight into the formal properties of these systems, and not the particular formalizations in themselves.

8.2.1 The aspectual network as a finite state machine[8]

The aspectual network as a computing device is meant to make explicit aspectual (and, to some extent, temporal) matters inside clauses of a language.

It is formed by a set of nodes (whose interpretation is not at stake at this point) and transitions among such nodes, labelled by overt linguistic phenomena (such as the progressive or the existence of a particular adverbial), or simply unlabelled.

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[8] The reader not familiar with formal languages or automata should consult reference books on the subject such as Hopcroft & Ullman (1979) or the more mathematically oriented Eilenberg (1985). Still, the amount of theory required to understand the present chapter is minimal.

An aspectual network can be easily interpreted as a (non-optimized) finite-state machine for the language of aspectual interpretation,[9] which, given a suitably parsed sentence produces a (set of) parse(s) for its aspectual meaning. The parses are cast in the form of paths in the aspectual network.

For example, given the following input (the order of which is not relevant):

(*destroy* progressive passive *for* past)

the output of the aspectual network analyser should yield something like the following, where transition labels are displayed in boldface and unlabelled transitions are not graphically marked:

(achievement **passive** acquisition event **progressive** state **for** accomplishment **past** past-accomplishment)

In other words, the aspectual network (used as a parser) should produce a sequence of states together with the operators that labelled the path arrows.

Depending on considerations having mainly to do with processing efficiency, one may consider/implement a parser which works from lexical classification to sentential classification, or the other way around. Similarly to the choice between top-down or bottom-up parsing strategies for phrase-structure grammars, the choice can at best be based on the branching factor in either direction.[10]

The networks were designed so as to minimize the number of choices in addition to the ones actually required (and overtly signalled) by the languages. Still, it is true that lexical classification is required in order to decide which is the initial node ("initial" in the sense of lexical), in cases where it is possible that an unlabelled arc might have been traversed.

However, to decide what the initial classification should be, the aspectual network can be useful in a different way: After gathering a considerable number of sentences involving such lexical items (partially) parsed by the aspectual network, a simple procedure can be devised that identifies whether the verb in question should be assigned a vague classification (in case two or more cases are joined by a vague node) or, rather, whether the lexical item in question only occurred in one of the (non-vague) classifications. In sum, the aspectual network itself could help in a monolingual task such as lexical aspectual classification, which is required for a full parse.

If no aspectual and/or temporal markers were available at the input, no parse would be possible with the aspectual network. This is not a mere academic question: Tenseless (and/or

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[9] From Figure 7.24 of the preceding chapter, for example, it is evident that finite state machines (or regular languages) are not powerful enough to describe all cases presented in the informal aspectual network format. The use of complex labels which correspond to parses in other parts of the aspectual network indicates clearly that a context-free grammar is required, or, equivalently, a push-down automaton.

I believe that the exact place in the grammar hierarchy is not the most interesting problem, though, and so I chose to disregard these matters here (as well as, in general, in the complete informal networks) and discuss the issues I consider relevant using a finite-state automaton.

[10] Albeit in general more common grounds for decision are related to the tools and interpreters the programmer has available. Another pertinent question would be whether the aspectual network analyser would work in parallel with the shallow syntactic analyser mentioned in Section 8.1, in which case it would have to follow the direction chosen for it. Here, my goal is simply to emphasize that the choice of direction is not essentially related to the problem at hand.

verbless) sentences are not infrequent in running text (see e.g. Santos (1992c)) -- and consequently can and will be translated --, but these cases are clearly outside the scope of the present dissertation.

Before providing a (sketch of the) description of the aspectual networks as finite-state machines, let me note that, in order to make the (formal) language described by the aspectual network empirically adequate, the loops corresponding to "no change of aspect" should be spelled out as a path between two nodes. I.e., simple past in English, instead of labelling a loop from achievement to achievement would label an arc from achievement to past achievement, and so on. (This option was mentioned in Chapter 6 in order to separate tensed from non-tensed entities.)

More precisely, the formalization of the aspectual network as a finite state machine is a system (S, V, g, s_0, F), where V is a set defining the machine's nonempty input alphabet, S a nonempty finite set of states, s_0 □ S an initial state, F ∏ S a nonempty set of final states, and g: S x (V ≈ {ε}) ∅ 2^S a mapping from states and input symbols (including null transitions, denoted by the symbol ε) into sets of states. A sketch of the finite state machines corresponding to the English and Portuguese networks follow (the subscripts E and P refer to English and Portuguese respectively):

S_E = {accomplishment, achievement, state, permanent-state, past-accomplishment, ...}
V_E = {progressive, for, passive, simple-past, result-adjective, ...}
s_{0E} = clause[11]
F_E = S_E - {clause, past-accomplishment, ...}[12]
g_E(accomplishment, passive) = acquisition
g_E(accomplishment, perfect) = acquisition
g_E(accomplishment, simple-past) = past-accomplishment
g_E(activity, ε) = accomplishment
g_E(activity, ε) = permanent-state
g_E(activity, result-adjective) = accomplishment
...
S_P = {obra, mudança, estado-temporário, obra-passada, ...}
V_P = {andar-a, PPC, durante, passiva-com-ser, parar-de, ...}
s_{0P} = oração
F_P = S_P - {oração, obra-passada, ...}
g_P(série, andar-a) = estado-temporário
g_P(obra, parar-de) = mudança

[11] This initial state is just a matter of form, in order to conform with the requirement of an unique initial state in the finite state machine definition. So, I add this state to the aspectual network diagram and assume unlabelled arcs from it to all states corresponding to tensed clauses.

[12] I presuppose that the search is done from classification of tensed sentences to classification of lexical items, which means that all non-tensed nodes are final nodes (considering the initial state as a tensed node).

...

The machine as defined above is non-deterministic, i.e., there is more than one possible transition from a particular state given some input symbol, and has ε-moves, i.e., may perform transitions on no input. However, it is well known that any non-deterministic finite-state machine with ε-moves has an equivalent ε-free deterministic one.

Such a machine, however, would correspond to a different set of states (and a different transition function) and would undoubtedly differ considerably from the informal aspectual network formulation. Therefore, I do not present it here.

On the other hand, it should be noted that, to work as a parser as described in Section 8.1, the machine representing the aspectual network should be conceived as having output. More specifically, it should output the classification corresponding to the name of the state it is in. So, a more correct specification would involve a finite automaton with (state-associated) output. Formally, such a machine would differ from the previous description, in that a six-tuple would now be involved (S, V, V_O, g, s_0, F), in which V_O (the set of output symbols) would be equal to S - $\{s_0\}$. In words, all states but the initial one would output its own identification.

8.2.2 The translation network analysed in detail

Turning now to a formal rendering of the translation network, it is not so simple to find models whose graphical description is similar to the one of the translation network.

In fact, it seems useful to provide first a general discussion of the formal properties intended in my informal description. From the presentation of the translation network model in Section 5.3 and its extension in Section 7.3, it is apparent that two distinct issues are at stake: One is the modification of the source network due to the influence of the target language, the other is how to make sense of the translational arcs.

I discuss each subject in turn.

8.2.2.1 Extension of the source aspectual network

One of the extensions to the source network is made through the addition of T arcs and (possibly) new nodes to the source network, when it is paired with a target network. It is very important to emphasize that this is addition in context, in the sense that one cannot take the new source aspectual network separately, and claim that it describes a new language. It only does so when coupled with the network describing the target language (or, alternatively, for each possible path, when coupled with its translation into the target language).

Hence, it seems to be impossible to separate the extension from the linkage with the target language. More specifically, one cannot define a new finite-state machine for the source language without taking into account the target pair as well.

This indicates that, whatever the treatment given to the extension question, it has to be carried out inside the larger issue of expressing the whole translation network, independently of the particular formalization chosen.

As to the other kind of extension, discussed in Section 7.3, necessary to encode the fact that sequences of nodes (and not simply the nodes themselves) may be relevant for the choice of translational arcs, this phenomenon can be handled taking two different courses of action:

1. One may considerably complicate the source aspectual network in order to have different source nodes for different translational arcs. In other words, one can make explicit the influence of translation in the source network -- to such a point that the original network may become unrecognizable. This was the path I described in Section 7.3.

2. Or one may maintain the form of the informal translation network, but complicate the interpretation of the translation arcs (for example, associating restrictions to their traversal, making them dependent on other arcs, etc.).

The kind of extension depicted in 1. is thus not strictly necessary, and so it fails to provide conclusive evidence for the need of simultaneously taking care of extension and addition of translational arcs.

8.2.2.2 The relation of translation as described by the set of translational arcs

I turn now to a description of the properties of the translation relation as defined by the translation network, in order to assess what is essential and what is accessory in the graphical illustrations I have been producing.

The form constraints (and corresponding motivation) are essentially related to the concepts of (contrastive) vagueness and compactness, which I intend to define here in more precise terms. In addition, I will discuss the subject of compositionality.

Vagueness and compactness. My presentation of the constrastive issues in Chapter 7 was organized around these concepts. However, there I did not provide an explicit bridge between compactness and/or vagueness and the form of the networks. Here, I will discuss these issues by viewing the translational arcs as defining a mapping.

The first relevant remark is that vagueness and compactness are here meant as contrastive concepts. Hence they do not necessarily relate to monolingual vagueness (or monolingual compactness), even though it is not surprising that they may be associated with them.

Contrastive vagueness stands for cases in which the source language does not make a distinction required by the target language. The source language may make such a distinction in other cases -- and thus that particular situation can be analysed as monolingually vague as well -- or it may never make that distinction, in which case it cannot meaningfully be described as monolingually vague.

In the translation network, contrastive vagueness can be modelled by T arcs, while monolingual vagueness is modelled by unlabelled arcs. When contrastive vagueness is absolute (i.e., the categories between which is vague do not have monolingual justification), an alternative model could use simply a 1-to-M relation, i.e., the same source node would correspond to more than one node in the target network.

Contrastive compactness corresponds, on the other hand, to (some kind of) dual of contrastive vagueness: it stands for situations where a single device in one language packs two or more pieces of information which have to be conveyed by independent means in the target language. Again, they may be distinguished in the source language, in which case one could talk about monolingual compactness as well, but not necessarily.

Compactness is not so simple to convey structurally in terms of the translation network,[13] since it implies that one source category (and/or source transition) is rendered in the target network by a combination of two or more categories and/or transitions. In fact, most probably, as discussed in Chapter 3, only one of them would be naturally involved; a combination of the two would in general correspond to translationese.

Compactness at the level of categories (nodes) corresponds to the cases of 1-to-N mappings in a translation network. (In order to distinguish this case from absolute vagueness discussed above, one alternative would be to label the translational arcs. Another way, which I will assume in what follows, is to require that all vagueness be encoded by T arcs.) A 1-to-N mapping corresponds thus to partial translation in the sense of Chapter 3.

