The need for MT-oriented versions of Case and Valency in MT

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ABSTRACT

This paper looks at the use in machine Translation systems of the linguistic models of Case and Valency. It is argued that neither of these models was originally developed with this use in mind, and both must be adapted somewhat to meet this purpose. In particular, the traditional Valency distinction of complements and adjuncts leads to conflicts when valency frames in different languages are compared: a finer but more flexible distinction is required. Also, these concepts must be extended beyond the verb, to include the noun and adjective as valency bearers. As far as Case is concerned, too narrow an approach has traditionally been taken: work in this field has been too conerned only with cases for arguments in verb frames; case label systems for non-valency bound elements and also for elements in nominal groups must be elaborated. The paper suggests an integrated approach specifically oriented towards the particular problems found in MT.

1. Introduction

Most (though not all) MT systems claim to incorporate versions of Valency grammar, and more recently have also looked to Case grammar. However, whatever theory they use is often imported more or less directly, without taking account of the fact that a model developed for one purpose may not be entirely appropriate for another. This is a less serious problem for Valency, though this was originally designed with a monolingual didactic purpose in mind (see Helbig & Schenkel, 1973:5) rather than the multilingual needs of translation. With Case however, it is often the much-maligned and quickly superceded Fillmore (1968) model which is adopted, or at best a 'consensus' model like that of Fillmore (1971) or Chafe (1970), loosely extended. What is not taken into account is the fact that these models typically concentrate on 'nuclear' arguments in verb-phrases, saying little about 'peripheral' roles, or about the structure of nominal or even adjectival groups. This paper will show need for a more task-specific model, combining Valency and Case into an integrated theory for the purposes of translation.

More specifically, we will show (a) the need for a more flexible Valency system with six degrees of valency-binding instead of the usual two; (b) the need for a finely tuned version of Case to fit the new version of Valency proposed: in particular what depth of abstraction is appropriate; and (c) the need for this combined Case and Valency model to extend beyond verbs, especially to nominal groups.

2. Valency in existing MT systems

The essential notion borrowed from Valency theory found in MT is the distinction between 'complements' and 'adjuncts'. In several MT systems we find that the lexicon contains information equivalent to that given in a valency dictionary like that of Helbig & Schenkel (1973) listing the complements predicted by the verb together with associated syntactic and semantic features. This lexical information is used in a straightforward manner to assist in the computation of structured representations for the source text, with the complements and adjuncts labelled appropriately. In this way for example, the functions of the prepositions in sentences like (1a) and (2a) can be differentiated, and the correct translations (1b-2b) arrived at.

(1a) Er wartet auf seinem Freund.
(1b) He is waiting for his friend.

(2a) Er wartet auf dem Bahnhof.
(2b) He is waiting at the station.

The identification of complements is useful in the bilingual transfer stage (or equivalent) of the MT system, and it is appropriate at this point to provide a set of example translation pairs (3)-(5) that illustrate an important problem that Valency can help with.

(3a) He likes the girl.
(3b) La fille lui plaît.

(4a) The farmer supplied the grocer with milk.
(4b) Le fermier fournit du lait à l'épicier.

(5a) Charles entered the restaurant.
(5b) Charles entra dans le restaurant.

Each of the sentence-pairs in (3)-(5) illustrates a change in complement structure between English and French. The example with *like* and *plaire* is something of a classic, involving a double argument change; but examples like (4) and (5), which, while less extreme, are nevertheless typical, suggest that the phenomenon is widespread.

The Valency approach to this problem recognises each of the three verb pairs in (3)-(5) as having the same valency, but as having different valency patterns, which must be mapped onto each other.

In the case of Rothkegel (1976), this mapping is achieved by simply juxtaposing the two entries, with equivalent arguments next to each other, roughly as in Figure 1.

supply Ns (animate) No (animate) Np (with,physobj)
fournir Ns (animate) Ni (animate) No (physobj)

Figure 1. Valency patterns in Rothkegel (1976)

Alternatively, in GETA's ARIANE-78 (Vauquois, 1978) and TAUM-Aviation (Lehrberger, 1981), the complements are assigned distinctive labels: in both systems the label ARG(ument) is used with a distinctive affixed numeral, roughly as in (6).