Depending on the particular form of the target aspectual network, i.e., on the existence or not of a (sequence of) transition(s) between two target nodes corresponding to the same source node, to preserve the information may or may not be possible. If there is a vague node corresponding to the two cases, a translation arc from a compact source node to a vague target node might be the optimal translation strategy, even though not information preserving.[14] Incidentally, this has been found to be widely used in practice, as several examples of Chapter 7 illustrate.

As for compact grammatical mechanisms (arcs, that is), the respective transition would be required to correspond to more than one transition in the target aspectual network. This cannot be directly read from the form of the translation network, though. In any case, I made it clear in Chapters 5 to 7 that most markers did not carry solely aspectual information, and thus compactness may not be exhausted by a more complex structural formulation of the networks, either. (Even though the addition of nodes for temporal information and perspectival aspect, suggested in Chapter 6, can be seen as an attempt in that direction). A different strategy to deal with compactness (not structural) will be followed in Section 8.3 below.

Compositionality. It seems appropriate to discuss compositionality at this point, too. Two kinds of compositionality can also be distinguished, namely contrastive and monolingual.

Contrastive compositionality (roughly, every distinction formally marked in the source

[13] Monolingual compactness is not in general identifiable by the form of the aspectual network, either. Rather, for the case of compact nodes, one needs to analyse the nodes themselves to identify it. For the case of compact arcs, a necessary requirement would be that they mirrored a sequence of two or more arcs linking the same two nodes. Even then, the import of the two sequences would not necessarily be the same, and thus an analysis of the meaning of the grammatical markers would be required to establish it.

[14] It is interesting to note that, once again, matters of truth seem not to exhaust the considerations relevant to translation: In fact, modelling compactness and vagueness as logical conjunction and disjunction, respectively, A □ B translating to A (or to B) is stronger than a translation into A Δ B, as Lauri Carlson noted. However, this latter preserves reference / mention to both A and B.

language is formally mirrored in the target language) has been shown not to exist in practice; no theory of translation I know of postulates it, either. As far as the form of the translation network is concerned, absence of compositionality brings no constraints.

On the other hand, one may be tempted to suggest that the monolingual models display a compositional approach to aspect in each language, in the sense that every marker described produces a transition, i.e., is given independent import.

Closer scrutiny, though, shows that the models are meant the other way around, i.e., only the markers that can be specified independently are displayed separately. The PPC, for example. was not compositionally separated into *ter* + Particípio passado and Presente, but specified syncategorematically.

Furthermore, due to coercion, it is possible that the combination of two markers produces a result different from the strict (mathematical) composition of their import, i.e., AB(x) in the aspectual network may result in something other than A(B(x)) or B(A(x)).

As a consequence, the models as I intend them remain silent about compositionality. They allow one to cast both compositional and non-compositional analyses when describing particular markers.

Summing up. In order to define structurally compactness and vagueness, two concepts which I selected empirically as translationally relevant, a generic translation network must have the following structure:

1. To model the vagueness of the source language, either 1-to-N arcs are necessary, or the source network is expanded with new categories coming from the target language, reached by T arcs which leave an arc without counterpart in the target language.

2. In cases where contrastive compactness (of aspectual class) is at stake, translational arcs necessarily define a 1-to-N mapping.

3. When the target language does not make distinctions which are relevant in the source language (vagueness of the target language), translational arcs define a N-to-1 mapping.

4. When the source language does not employ a particular category used by the target language (and, in addition, such category is not necessary to translate other categories), such a target node will not be reached by any translational arc. In technical terms, the relation is not onto.

8.2.3 The translation network as a finite-state transducer

In a formal language setting, the easiest way to conceive of the translation network is to define a transducer whose state set is the Cartesian product of the states of the two aspectual networks, whose transitions may be made on individual or joint transitions in the original networks, and whose output measures matches between states related by translational arcs.

More formally, take e.g. the English-to-Portuguese translation network, corresponding to the linkage of an English source aspectual network, defining the language L_E, with a Portuguese aspectual network, defining the language L_P.

The following machine can then be defined, where N_X stands for the set of nodes in the aspectual network of language X, V_X for the corresponding input vocabulary, F_X for the corresponding set of final states, and T for the subset of the states of the transducer which correspond to those pairs of nodes linked by a translational arc in the informal translation network:

State set:
N_E x N_P

Input:
(V_E ≈ {Ø}) x (V_P ≈ {Ø})

Transitions (in the form "input state, input in pair form □ output state, output"):
(q_E,q_P), Ø, b □ (q_E,q'_P), *v*
(q_E,q_P), a, Ø □ (q'_E,q_P), *v*
(q_E,q_P), a, b □ (q'_E,q'_P), *v*

Output:
v is 1 if the output state is in T ∏ N_E x N_P, otherwise *v* is Ø

Acceptance:
x,*y* such that δ [($q0_E$, $q0_P$), x,y] is in F = F_E x F_P

In words, the transducer accepts all pairs *x*,*y* such that *x* belongs to the language L_E and *y* belongs to the language L_P, and its final output is the length of the output string.

Note that Ø is a symbol not in VE ≈ VP, and is not taken to denote ε-moves in either aspectual network: it is a symbol only relevant for the present (translation) transducer, which is required to model lack of parallelism in source and target paths. δ is the usual transition function defined on strings.

This is a fairly trivial kind of transducer, which, due to its simplicity, does not deserve a more detailed specification here, but it can obviously be made less trivial if a more refined output is provided, and translational arcs are actually weighted according to criteria of information preservation, translationese, and the like.

In order to be used in practice, acceptance would have to be more restrictive, requiring, at least, that the output length were greater than zero (otherwise, any pair of sentences in the two languages would "parse" in this translation network).

As to the encoding of the T arcs, and assuming that the new categories had already been included in the source aspectual network, as well as the corresponding T arcs (i.e., the source aspectual network is already in extended form), the requirement that only corresponding transitions could be done by traversing T arcs is trivially specified by allowing only the correct transitions in the transducer. For example, in the case of the English aspectual class "state", interpreted as a temporary or a habitual state induced by translation into Portuguese, the only two transitions allowed would be:

(state, estado temporário), T, Ø □ (temporary state, estado temporário)
(state, estado permanente), T, Ø □ (habitual state, estado permanente)

which would entail that the following translations would not be permitted:

(state, estado temporário), T, Ø □ (habitual state, estado temporário)
(state, estado permanente), T, Ø □ (temporary state, estado permanente)

In a similar vein, the encoding of the dependencies between translational arcs could be enforced in the transducer by simply not allowing some sequences of (transducer) states. In the case of the example discussed in detail in Section 7.3,[15] the following transition would not be allowed by (i.e., would not be defined in) the transducer:

(obra, achievement), MQP, perfect □ (obra completa, acquisition)

Alternatively, the extension could have already been encoded in the (extended) source aspectual network as described in Section 7.3.

Finally, the transducer could also be extended in order to allow for sequences (words in the language of the aspectual networks), a particular case being its defining a gsm mapping.[16] This would allow the encoding of dependencies inside each language, such as sequences of transitions in the target language corresponding to one transition in the source language. In this way, it would provide a way to express contrastive compactness of arcs (cf. the definition of this concept above).

8.2.4 The networks as specifying abstract data types

Another possible way to view the aspectual network, inspired by close resemblance with its graphical format,[17] is to consider it as an ADJ-diagram, as suggested in Goguen et al. (1978) for the specification of abstract data types in computer science.[18]

This graphical notation is meant as a convenient way to display a (multi-sorted) signature, whose sorts are the node names, and whose operations are the arc labels. A precise algebraic interpretation of such graphical devices consists of a collection of sets (each set extensionally defining a sort, hence called the carrier of the sort), and a collection Σ of functions among the sorts, forming an S-sorted Σ-algebra. Then, further restrictions on the objects and operations defined are expressed in equational (or other) form.

Let me analyse briefly the aspectual network in this light.

8.2.4.1 Aspectual classes as abstract data types

Aspectual classes are the datatypes to be defined. Due to the high connectivity of the aspectual networks, the definition of aspectual classes gets conveyed by interrelationships among

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[15] Namely, where either the path OBRA MQP OBRA COMPLETA is translated by ACHIEVEMENT perfect ACQUISITION or OBRA is translated by ACHIEVEMENT.

[16] Formally, a gsm (generalized sequential machine) is defined by a six-tuple $M = (S, V_I, V_O, g, s_0, F)$, S being the set of states, V_I the input alphabet, V_O the output alphabet, s_0 the initial state, F the set of final states, and $g: S \times V_I$ ∅ $S \times V^*_O$ defining a mapping from pairs of states and input symbols to pairs of states and finite subsets of output symbols.

Note that a transducer and a gsm are basically the same computational object, only the perspective on it changes: V_I and V_O of the gsm correspond in the above transducer to two inputs.

From an implementation point of view, this amounts to viewing the transducer as a translation checker, or evaluator, and a gsm as a translator.

[17] suggested to me by Amilcar Sernadas.

[18] The reader not familiar with this tradition could also consult Ehrig & Mahr (1985) or Wirsing (1990).

the whole language system (e.g., the specification of the data type "accomplishment" is dependent on all (or many) of the other data types). Aspectual transitions are viewed as meaningful operations on data types.

The basic formalism is typed, i.e., an operator has its arity and rank as part of its definition, but it is possible, and even common, to employ overloading of operator names in practice; cf. Wirsing (1990:680).[19]

It is thus not necessary to change labels, for example, for the progressive operator, even though it operates from accomplishment to state and from state to temporary state. I.e., PROG will belong to both $\Sigma_{accomplishment,\ state}$ and $\Sigma_{state,\ temporary\text{-}state}$.

The view of arcs as operators has as consequence that unlabelled arcs, too, correspond to operations (which only differ in that they are not linguistically marked). I.e., to each particular unlabelled arc a particular operation (in general, different) is assigned. Henceforth, I will use the naming convention $UNLAB_{x,y}$ to denote the operation associated with the unlabelled arc from x to y.

One particular advantage of formalizing arcs as operations, and given that there is no restriction to the arity of the operators, is that this model allows one to represent compact aspectual classes as the combination of two or more inputs. A case in point is the syntactic combination, in English, of an activity verb and a result adjective. This, in a unary perspective (as is the case of the informal aspectual network) can be modelled as a parameterized family of operators (one per adjective), and is expressed in an algebraic formulation as a unary operator RESULTADJ □ $\Sigma_{activity,\ accomplishment}$. It is plausible that a more adequate formulation, however, would have a binary operator ADDRESULT belonging to $\Sigma_{activity\ result\text{-}state,\ accomplishment}$ instead.[20] The same is possibly true of the cases, described in the previous chapter, which involved two levels of the aspectual network, i.e., that corresponded syntactically to clausal embedding.

Comparing a formal language description with the specification of a data type, the two seem to focus on different faces of the same coin:

The formal language description is concerned with the (syntactic) elements that constitute the language, i.e., with the terminals that have aspectual import: progressive, past tense, result adjectives, etc. Nodes (aspectual classes), corresponding to non-terminals of a grammar, are just devices that help in the parsing, or, at most, are the output of the parsing process (if the automaton is considered to have output). In order to optimize processing, reshuffling of nodes suggests itself (in particular, to dispose of null transitions, and to obtain a deterministic automaton).

By contrast, the algebraic specification is geared to define the meaning of the nodes (is

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[19] Rydeheard & Burstall (1988) claim that such a facility (i.e., polymorphism) is essential for specification languages.

[20] Even though an adjective is not in itself a result state and some coercion into a verbal class would probably be necessary as well.

thus, basically, semantic), to which goal it requires (or suggests) a reshuffling of the arcs instead.

So, compared to the informal aspectual network, there is a proliferation of nodes in the formal language description, versus a proliferation of arcs in the algebraic description, both of which have costs as to my intended interpretation.

Still, the view of the nodes as primary conforms better to the views defended in the present dissertation, since (i) not all operators were taken into account in the informal networks (but, in principle, the set of aspectual classes is complete) and (ii) I defended in Section 5.1 that the aspectual classes in themselves were more relevant than the features they might include.

I present here a flavour of what a data type formulation of the (English) aspectual network would look like. The names of the sorts are:

S = {state, temporary state, acquisition, accomplishment,...}

Letting $\Sigma_{\lambda,s}$ denote the (set of) constants of sort *s*, and $\Sigma_{r,s}$ denote the (set of) operation symbols of arity *r* and of sort *s*, possible members are:

$\Sigma_{\lambda,\text{ state}}$ = {John be a teacher}
$\Sigma_{\lambda,\text{ accomplishment}}$ = {*John build a house*}
$\Sigma_{\lambda,\text{ acquisition}}$ = {*John be angry*}
$\Sigma_{\lambda,\text{ activity}}$ = {*the wind brush the sky*}
...
$\Sigma_{\text{state, state}}$ = {PAST}
$\Sigma_{\text{acquisition, state}}$ = {$\text{UNLAB}_{\text{acquisition, state}}$}
$\Sigma_{\text{activity, accomplishment}}$ = {RESULTADJ, $\text{UNLAB}_{\text{activity, acc.}}$}
$\Sigma_{\text{state, temporary state}}$ = {PROG, PERFECT}
...

Not all data types (aspectual classes) have constants, i.e., there may not exist lexical items of a particular type, as is the case of "habitual state". On the other hand, the possible constants (the verbs in the lexicon) are far too many to specify graphically or as a simple list, so I have provided here only one example constant per aspectual class.

Computing the corresponding (ground) term algebra according to the standard procedure in multi-sorted equational logic, elements of it would be:

PAST(John be a teacher)
$\text{UNLAB}_{\text{acquisition, state}}$(*John be angry*)
RESULTADJ(*the wind brush the sky*)
PAST($\text{UNLAB}_{\text{acquisition, state}}$(*John be angry*))
PAST(PAST(*John be a teacher*))
PAST(RESULTADJ(*the wind brush the sky*))
PAST(PAST(UNLAB(*John be angry*)))
...

These are terms of the term algebra corresponding to the basic data types defined by the signature. Then, the equations (irrespective of their precise form) are meant to dispose of many of these terms -- for instance, the ones corresponding to repetition of morphological operators, the ones involving more than one unlabelled operation in a row, etc.

A specific advantage of this formulation, that is made apparent here, is that one can inspect directly the (series of) resulting terms and check whether they are intuitively meaningful.

8.2.4.2 The translation network defining a morphism

Turning now to the use of abstract data types specification tools for the formalization of the translation network, I will look into several different approaches, beginning by signature morphisms and morphisms between algebras.

The idea of letting the target language influence the form of the source language seems to agree nicely with the concept of a morphism, because, intuitively, what coercion by translation does is bringing together the form of the two aspectual networks, as noted by Amilcar Sernadas (p.c.).

First, I consider viewing the translational arcs as defining a signature morphism, i.e., a mapping between two signatures (a pair of mappings: one between the sorts and another between the operators) "in such a way that the types are preserved" (Wirsing, 1990:681). Formally, a signature morphism trans: Σ ∅ Σ', with Σ = (S,F) and Σ' = (S',F'), is a pair <$trans_{sorts}$, $trans_{opns}$> where $trans_{sorts}$: S ∅ S' and $trans_{opns}$: F ∅ F' are mappings such that, for any f: w ∅ s, type($trans_{opns}$(f)) = $trans_{sorts}$*(w),$trans_{sorts}$(s).

Now, no pairing of operators is done in the informal translation network, and thus it is not evident how $trans_{opns}$ would in general be defined. The case of the path OBRA MQP OBRA COMPLETA discussed above shows, however, that in some cases this is actually required, resulting in perfect □ $\Sigma_{achiev,acquisition}$ being the image of MQP □ $\Sigma_{obra,\ obra\ completa}$, i.e., $trans_{opns}$(MQP)= perfect.

The fact, noted in Section 8.2.2.2 above, that source language compactness necessarily implies irreducible 1-to-N relations indicates, nevertheless, that translation in general does not preserve the source language's "data types". One must therefore postulate a family of (partial) morphisms instead, each implementing a particular translation into the target language. This formalizes, in a way, the celebrated "free choice" of the translator.

For the sake of concreteness, let me specify the translation network displayed in Figure 8.5 in this form.[21]

Mapping of sorts:

$trans_{sorts}$(habitual state) = estado permanente

$trans_{sorts}$(particular event) = obra

[21] This translation network corresponds to the (partial) informal translation network presented in Figure 7.6, with all influence of translation spelled out carefully.

$trans_{sorts}$(acquisition) = aquisição

$trans_{sorts}$(temporary state) = estado temporário

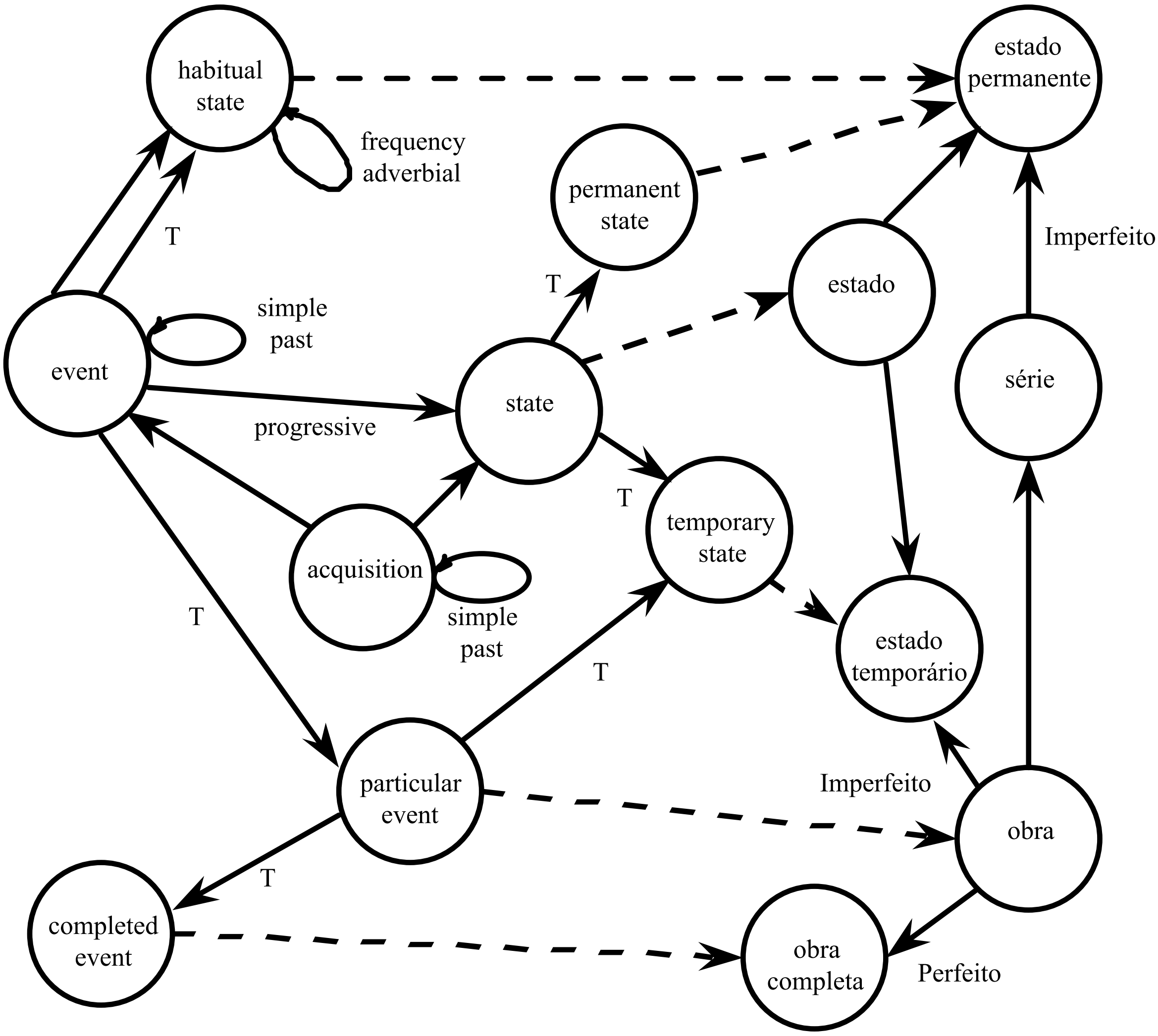
$trans_{sorts}$(permanent state) = estado permanente

$trans_{sorts}$(event) = UNDEFINED

$trans_{sorts}$(state) = estado

"UNDEFINED" indicates that there is no analogue in the target system. In other words, the best one can do is to have a partial morphism, i.e., have no mapping whatsoever involving the node "event".

Figure 8.5



The mapping of operations is then necessarily also partial. In the particular case at hand, and due to the fact that (by coincidence) most arcs in the source network leave from a node corresponding to a sort for which $trans_{sorts}$ is not defined, specification of $trans_{opns}$ results in only:

$trans_{opns}$(Tparticular event, completed event) = Perfeito

$trans_{opns}$($T_{\text{particular event, temporary state}}$) = Imperfeito

In any case, a signature morphism is clearly too weak, in the sense that it does not involve the whole specification of the (aspect) data types, but only its more syntactic part.

One should thus work with whole algebras and not only with signatures. The notion of Σ-homomorphism between algebras is available for such a purpose; cf. Wirsing (1990:682): "a Σ-homomorphism maps the "data types" of one Σ-algebra to those of another in such a way that the operations are preserved". Formally, a Σ-homomorphism h: A ∅ B, where A and B are two Σ-algebras, is a family of maps $\{h_s:A_s \emptyset B_s\}_{s \square S}$ such that for each $f:s_1...s_n \emptyset s \square F$ and $a_1 \square A_{s_1},... a_n \square A_{s_n}$, $h_s(f^A(a_1,...a_n)) = f^B(h_{s_1}(a_1),...h_{s_n}(a_n))$.