(6a) The farmer supplied the grocer with milk.
      ARG1   PRED   ARG2   ARG3

(6b) Le fermier fournit du lait à l'épicier.
         ARG1   PRED   ARG2   ARG3
     or ARG1   PRED   ARG3   ARG2

Notice here the two possible uses of these numbered
ARG labels: either they are assigned more or less
arbitrarily, and an ARG-for-ARG mapping defined for
the particular verb pair; or the ARG labels
correspond to some aspect of the analysis (typically
deep syntactic function). In this latter approach,
there are several advantages. First, it is possible
to assign ARG numbering in a non-arbitrary manner:
the ARG labels therefore take on some significance
which can in fact be used for other tasks too.
Second, one may assume a default mapping of like-
numbered ARGs onto each other, and this indeed works
partially or completely for a number of verbs.
However, there remains the disadvantage when it does
not, where one can expand the traditional two-value
shall return to this question in the next section,
because the introduction of Case notions gives us a
third possibility, with non-arbitrary labels but
without special mapping algorithms either.

Let us consider now how the distinction of
complements and adjuncts is used in MT. Again we can
look to ARIANE-78 and TAUM-Aviation for
exemplification, for crucial in these systems is the
ARG-CIRC(umstantial) distinction. Nominals that
cannot be matched against the valency pattern of the
verb are marked as CIRC, and this distinction gives
rise to different transfer strategies. The key area
here is the translation of prepositional phrases: the
theory is that the preposition in a valency-bound
element (ARG) is semantically void, and governed by
the verb. Prepositions in adjuncts (CIRC) (e.g.
under the table vs. on the table) on the other hand
are meaningful, and so participate in the translation
process.

This neat correspondence between ARG and formal
preposition versus CIRC and functional preposition is
very convenient, though unfortunately it does not
fully match the facts. On the one hand, we have
valency-bound directional elements with verbs of
movement, where the preposition is meaningful (go
to/in/on etc.). Interestingly, ARIANE-78 treats
these as 'valency bound circumstantials', perhaps
after the fashion of Tesnière (1959:128) and this
makes sentence pairs like (5) problematic, since in
English the restaurant is ARG, but in French dans
le restaurant CIRC. On the other hand we do not
always have isomorphy between a given circumstantial
relationship and the preposition that expresses it:
for example, 'location at' is expressed by any of on,
at, in, in English (7a), depending on the nature of
the location, while in French the dependence is given
by quite different factors (7b):

(7a)   in -- cities, countries, enclosed spaces
       on -- islands, mountains, streets
       at -- buildings

(7b)   à Paris / en Avignon   (phonetic)
       en France / au Japon   (gender)
       en Corse / sur l'Île d'Elbe (political status)

3. The need for six degrees of valency-binding

In Somers (1984) I discuss at length the question of
whether the complement-adjunct distinction is simply
binary, or should be replaced by a scale covering a