At first sight, therefore, the translation network could define a Σ-homomorphism between the algebras of source language aspect and target language aspect. The problem with such a view, however, is that it runs counter the empirical evidence. For example, assuming the mapping of sorts presented above, the homomorphism h would define maps for the basic elements of the carriers $h: A_{state} \emptyset B_{estado}$, and would have to obey equations such as:

$h_{state}(progressive(x_{event}))=progressiva(h_{event}(x))$

But, as previously noted, neither there is a corresponding operation in general (such as I assumed "progressiva" corresponded to "progressive" in the example at hand) nor the value of h_{event} is defined. And so, it seems that one has to stick to a signature morphism formulation, although it is admittedly too weak.[22]

8.2.4.3 Translational arcs as operations

Another alternative, also in the algebraic spirit, would be to define translational arcs as representing operations between data types.

Restrictions associated with translational arcs could then be expressed in equational form. Allowing translational arcs to be defined on sequences of operations:

TRANS1(MQP(obra)) = PERFECT(achievement)
TRANS2(obra) = achievement

a plausible encoding of the necessary restriction would be:

TRANS1(MQP(X)) exclusive-OR TRANS2(X).

Looking at the translational arcs as operations has, moreover, the advantage of expressing translation as a set of specific (and possibly very different) operations with which an explicit semantics may be associated.

An additional advantage of this perspective is that the phenomenon so far encoded by T arcs could be recast by considering translation a binary operation (having one operand in each

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22 Cristina Sernadas has noted that, in line with the general approach of looking at the translation network as defining a morphism, I should have considered a morphism between (finite) automata as well, in the sense of a mapping between alphabets and an inverse mapping between the states, subject to conditions on the transitions and the initial and final states.

aspectual network) whose result is a target network data type, dispensing with the extension of the source aspectual network altogether. Coercion by translation would be modelled thus:

TRANS3(state, estado temporário) = estado temporário.

Finally, at a still higher level of abstraction, one could consider the class of all possible aspectual networks as defining a category in its own, and formalize the translational arcs as a functor in that category. To be developed in detail, this approach requires, however, more knowledge of category theory than I have now.

I will therefore try to give more semantic content to the translational arcs, instead, by pursuing, in the next section, a specific model that combines insights from the two kinds of frameworks investigated here, leaving for Section 8.4 an assessment of what has been achieved in the whole chapter.

8.3 A detailed formalization based on Carlson's model of aspect

I have not attempted so far at an explanation why some transitions in the aspectual network are allowed and not others, nor have I tried to explicate the distinction between unlabelled and labelled transitions. Neither have I discussed why there are some translational arcs and not others in the translation networks, clearly the most relevant issue to properly understand this device.

In order to answer these questions, a deeper analysis of both the aspectual and the translation networks must be effected, and node and arc labels alike must be explicated in terms of other concepts. To do so, I will investigate L.Carlson's formalization of aspect suggested in Carlson (1993, 1996).

A remark is in order here, though. It should be clear that Carlson's model of aspect was not devised to formalize my (or Moens's) aspectual network. It was designed, in fact, to explain exactly the same matters of language behaviour, but not necessarily with the same conceptual tools. And thus, when in what follows I talk about networks, coercion, or vagueness, it must be borne in mind that such concepts were not originally in Carlson's proposal. I am, therefore, "twisting" it to some extent for my purposes here.

8.3.1 Aspect as a regular language over events

In unpublished work (1993,1996), Lauri Carlson suggested the following formalization of tense and aspect: the world W is a partially ordered set of event (token)s. An event type is a set of complex events (i.e. a subset of all chains of events in W (W*)), expressed as a regular expression.

The language of aspect contains the following operators: concatenation, ¬ (complement), * (iteration), ≈ (union) and ↔ (intersection), as well as variables bound by a lambda operator (graphically denoted by ":" after the variable). The lambda operator is extended from propositions to regular expressions by defining the expression e:peq to denote the language u: ∃v v = xuy □ v □ peq □ x □ p □ y □ q.

Variables can then also be contextually or existentially bound in the propositions which result from tense application.

Aspectual classes are thus special kinds of event types, those that obey some particular properties, expressed as equations over the language. E.g.:

an activity is closed under iteration	$\mathbf{a = a^*}$
a series is an iteration of some other type of event	$\mathbf{r = e^*}$
a bounded event type is such that	$\mathbf{e \leftrightarrow ee = Ø}$
a Mudança is a sequence of a state and its complement	$\mathbf{m = \neg ss}$

Carlson's model is essentially semantic, and, therefore, the description of vague aspectual classes in his model is not done at the same level, but as something linguistic which can correspond to either case. He thus introduces the notion of "aspect type" for linguistic classes whose model corresponds to a disjunction. But, if one is happy to model aspect types extensionally in terms of a union of the two possibilities, the notion of aspect type can be dispensed with by transferring the disjunction to the language of events. E.g.:

an acquisition is the disjunction of a state and an incipient change $\mathbf{q = s \approx \neg ss}$

Aspect operators map event types to event types. Their definition in Carlson's system thus proceeds in the lines of the following examples ("a:" reads "lambda a"):

the imperfective cuts out of an event type an unbounded one impf: $\mathbf{e \varnothing a: e \leftrightarrow a}$
the perfective turns an event type into a bounded event type perf: $\mathbf{e \varnothing \neg ee\neg e}$
the progressive selects the state of being inside a process (inside an event)
prog: $\mathbf{e \varnothing s{:}xsy \leftrightarrow p \leftrightarrow e}$[23]

Not all aspectual operations are required to be formally marked in natural languages, i.e., Carlson notes that habituality is unmarked in English, but corresponds to the semantic operator **hab**. This operator has a modal import which cannot be represented in terms of the regular operators. (One way to describe its import is to say that it turns a repeated activity into a property of a participant of the activity).

hab: $\mathbf{e^* \varnothing s}$

Temporal operators, on the other hand, are represented as ordering relations between events and times represented by temporal variables, some contextually bound (like the one for reference time), others existentially bound. Times are in Carlson's system complex event types too (collections of events whose common property is being simultaneous). Tenses are modelled as operators from events into propositions involving sentences of the form **e at t** or **e in t**, which are abbreviatory conventions respectively for "**e □ t**" and "**xey □ t**". These expressions are

[23] If **e** is a process already, then the progressive definition simplifies to $\mathbf{p \varnothing s{:}xsy \leftrightarrow p}$, given that, obviously, $\mathbf{p \leftrightarrow p = p}$.

suitably extended to (set) inclusion, if the first argument is an event type.[24]

Here are some examples of temporal operators as suggested by Carlson (1996) (in brackets I display the kind of input event type presupposed in their definition):

English simple present:	[s] **s at r □ r = now**
English present perfect:	[e] **e in x □ x ≤ now □ x in r □ now in r**
Perfeito:	[e] **perf(e) in t □ t < now**
Imperfeito:	[e] **hab(e*) at r □ t in r □ t < now**

From the examples above, it can be seen that (a sort of) coercion is implicitly defined in the meaning of some operators. For example, Perfeito is modelled as turning its argument into a perfective event. In case this is not possible, Perfeito would not be felicitous. Likewise, English simple present requires a state. Its application to a lexical event would thus correspond to the following (derivational) path in Carlson's system, before the simple present could be applied:

event ---(series formation)---> series ---(habit formation)---> state

Let me now discuss some relevant properties of this model of aspect, before providing a more exhaustive description, dealing with the particular aspectual networks.

First, classification is seen in implicational terms: For example, considering that a natural expression for a Mudança would be **¬ss**, no claim is being made that the meaning of *ir a Lisboa* ('go to Lisbon') is exhausted by the existence of a state of not being in Lisbon followed by a state of being in Lisbon. Rather, what is being claimed is that, if the expression *ir a Lisboa* is correctly used, in the possibly infinite set of possible conceptualizable events associated to that expression, one will always find two of that form (and with that temporal ordering).

A similar point relates to the question of result. The attentive reader may have noticed that no mention of result has been made in this framework. Yet, I have claimed that, for English events in general and for Mudanças in Portuguese in particular, this was a crucial notion. The way this model tackles the concept of result is simply by mentioning a change of state in the implicational definition, i.e., all event types described by a change of state "¬ss" have "s" as their result.

This does not mean that any state followed by its negation (or vice versa) corresponds to a resultative event. On the contrary, what is stated is that, whenever resultative events are expressed in natural language, there is a verification procedure which allows us to detect such things as "¬s" and "s".

This is undeniably a great advantage of the present framework: it allows one to bypass the philosophically complex questions of result and causation when working on a model of aspect.

In addition, the formalism seems to have the necessary ingredients to deal with the temporal contribution of the tenses:[25] As noted above, tenses are allowed to introduce

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[24] For example, if **t** and **t'** are times, **t at t'** corresponds to ∀ **x □ t** **x at t'**.

[25] Elsewhere (Carlson (1994)), Carlson provides a more formal characterization of tense and aspect in a theory of rational dialogue, where "the truth of a sentence p is defined at a period h'' in a period h' of a history h through a

contextually dependent variables, as well as precedence relations. This is in accordance with the view (reviewed in Chapter 4) that tense is relational and often referential (deictic and/or anaphoric).

Also, allowing temporal operators to have aspectual requirements (requirements on the form of the event they localize temporally) is a convenient way to model the fact that tense and aspect are intrinsically mingled, incidentally something which, though several times emphasized in the present dissertation, has not received an adequate model in the networks, in which only aspectual contrasts are explicit.

So, it will not come as a surprise that not only the translation contrasts involving temporal reference but also the import of operators like *já*, which is more of a (non-deictic) tense than an aspect operator, will be more adequately described in this framework.

8.3.2 The aspectual network

After this general overview, let me present Carlson's proposal in more detail as far as the particular description of event types is concerned, with a view to express an aspectual network in the framework. Carlson distinguishes between the following semantically defined event types in equational form:

activities:	**a = a***
processes:	**p = e***, where **e ≠ p**
series:	**r = (¬ss)*** (or equivalently, **(¬ss¬s)***)
states:	**s =t: xty ↔ s**

All these are unbounded, in the sense that e=e* (over some granularity level). Conversely, the following event types are bounded, i.e., X≠X*:

events:	**e ↔ ee = Ø**
changes:	**¬ss**
pulses:	**¬ss¬s**

Note that types are not mutually exclusive: for example, changes are events.

Even though Carlson presents these semantically defined event types as language independent, diferences between languages can show in which different combinations are present, both in the lexicon and in grammar.

In other words, some languages may lexicalize some of these event types in one particular aspectual class. Alternatively, languages may have vague predicates (encompassing more than one entity). For example, still according to Carlson, English does not lexically differentiate between pulses and series, which means that English would have an aspect type corresponding to

trend H for a choice function C" (Carlson, 1994:385). Aspect only deals with the at-index, while "the general form of a tense-logical truth condition is p is true at h' in h''" (ibidem, 389), the at-period and the in-period corresponding to Reichenbachian event and reference times, respectively.

the disjunction of both entities.[26]

Likewise, particular languages may have combinations of these basic event types, as is the case of English accomplishments, modelled as a process bounded by a change **¬sps.** I consider such a class as not existing in Portuguese -- as noted in Chapters 6 and 7 above --, but it is undoubtedly pertinent for English.

8.3.2.1 Nodes (aspectual classes)

Let me thus specify the aspectual classes of the two languages in this form. In order to make clear that the translation corresponds to semantic (and not linguistic) aspectual classes, I prefix "S_" to the names of the informal aspectual classes.

I start by displaying the English (simple) lexical aspectual classes:[27]

S_states: **s** such that **s = t: xty ↔ s** (homogeneity)
S_activities: **a** such that **a = a*** (closure under iteration)
S_achievements: **e** such that **e = ¬ss**
S_accomplishments: **e** such that **e = ¬sps**

And proceed by displaying the non-lexical ones:

S_series: **r** such that **r = e***
S_temporary states: **s** such that **s = t: ¬tt¬t**
S_permanent states: **s** such that some modality is involved

Aspect types like acquisitions and gradual accomplishments correspond to the disjunction of the corresponding "constituent classes":

S_acquisitions: **a** such that **a = s ≈ ¬ss**
S_gradual accomp.: **g** such that **g = p ≈ ¬ss**

The difference btween gradual accomplishments and other accomplishments is only in the intrnal dtail of the activity: it is of the form s1s2...sn where the stats are ordered along some dimension.

In order to cast the Portuguese ones, let me first describe how to encode, in a regular language over events, the notion of having duration, which I considered definitional for Obras. On the one hand, it is enough to require that the event type Obra has more than one distinct part: recasting a purely temporal concept in terms of internal structure requirements. On the other hand, in order to separate Obras from Mudanças, it is necessary to require that the second part is not the negation of the first. This allows for heterogeneous (**b ≠ a**) and homogeneous (**b = a**) Obras.

S_obras: **e** such that **e = ab** and **b ℵ ¬a**

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[26] This is actually "built in" in the meaning of *, i.e., **e* = e ≈ e+ ≈ Ø**.

[27] Henceforth, the letters "e", "s", "a" and "r" abbreviate respectively "e is a bounded event or a S_activity", "s is a S_state", "a is a S_activity", and "r is a S_series".

S_mudanças: **e** such that **e = ¬ss**

S_séries: **r** such that **r = e***

S_aquisições: **a** such that **a = s ≈ ¬ss**

S_mudança+obra: **q** such that **q = ¬ssab** and **b ℵ ¬a**

S_obra+mudança: **q** such that **q = abs¬s** and **b ℵ ¬a**

S_estados_permanentes: **s** such that some modal element is involved

S_estados_temporários: **s** such that no modal element is involved

S_estados: **s**

S_propriedades_sociais: **s** such that **s = t: et** and some modal element is involved

S_propriedades_essenciais: **s** such that some modal element is involved

Now, it is obvious, from the previous definitions, that the inability to express modal values in this framework, which was quite a marginal concern for English, was much more damaging for the formalization of Portuguese. In fact, no equational definition in terms of event types was found that allowed one to express permanent states or essential properties and consequently states are not really handled in the present framework.

Also, I have considered that more concern with temporal duration is required in Portuguese than in English.[28] In fact, this framework does not handle metrical properties of times such as length, but allowed an alternative definition (that of having internal structure), that entails duration.

As will be seen in Section 8.3.3 below, the present definitions already allow some interesting contrastive conclusions. But, in order to obtain a model of the aspectual network, I have to suggest a formalization for the operators first.

8.3.2.2 Arcs (aspectual operators)

In a way similar to his view of event types, Carlson's aspect operators are language-independent (or, at least, are meant to encompass aspect operations in languages as diverse as English, Finnish, Portuguese and the Slavic languages). So, I conceive of his imperfective operator as sometimes being materialized in English through progressive, as when it applies to pulses conveying iteration, although the progressive has its own (more specific) aspectual import when applied e.g. to accomplishments.

It is thus possible for the "same" linguistic operator to correspond to more than one semantic operator in Carlson's system, so the semantic operators do not necessarily correspond exactly to the meaning of the correspondingly named devices in particular natural languages, making the convention of prefixing an "S_" to the original name still more useful. Since, strictly speaking, there are no unlabelled operators in the semantic aspectual networks, I present, for ease

[28] Provided one agrees with the formulation of English accomplishments and achievements presented here in the first place. Vlach, in disagreement with e.g. Moens's (1987), Carlson's (1993) and my own views, claims that "the difference between achievements and accomplishments is simply that achievements are momentary but accomplishments span extended intervals" (Vlach, 1993:243), in other words, a simple question of temporal duration.

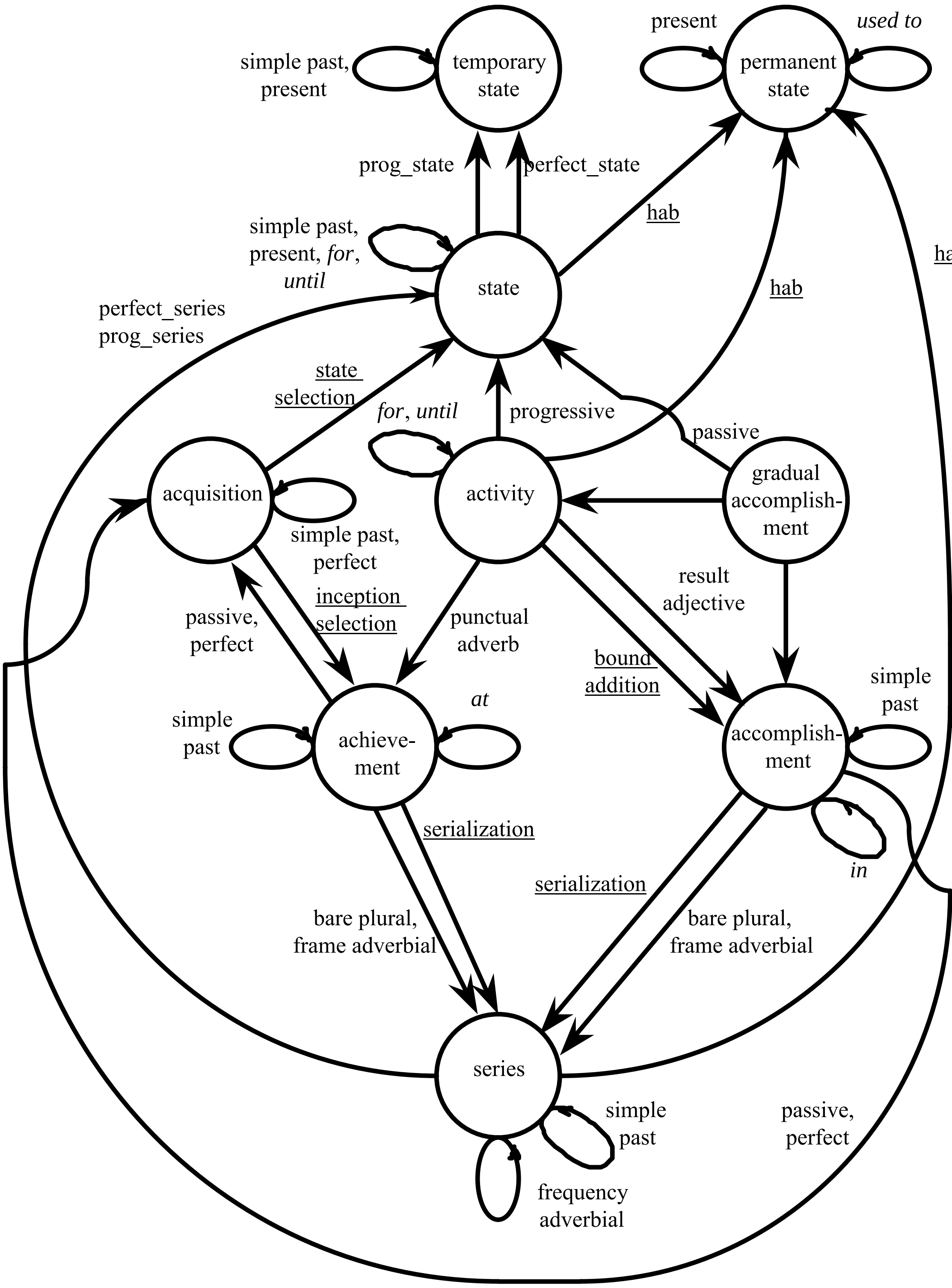
of reference, the new aspectual networks, in which the names of the formally unmarked operators are displayed underlined, in Figures 8.6 and 8.7.

One thing that should be made clear is what it means for an operator to have an output whose type is a disjunctive class, which is the case of the perfect and the passive in the English aspectual network. There are two possible answers here: the corresponding operation may yield a disjunctive output, or else its output may be vague (non-specified) relative to one particular distinction.

In any case, the operations must be defined in such a way that further conclusions can be taken regarding the properties of the complex expressions that resulted from their application.

This is an important point. Since Carlson's system provides a translation for both aspectual classes and operators (i.e., it gives an interpretation to both transitions and nodes of the aspectual network), it entails (or requires) that the nodes and transitions are further subject to the restriction of logical coherence. This is, actually, the major purpose of the present exercise: to be able to express the operations corresponding to linguistic operations so that they are compatible with the output class assigned by the informal aspectual network(s).

Figure 8.6: The semantic English aspectual network



For example, in the realm of aspectual classification, Carlson (p.c.) shows that, given that "move" is an activity, it is possible to derive that the complex event "move + move" (where "+" stands for concatenation) is still an event of the kind "move", but the same does not hold of "move_to_A+move_to_A", if "move_to_A" is an accomplishment (i.e., "move_to_A" is cast in terms of an activity plus a change of position: ¬be_in_A+move+be_in_A).

I thus suggest the following translation for the English semantic operators, commenting on some of the choices made:[29]

S_hab: **r ∅ s** (with some modal element)

S_serialization: **e ∅ e***

S_bound_addition: **a ∅ ¬aa¬a**

Bound addition must add a bound in the two extremes, otherwise *X did Y in 5 minutes* would be synonymous with *X finished doing Y in five minutes*.

S_prog_event: **e ∅ s: xsy ↔ p ↔ e**

S_prog_series: **e* ∅ s: s ↔ e***

Strictly speaking, one need not specify this separately here, since this is a special case of the former. However, since it corresponds to a different arc in the aspectual network, I put it here.