greater range of values. The conclusion drawn there
is that one can expand the traditional two-value
system to a six-value scale of valency-binding, with
three different types of complement, and so-called
'middles' and 'extra-peripherals' in addition to
adjunct which is kept (see Figure 2).

```
         integral complement
                 |
        obligatory complement
                 |
         optional complement
                 |
              middle
                 |
              adjunct
                 |
          extra-peripheral
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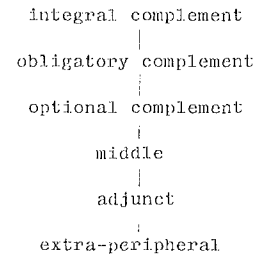
Figure 2. Hierarchy of valency binding

(i) Integral complements are complements which are so
much part of the predicate that they cannot be
omitted under any circumstances at all, nor can they
enter substitution paradigms (e.g. pronominalisation,
replacement by a relative clause). They are
lexically determined by the verb, whereas other types
of complement can be characterized by more general
semantic and morpho-syntactic restrictions. Examples
are the nominals in pave the way, take a risk, keep
pace, etc. The idea is after Weissgerber (1983).

(ii) Obligatory complements are those complements
which are 'obligatory' in the traditional (Valency)
sense, i.e. in active declarative sentences. Notice
that it is not only discourse phenomena like
'ellipsis' (Heringer, 1968:427) that can lead to
these complements being omitted: in non-finite verb-
phrases, and in nominalisations, such omissions are
unremarkable. Obligatory complements need to be
distinguished however since, when omitted from
surface structure, they must often be 'recovered' in
deeper representations, e.g. for the purposes of
control (Bresnan, 1982).

(iii) Optional complements are those elements which
are predicted (or subcategorized) by the verb, but
which are not obligatory as in (ii): these correspond
closely to the traditional Valency 'complement'.

(iv) The middles value is needed for elements that
are not valency-bound as in (i)-(iii), but yet are
still loosely predicted by the verb-type, and are
less peripheral than adjuncts (see (v)). By way of
example consider (8), where Bill and window are
clearly complements, but where with a stone seems to
be more closely bound to the verb than yesterday,
without actually attaining complement status.

(8) Bill smashed the window with a stone yesterday.

(v) Adjuncts are the remaining traditional
circumstantial elements, often expressing time,
location, manner, cause, consequence and so on;
contrary to the traditional view however, these are
not "insertable to or eliminable from any sentence
almost at will" (e.g. Helbig, 1971:36). Adjuncts are
subject to rather vaguer semantic restrictions
deriving from the central predication (verb +
complements) as a whole.

(vi) Extra-peripherals are on the other hand more or

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less free in this sense. These are sentence modifiers, such as <u>as mentioned above</u>, <u>indeed</u>, <u>in contrast to this</u> and so on.

Notice that the scope of each type of element is the predicate plus those elements above it on the scale. Thus, middles pertain to the predicate plus complements; adjuncts modify this extended predication; extra-peripherals range over the entire sentence.

4. How the extended system helps in MT

Let us now consider the effect of this concept on mapping of arguments in transfer in MT. We assume that the general transfer algorithm has the possibility of correctly matching complements in corresponding valency patterns (whether by arbiitrary numbering, on a verb-by-verb basis, or using Case). We also assume that adjuncts and extra-peripherals can be dealt with satisfactorily. We must now consider what to do when, on a bilingual basis, there is some mismatch between the valency bindings of corresponding elements. Notice that this is a major problem in the old two-valued system.

The most likely realisation of this problem seems to be as follows: assume that in a source language analysis of (8), <u>with a stone</u> has been assigned our 'middle' label, whereas in the target language either (i) the equivalent argument is considered to be valency-bound for the predicate; or (ii) the equivalent argument would be regarded as wholly circumstantial. In the case of (i) we can treat the element as if it had been a complement all along: the valency pattern for the target verb will tell us what to do with it. Likewise in the case of (ii) we can treat it as if we always knew it was an adjunct: depending on the nature of the algorithm for treating adjuncts, we may be required to compute some more information about it (its case role for example), but this is no problem.

It is easy to see that a generalisation of this solution is one in which each degree of valency-binding in Figure 2 is allowed to map onto either itself, or its nearest neighbour in either direction. Thus, integral complements and ordinary complements should be compatible, as should adjuncts and extra-peripherals. This blurring of the distinctiions up and down the hierarchy accords well with intuitions, which suggest that because the syntactic (and semantic) behaviour of elements at neighbouring points on the hierarchy have aspects in common, partial compatibility should be achievable. If we add, at the very top of the hierarchy, a notional empty or 'zero' binding, we are even able to account for those cases where a verb plus integral complement in one language is expressed as a simple lexical verb in another, as for example with the English and French pairs in (9):

(9) take part   participer
     make a mistake   se tromper
     catch cold   s'enrhûmer

     welcome   faire accueil
     reverse   marcher en arrière
     stroke   donner une caresse

Problems would arise if analyses of two languages were so different that a complement in one was regarded as an adjunct in another (though note that in the current two-value system, this is common), or an integral mapped onto a middle, and so on. Nothing much could be done in such a case, and it can only be said that the single condition upon which this system depends is that that situation simply does not arise.