S_prog_state: **s ∅ ¬ss¬s**

S_result_adj(ADJ): **a ∅ ¬ADJ a ADJ**

S_perf_events: **e ∅ s: e ↔ xs**

S_perf_states: **s ∅ ¬ss¬s**

S_perf_series: **e* ∅ s: xs ↔ e***

The aspectual import of the perfect of events is construed so that it picks the result state. If an event has no result state, it must be coerced into having one by the present definition (**e ∅ es**), otherwise it has only a temporal import: the present perfect indicates that the event (a state or activity) is continuing up to the present, as will be described below.

In what concerns the passive, I suggest that it has a behaviour similar to the perfect, in that it only carries aspectual import when it has a stative result (its other function is not aspectual, it simply reverses arguments in an event). This has been described in Quirk et al. (1972, §12.17) as two kinds of passives in English, the one I am treating here is their "result passive":

S_passive: **e ∅ s: es**

Turning now to Portuguese, the aspect operators receive the following translation:

S_estar_a: **e ∅ s: asb ↔ e**

S_ir+ger_obras: **e ∅ s: e* ↔ s**

S_parar_de_séries: **e* ∅ e*¬e**

S_parar_de_obras: **ab ∅ ab¬(ab)**

S_continuar_a_séries: **e* ∅ p: e*pe***

S_continuar_a_obras: **e ∅ c: acd ↔ e**

S_passiva_estar_obras: **e ∅ s: abs ↔ e**

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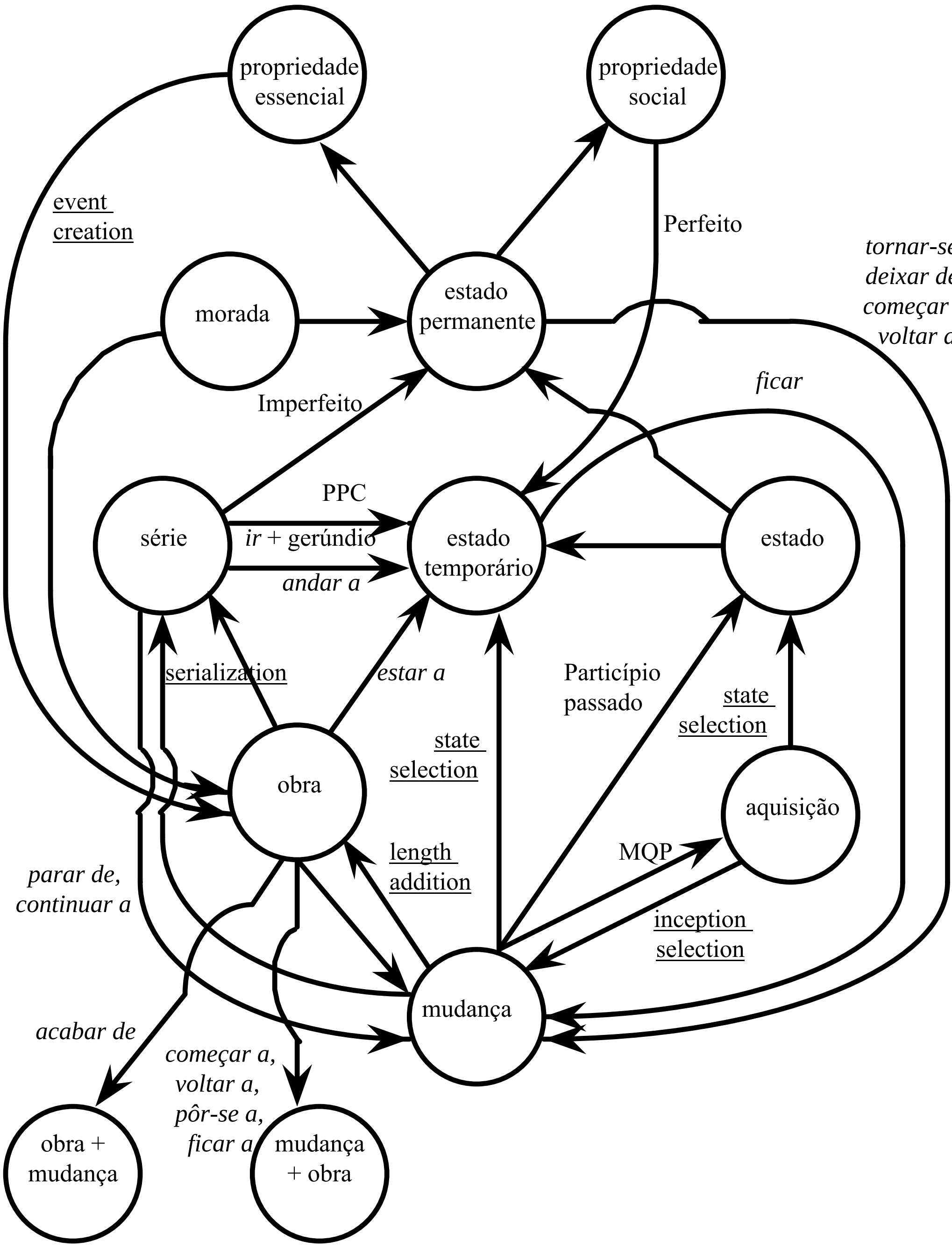
[29] Whenever the same linguistic operator translates into more than one semantic operator, I specify its input class in the name of the latter, e.g. "S_prog_event" is the semantic operator corresponding to the progressive applied to events.

S_serialization: **e ∅ e***
S_length_addition: **¬ss ∅ ¬sabs** and **b ℵ ¬a**
S_state_selection: **¬ss ∅ s**
S_event_creation: **s ∅ e** such that e instantiates the property s

Figure 8.7



8.3.2.3 Arcs (temporal operators)

Temporal operators will provide reference to specific events and allow one to assert specific propositions about it.

Their meaning may additionally include aspect changes, which in themselves may produce coercion -- in the cases when the input does not belong to the appropriate type.

Here are some of the most interesting temporal operators in the two languages:

S_simple_past: **e in t □ t < now**
S_simple_present: [s] **s at r □ r = now**
S_present_perf_events: [e] **(perfect(e)**[30] **in r Δ e in r) □ now in r**
S_present_perf_states: [s] **s in r □ now in r**
S_PPC_séries: [e*] **e* at t □ now in t**
S_PPC_estados: [s] **s at t □ now in t**
S_MQP_mudanças: [¬ss] **(¬ss at t □ t < r < now) Δ**
(¬ss at t □ s at u □ u ≤ r < now)

Note that the difference between the two interpretations of Mais que perfeito with Mudanças (corresponding to its output classification as an Aquisição) is that the second one involves an assertion about (the localization of) the state, while preserving the information conveyed by the first one, namely that a Mudança occurred in a time strictly preceding the reference time. In other words, the clauses **¬ss at t** and **t < r < now** are common to the two interpretations, while reference to s (**s at u**) is only in the more specific one.

S_MQP_obras: [e] **perf(e) at t □ t < r < now**
S_MQP_estados: [s] **s at t □ ¬s at r □ t < r < now**
S_Perfeito_acontec: [e] **perf(e) at t □ t < now**
S_Perfeito_estados: [s] **s at t □ ¬s at u □ t < u ≤ now**
S_Perfeito_prop_social [s] **es¬s at t □ t < now**
S_Imperfeito_estados: [s] **s at t □ t < now**
S_Imperfeito_acontec.: [e] **impf(e) at t □ t < now**
S_Imperfeito_séries: [e*] **hab(e*) at u □ t in u □ t < now**
S_já_acontec: [e] **e at w □ w < r □ t in r □ close (w,t)**
S_já_estados: [s] **s:¬ss at w □ s at r □ t in r □ close (w,t)**

Note that I analyse *já* here as a sort of non-deictic tense, which introduces another time *w*, which for events must be supplied by the context, as well as a reference time *r*. In addition, it signals some sort of closeness between the two times involved, but expressing the meaning of **close** is clearly beyond the expressiveness of a regular language over events. (Note that close does not appear in Carlson's formulation.)

8.3.3 The translation network

The time is now ripe to explain the translational arcs and to discuss their import in terms of the characterization of information preservation presented in Section 3.5 above.

In fact, the way the translational arcs can be made sense of, in this setting, is to consider

[30] **perfect(e)** abbreviates the definition given above for S_perf_events, namely **e ∅ s: e ↔ xs**.

them as indicating the pairs of aspect (sequences) where shared entailments are maximal.

The model thus allows for an explanation why there are some translational arcs and not others, as well as provides a more fine-grained rendering of the information differences involved in each case, but it cannot predict the existence (or absence) of particular translational arcs -- and, in this sense, does not provide a computational description of the informal translation network.

This is, however, as it should be, since translational arcs cannot be predicted (solely) on logical grounds: in addition to information preservation concerns, their existence obeys requirements of translation practice and target language naturalness.

The way the translation network is modelled in the present section is, therefore, by first describing the translational arcs in terms of differences in information conveyed, in Sections 8.3.3.1-2. And then, since one of the clear advantages of the present model is its integration of aspect and temporal reference, several cases of interplay of the two domains will be analysed in Section 8.3.3.3.

But let me first introduce the method of contrast employed, suggested by Carlson's (1996) comparison of the information conveyed by the English and Finnish present perfects, displayed here for convenience:

S_English_pres_perfect: **e in x □ x ≤ now □ x in r □ now in r**
S_Finnish_pres_perfect: **e in x □ x ≤ now □ x in r**

Carlson notes that the (slight) difference between these two (analytic) tenses is that the semantic operation associated with the Finnish present perfect does not contain the clause **now in r**. This fits in nicely with the fact that the Finnish perfect allows, in contradistinction to the English one, co-occurrence of adverbials referring to totally past periods.

Despite the little relevance of this specific pair for the present dissertation, its comparison is brought to the fore here because it explicitly handles (a form of) contrastive vagueness (in terms of temporal reference). In other words, it shows that, in the present framework, contrastive vagueness can be modelled by the absence of particular pieces of information (clauses) in an otherwise shared definition.

Comparing now the English present perfect with the Portuguese Perfeito, repeated here for ease of reference, deeper differences appear:

S_English_pres_perfect: **e in x □ x ≤ now □ x in r □ now in r**
S_Portuguese_Perfeito: **perf(e) □ e at t □ t < now**

First, the definition of Perfeito introduces the requirement of perfective aspect. This means that Perfeito is not aspectually neutral: an event is perceived in its entirety.[31] And then, there are

[31] This does not mean that an event has to attain its intrinsic, internal, conclusion. It only expresses that the event must not go on, i.e., Perfeito selects maximal stretches of events. This can clearly be observed in connection with the unmarked sentences *Ela leu 50 páginas do relatório* ('She read fifty pages of the report') and *Ele correu um bocado*

two differences at the temporal level: there is no reference time involved (the contextually bound **r**), and, instead of "≤" (precedes), the relevant temporal inequation involving **now** is "<" (strictly precedes).

Actually, I believe this pair is a more realistic example of the kind of differences involved in two translationally related devices in general, because substitution of one device for the other brings about <u>both</u> loss and addition of information.

Such a situation is, in my view, what should be expected of a formulation of the translational arcs: most translational arcs will both add and lose some information. In fact, I have argued in Chapter 3, and illustrated in Chapter 7, that there are not many cases of (strict) information preservation in the pair English-Portuguese. Such a rendering of the "meaning" of translational arcs also explains why, in particular translations, there are often several reasonable choices.

I turn thus to a presentation of the translational arcs in these terms, followed by the treatment of some complex cases of interaction between aspect and temporal reference which were surveyed in Section 7.4. There, I have acknowledged this interaction as one area where the translation network needed to be supplemented. In fact, by integrating the information of both domains, this framework will be able to provide a precise description of cases which so far in the present text have only been described in words.

8.3.3.1 The English to Portuguese translation network

I begin by the English to Portuguese translation network. In what follows, I display the translation of the English aspectual class to the left, then "□" standing for translational arc, and the translation of the Portuguese aspectual class to the right, followed by the corresponding name inside parentheses. In the discussion, I will point to the places in Chapter 7 where particular examples of the kind at stake have been presented.

A caveat is in order here. Strictly speaking, names of event types should not be considered co-referential, e.g., an "s" to the left and an "s" to the right of the translation sign do not necessarily denote the same events (just named differently by the two languages). In fact, it should be emphasized that lexical matters are not being taken into account here. Lexical gaps may actually provide translations not appearing in the translation network (i.e., they may give rise to fairly unsystematic particular translations).

I start with the achievement case, which is probably the least interesting because it correspond to a good overlap between the descriptions in the two languages. Still, this is shown not to be the whole story, and further translation possibilities will be discussed as well.

Achievement:

¬ss	□	¬ss	(Mudança)
		¬ssab such that b ℵ ¬a	(Mudança+Obra)

('He ran a little'). These sentences indicate clearly that the reading is over, and that the running is over, not that these actions are completed, whatever that might mean.

Here, it seems that there is even an equivalent rendering of English achievements by Portuguese Mudanças (provided the "s"'s are comparable across languages).

In cases where the achievement corresponds to an inception (being the beginning of a larger event, typically an activity), however, there is another fairly good translation available in terms of information preservation: Mudança + Obra, which is, however, rarely used in practice (cf. Section 7.1.3).

Rather, an Obra in a bounded form is preferred, producing the following translationally related descriptions -- for which the combination of temporal and aspectual information is, incidentally, essential --, corresponding to the paths ACTIVITY punctual adverbial ACHIEVEMENT simple past ACHIEVEMENT and OBRA Perfeito OBRA COMPLETA:

¬aa at t □ t < now (English)
perf(ab) at t □ t < now / ¬(ab)(ab)¬(ab) at t □ t < now (Portuguese)

The situations depicted by the two languages both express inception, but Portuguese adds termination (a terminal point), and, instead of reference to a punctual time, as in English, describes an extended time (the temporal location of the Obra). On the other hand, **b** may well be taken as equal to **a***, since its only restriction is that it must be different to **¬a**, so there is not necessarily a difference here.

Accomplishment:

¬sps □	ab such that b ℵ ¬a	(Obra)
	¬ss	(Mudança)
	s	(Estado)
	ab¬ss such that b ℵ ¬a	(Obra+Mudança)

An accomplishment is a standard case of compactness in English. Translating into Portuguese, it can be rendered by an (inherently bounded) Obra, by a Mudança if the change is mainly at stake, or even by the result state. This latter case originates in fairly restricted situations, though (cf. Section 7.2.2.1). The most preserving translation is actually the one by Obra+ Mudança, which is, however, still more restricted in lexical terms (cf. Section 7.2.1.3).

Gradual accomplishment:

(a = a*) ≈ c* □	ab such that b ℵ ¬a	(Obra)
	e*	(Série)

I have noted above that gradual accomplishments are similar to Obras, because both imply temporal duration (both have several parts), and none presupposes absence of change. If a sequence of several events is relevant, a Série may be employed (cf. Section 7.2.2.1); however, it is generally not common to translate one event by a sequence of other events.

Activity:

a = a* □	ab such that b ℵ ¬a	(Obra)

Finally, activity has only one translational arc in the English to Portuguese translation network, which could indicate a fairly good match. However, in my view, this corresponds, rather, to a defficient coverage of such a concept in Portuguese. In the arc from activity to Obra, there is mainly a loss, because homogeneity is no longer conveyed; temporal duration is nevertheless preserved.

8.3.3.2 The Portuguese to English translation network

Turning now to the Portuguese to English translation network, and using the same format and approach employed in the English to Portuguese case, let me provide a rendering of some translational arcs as well:

Mudança:

¬ss	□	¬sps	(accomplishment)
		¬ss	(achievement)
		p ≈ ¬ss	(gradual accomplish.)
		p	(activity)

The order of presentation of the above alternatives is meant to reflect actual translation practice. In fact, it is common that the English translation adds manner, which is not conveyed in Portuguese. This is especially conspicuous in cases of translation of change of location by movement (resulting in a gradual accomplishment or even in a simple activity); cf. Sections 7.2.1.2-3. But there is also, as foreseeable, an information preserving translation, namely of Mudanças into achievements. I suggest, actually, that the choice between accomplishment and achievement is lexically conditioned to a large extent.

Obra:

ab such that b ℵ ¬a □	p ↔ ¬ss	(accomplishment)
	p	(activity)

By contrast, when one translates a Portuguese Obra, a change may be added, but the information that it takes time is only implicitly conveyed.

A more interesting case is the translation of an Obra completa by an acquisition (cf. Section 7.1.7.2), which, as insisted on in Sections 7.3 and 8.2, is only relevant in connection with the paths OBRA <u>Mais que Perfeito</u> OBRA COMPLETA and ACHIEVEMENT <u>perfect</u> ACQUISITION <u>simple past</u> ACQUISITION, and which entails that the Obra does not correspond to the achievement. (I.e., even if the Obra has a clear result, the achievement in the English translation does not correspond to its bringing about. Instead, it denotes the inception of the Obra.)

This can be cast as follows:

¬(ab)(ab)¬(ab) at t □ t < r < now	(Portuguese)
(¬ss at t □ t < r < now) Δ (¬ss at t □ s at r □ t < r < now)	(English)

Note that no end of (whatever corresponds to) the Obra is actually conveyed in English, but rather its beginning and/or continuation. (Note that, for all purposes, "s" could be replaced by "a", i.e., English acquisitions, as described in Section 7.1.2, do not necessarily distinguish between states or activities, and thus "s" and "ab" may correspond to the "same" activity, as was the case in several of the examples in Section 7.1.7.1.)

Finally, there remain several translational arcs involving stative expressions, but the present framework does not seem suited to explain them. Its power, on the other hand, can be appreciated by discussing further cases of temporal reference contrast, to which I turn now.

8.3.3.3 Examples of translation detailed

I deal with a bunch of examples here, mainly in order to sketch a more encompassing treatment of temporal matters in connection with aspect, and not for their own sake.

I proceed as follows: For each member of the translation pair, I describe, first, the paths in the aspectual networks and then, produce the corresponding set of formulas in the present model. Finally, I explain the differences in meaning between the formulations in the two languages that become apparent in such a decomposition.

1. In the first case, introduced in Section 7.2.3.2, the event and the result conveyed by the English pluperfect of an achievement are rendered by the Perfeito of a Mudança:

> *"Do you think they would take you back alive to say they* ***had stolen*** *it?"*
> *--Pensas que te levarão vivo para dizerem que ta* ***roubaram****?*
> 'Do you think that they will take you alive for them to say that they stole it from you?'[32]

The corresponding paths and relevant equations ("s" standing for "pearl in possession of the thieves") are:

ACHIEVEMENT (steal) <u>perfect</u> ACQUISITION <u>simple past</u> ACQUISITION

s at r □ r < now OR
steal (e) & e at t □ t < r < now

MUDANÇA (roubar) <u>Perfeito</u> MUDANÇA

¬ss at t □ t < now

The Mudança *roubar* ('steal') expresses equally well the result ("you don't have the pearl") and the change ("they stole it"), whereas one of the contributions of the English pluperfect is precisely to focus on the result state.

A subtle difference between the formulations in the two languages is that the English sentence presupposes that **r** is the time of "saying" (i.e., "pearl in possession of thieves is true at the time when "you" say..."), while the Portuguese sentence merely identifies an (indefinite) time **t** in which the theft took place, i.e., in which "pearl in possession of the thieves" began to be

[32] Note that in this example the subject of say has been mistranslated into Portuguese; in any case the temporal and aspectual properties of the correct rendering would be the same; cf. *Pensas que te levarão vivo para <u>dizeres</u> que ta roubaram?*

true).

This also explains why a Mais que perfeito formulation would sound weird here:

¬ss at t □ t < r < now OR

¬ss at t □ s at u □ u ≤ r < now

The explanation is that one of its interpretations does not rule out the possibility (in fact, I even think it suggests it) that the "you" had the pearl back again after the theft (i.e., **s** is no longer true at **r**, or at **now**).

2. Consider now the following often cited example (cf. Section 3.5):

He was trapped as his people ***were*** *always trapped*
Estava peado, como todos os da sua raça sempre ***tinham estado***
'He was trapped as his people had always been'

Disregarding *always* and *sempre* for the moment, this example can be modelled as involving the following paths:

ACCOMPLISHMENT (trap) <u>passive</u> ACQUISITION <u>simple past</u> ACQUISITION T> STATE

OBRA (pear) <u>Passiva com estar</u> ESTADO TEMPORÁRIO <u>Mais que perfeito</u> ESTADO TEMPORÁRIO

These paths can in turn be analysed as conveying the following pieces of information, respectively:

trap (e) □ (s at t Δ e at t) □ t < now

pear (abs) □ s at t □ ¬s at r □ t < r < now

Now, in addition to the difference between Obra (**abs**) and accomplishment (**¬sps**), one notes that the time at which the state **s** holds in English is not required to have finished by now, in contradistinction to the Portuguese rendering.

It is thus interesting to follow the other possibility for translation into Portuguese (using Imperfeito, cf. *Estava peado como todos os da sua raça estavam sempre*) and see the consequences:

OBRA (pear) <u>passiva com estar</u> ESTADO TEMPORÁRIO <u>Imperfeito</u> ESTADO TEMPORÁRIO

pear (abs) □ s in t □ t < now

Now it is no longer required that the result state is over, which might at first blush suggest that this would be a better translation. However, the quantification information must still be dealt with. Its import, in English, preserves the vagueness, since *always* can be taken to denote quantification over events or over times, conveying respectively that, in all relevant events, "they" were trapped (for every **e**), and that the state of being trapped occurred in all past (whatever **t < now**).

By contrast, the Portuguese sentence with Imperfeito cannot be taken to mean "for all time", because it already refers to a particular (although imprecise) **t**. At most, it can be interpreted as for every **s in t**, i.e., quantification over (possible) situations where Imperfeito would be acceptable.

This seems to be the reason for the translator's choice, since the formulation with the Mais que perfeito above takes quantification over (strict) past times.

3. Consider now the following instance of Perfeito rendered in English by the pluperfect:

Eu, que ***levei*** *anos a curar-me dos sustos [...] fiquei estarrecido.*
I, who ***had spent*** *years recovering from the fears [...] I was appalled.*
'It has taken years for me to recover from the frights [...] I got appalled'

The transitions involved, and the corresponding formulas, are:

OBRA (levar) <u>Perfeito</u> OBRA COMPLETA

ACTIVITY (spend) <u>duration argument</u> ACCOMPLISHMENT <u>perfect</u> ACQUISITION <u>simple past</u> ACQUISITION

levar (e) □ ¬ee¬e at t □ t < now
spend (a) □ a at t □ t = years □ t < r < now OR
spend-lim[33] **(e) □ s at r □ r < now** (s=perfect(e))

So, the Portuguese text conveys clearly a bounded period wholly in the past, at some time in the past, i.e., indefinitely located. To convey that the period has ended, the English past perfect seems to be required. The English sentence is vague between the statement of a stretch of activity in a period preceding the reference time (which can then be pragmatically identified as the point where the period ended) and the statement of a delimited event whose result is relevant from then on. This latter alternative is, incidentally, a good interpretation of the reason why the Portuguese sentence would have been uttered in the first place, but it should be equally clear that the Portuguese sentence does not mention any result or state.

Further justification for the use of the pluperfect can be adduced by comparing its common alternatives. Starting by the present perfect:

spend-lim (e) □ (s in r Δ e in r) □ now in r

Such a translation would strongly imply an extended now, instead of a situation totally in the past. It would thus be compatible with a state of affairs where **e** had not yet stopped, i.e. the "I" would still be spending those years at **now** (as in *I have lived here for two years*).

Likewise, the simple past rendering would result in:

spend (a) □ a in t □ t < now

This would fail to convey the perfectivity, and could thus, again, be taken to denote that the spending activity could extend until the present (since *he spent* does not preclude *he is still spending*).

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33 **Spend-lim** denotes a kind of event which was due to the coercion into accomplishment caused by the application of the perfect. So, **e** corresponds to the bounded event which ends after the time period identified by "years".

4. Let me also cast the common translation of Imperfeito by the English perfect (discussed in Section 7.2.5) also in these terms:

> *Ele, que* ***via*** *almas de brâmanes passarem a cães,*
> *He, who* ***had seen*** *Brahmins' souls become dogs'*
> 'He, who (often) saw Brahmins' souls go to dogs'

There are actually two possible paths for the target sentence of this translation pair:

OBRA (ver) @> SÉRIE <u>Imperfeito</u> ESTADO PERMANENTE

ACQUISITION (see) @> ACHIEVEMENT <u>plural argument</u> SERIES <u>perfect</u> STATE <u>past</u> STATE

ACQUISITION (see) <u>perfect</u> ACQUISITION <u>past</u> ACQUISITION

The formal translation of the English member of the pair is, moreover, manifold, because of the acquisitional import:

ver (e) □ hab(e*) at r □ t in r □ t < now

see (e) □ e* at t □ s at r □ r < now (s = perfect (e*))

see (e) □ e at t □ t < r < now OR

see (s) □ s at t □ ¬s at r □ t < r < now OR

see (e) □ s at r □ r < now (s = perfect(e))

Note that, in addition to the absence of a property-like connotation in the case of the English sentence (due to **hab** in the Portuguese sentence), the "presentness in the past", which is available, and conspicuous, in the Portuguese text -- modelled by having **t** co-temporal with the series of "seeing" events -- is lost in the English interpretation.

In fact, analysing in detail the four possible translations, one sees that the first forces the series to be over, the second involves one single (and past in the past) event, the third specifically indicates that the state **s** of seeing is no longer true, and the fourth and most natural reading refers to a single event of seeing which is still present (i.e., the state of seeing is still in force) but no mention is made of temporal duration or plurality in time, i.e., "he" could still be seeing the <u>single</u> event of a plural number of souls together changing into dogs.

This explains my claim that the simultaneous conveyance of habituality and present property, typical of the Portuguese Imperfeito, is impossible to render in English, even though the very last case observed does not preclude the interpretation that a series of events (as opposed to one collective event) would be the case.

5. Finally, I turn to a case involving the PPC, discussed in Section 7.2.4:

> *E eu disse [...] que* ***tens trabalhado*** *muito e até* ***tens estudado*** *com o Padre Manuel para que as palavras santas fiquem todas certas e nos seus lugares.*
> *And I said [...] that you'****ve worked*** *much and* ***have*** *even* ***studied*** *much with Padre Manuel so that the holy words would come out right and in their proper places.*
> 'And I said [...] that you've been working much and have even been studying with Padre Manuel so that the holy words would all come out right and in their right places.'

Selecting the first clause, for simplicity's sake, one would have:

OBRA (trabalhar) @> SÉRIE PPC ESTADO TEMPORÁRIO

ACTIVITY (work) @> ACCOMPLISHMENT much SERIES perfect STATE

ACTIVITY (work) much ACCOMPLISHMENTS perfect ACQUISITION

trabalhar (e) □ e* in r □ now in r

work (a) □ s at r □ now in r (s = perfect (a*))

work-much (e) □ (s in r Δ e in r) □ now in r (s = perfect(e))

One can see that, while the series of workings conveyed in Portuguese includes the present, none of the two English interpretations manages to describe exactly that state of affairs. In fact, the first alternative, although referring to a series, explicitly denies the possibility that it extends up to the present, i.e., the series must be completed. The second alternative, in turn, although compatible (in the event reading) with an interpretation up to now, involves a single activity, i.e. a single stretch of working (much).

It is, in fact, very interesting that the second clause adds a *much* to the information conveyed in the source language, as if to allow for the transition which would otherwise not be felicitous.

And this concludes the illustration of the power of this model, as well as hopefully provides more insight into some of the contrastive cases least thoroughly explained in Chapter 7, because of the lack of a corresponding model of temporal reference.

8.3.4 Discussion

This framework allowed me to systematize and explain further many of the contrastive findings presented in this dissertation. In particular, it provided a way to express adequately vagueness and compactness involving temporal reference, something for which the translation network had to be supplemented anyway: in Chapter 7, the relevant contrasts had only been discussed informally.

The main drawback of the present formalization is its defficient coverage of the state realm: except for result states, stative expressions were not adequately described. (This, in fact, is something that the present model shares with all event-based formalisms, Moens's original system included, as was pointed out by Herweg; cf. Chapter 4.)

Although the only differences handled were, consequently, related to events, this might be a plausible state of affairs anyway. In other words, since English itself is such an event-centered language, such a restriction to events might already be inherent in the language pair. The complexity of stative descriptions in Portuguese, no matter how conveniently described in a different model, would always result in loss when translated into the English coarse-grained stative description. By contrast, the event realm, albeit different, seems to be comparable in complexity in the two languages, and thus its comparison would be more revealing.

8.4 Concluding remarks

The main concern of the present dissertation is, obviously, neither formalization nor implementation. Therefore, the remarks on both matters were admittedly sketchy.

In particular, Section 8.1 simply aimed at describing an ideal translation browser, for which power the models put forward in the present dissertation would mainly be responsible, but without rehearsing an actual implementation.

And Section 8.2 is not to be read as concerning automata theory or algebraic specification. As a language engineer, I only resorted to basic concepts in both disciplines in order to debate some issues that would be relevant for any formalization of my proposals and to make more clear the informal specification intended.

As far as Section 8.3 is concerned, it is just fair to say that I only used Carlson's model and did not provide any contribution as far as formal matters are concerned.

One might thus ask the following question: What has been gained by viewing the networks at the light of the three frameworks discussed here?

An undeniable advantage was to make more precise (to myself and to others) what I had in mind. The relevance of such an achievement cannot be enough emphasized: It suffices to observe that Moens's model -- in particular, his notion of coercion -- has been interpreted in radically different ways by subsequent work (contrast e.g. Lascarides (1988), Glasbey (1990) and Kent (1993)).

Making the models more precise also uncovered some of their limitations, as well as brought to the light several hidden assumptions (and/or external restrictions). Examples of these, in the case of the aspectual network, are the presupposition of uniqueness (per path) of some grammatical devices, and the prohibition of a sequence of unlabelled arcs in a row, which, although stated in words in Chapter 5, was not encoded. It also uncovered a hidden similarity between parameterized transitions and syntactic embedding, both conceivable of as binary operations.

Especially in the case of the translation network, the requirement for precision made it apparent that several different things had been involved in my informal design, each of which has received a different -- and I would say complementary -- treatment in the present chapter.

In fact, the translation network was first seen as a translation matcher, i.e., a device for describing real translation pairs, and a formal rendering of such a computational object was provided as a finite-state transducer (whose practical application is obvious).

Then, it was seen as describing the properties of the translation between the systems of two languages, and interesting insights on the mathematical properties of such a relation were brought to the fore.

Finally, an explanation in logical terms of why some translations and not others would systematically occur was investigated, and actually conceived of as additional information carried by a translation network.

Even though I was not able to provide one integrated formal framework to state the three perspectives, I believe that this fact is due to my lack of expertise in formal matters and does not indicate any inherent defect of the (informal) specification. I thus hope that subsequent work on these subjects will succeed in provide a more unified formal treatment of the (informal) objects proposed here.

3. Let me now turn to

Perhaps he alone did this and perhaps all of his people ***did*** *it.*
Talvez ninguém mais fizesse aquilo e talvez todos os seus o ***tivessem feito****.*
'Maybe nobody else did that and maybe all of his had done it'

The corresponding formulation in the translation network would be, noting that the English source is (linguistically) ambiguous between two interpretations (pragmatically, the first is easily seen to be the correct one in the context):

ACTIVITY (do) @> ACCOMPLISHMENT plural argument SERIES @> PERMANENT STATE simple past PERMANENT STATE

ACTIVITY (do) @> ACCOMPLISHMENT simple past ACCOMPLISHMENT

OBRA (fazer) @> SÉRIE ter + Particípio passado SÉRIE COMPLETA Imperfeito do conj. ESTADO

Choosing the first interpretation in English, the formulas involved will be:

do (p) & p* & s associated to p* & s at t & t < now
fazer (e) & e = ab & e* at t2 & t2 < r & r < now

It is possible that the English series continues (and thus the property "s" may be true at present), whereas the completion of its Portuguese counterpart is explicitly conveyed by the Portuguese translation.