However, there is a second problem arising from the question of non-matching valency patterns, and indeed, this is a problem for which Case seems to offer a solution. The problem is this: in language A, verb V is considered to have two valency-bound arguments, but in language B, the corresponding verb takes three complements. When we come to transfer between A and B, how do we know which two of the three complements specified for V in language B map onto the two specified for V in language A?

5. Case in MT

Compared to the number of systems using Valency, there are relatively few systems that use Case in MT, even though there are a number of problems, as we have seen, with the bare Valency approach. Yet Case obviously has attractions for MT, especially due to its character as a bridge between syntax and semantics. There is some dispute as to what amount of 'semantics' is needed for successful translation, or indeed whether Case can properly be described as being part of this domain.

Nevertheless, we have seen in the previous sections at least two problems which, we suggested, could be solved using Case. The first was the <u>like</u>/<u>plaire</u> example, where we had to have a special mapping algorithm, whether between arbitrary ARG labels, or between numbered ARG labels interpreted in terms of syntactic function. The point about case labels in this example is that they will provide a non-arbitrary transfer medium which is intuitive in both languages. If we extend the system to make it multilingual, the case for Case is even stronger, since it provides a single language-pair independent mapping in contrast to the necessary $\underline{n}(\underline{n}-1)$ (for $\underline{n}$ languges) bilingual mappings, which might, remember, need to be replicated for almost every verb. Even in the problem case above, where analyses required non-neighbour mapping, a solution in terms of case labels suggests that the valency-binding labels can be ignored where they do not help us. And the Case solution to the final problem mentioned above – how to identify which arguments are considered in both languages to be valency-bound – is self-evident.

The point about Case is that it exactly meets the need in MT for a level of representation that is both deep enough to serve in a manner relatively independent of surface form, while still being shallow enough to allow a fairly straightforward mapping from and onto these other levels of description (i.e. surface syntax, canonical form, etc.). This view is countered by Tsujii (1982:382), who claims that with only the shallow meaning representation afforded by Case, one does not avoid the necessity to look still at specific verbs in order to interpret the case labels and so to determine the appropriate strategy. But Tsujii wrongly attributes to advocates of Case for MT the idea that it should replace other forms of labelling in the representation of analysis.

It should be made clear that indeed information about

syntactic configuration goes hand in hand with case structure information. The introduction of case labels permits certain generalisations that can act as defaults to reduce the amount of explicit information associated with each verb, in the manner of lexical rules in LFG or metarules in GPSG. Although we may consider Fillmore's (1968) notions of a case-hierarchy for subject selection, or the association of prepositions with cases to be overstated, this is only because he made the mistake of positing these as generalisations rather than defaults.

Of course, Case does introduce new problems, not least of which is the definition of a comfortable case set. But this is not a design problem, but a development problem, and one would like to believe that the appropriate case distinctions will become evident during a period of experimentation with a prototype system. Like in any engineering (as opposed to theoretical) undertaking, one must be prepared for a period of flux where the appropriate tools are developed and modified.

It is appropriate at this point to look briefly at the extent to which Case is currently used in MT systems. Perhaps the most extensive use of Case is found in LRC's METAL system (Lehmann et al 1980). The system is basically transfer-based, with the results of a context-free parse of the source text passed to the 'case frame processor'. Case frames are also used in transfer. The cases in the system are divided into two types, 'central' and 'peripheral', corresponding roughly to the traditional Valency distinction between complements and adjuncts respectively.

A key aspect of the METAL conception of central and peripheral cases is that these form two discrete sets of cases. This means that each of the cases that are recognized is regarded as either typically "conditioned by the particular verb" or not verb-specific. However, it is recognised that "... a few classes of verbs may be closely associated with arguments which are usually considered peripheral for most verb classes" (Lehmann et al, 1980:I-24), the example given being verbs of motion which often specify a locative complement.

Lexical entries indicate the range of cases for each verb, for each of which three types of subcategorization information are given, as follows: (a) the 'semantic type' of the argument; (b) its canonical syntactic role (surface case); (c) the syntactic form of the argument, i.e. the kind of constituent expected for each argument, e.g. clause, noun-phrase, prepositional phrase, adverb.

In addition, verbs are assigned to a 'transitivity type'. This feature gives the "potential configuration of arguments", that is, relating the possible case roles to the canonical syntactic roles according to the mood and voice of the verb. This feature does add information not expressed elsewhere, even though at first sight it would appear only to corroborate the correspondence between deep and surface case: it is according to transitivity type that rules regarding sentence forms other than simple active indicative can be generalised.

In contrast with traditional approaches to Case, note that requirements regarding semantic and syntactic restrictions are not necessarily directly associated with the cases, as was found in Fillmore's original (1968) proposal, but can be specified for individual verbs, though a system of defaults does apply.

The case frame processor attempts to 'use up' the available arguments by matching them to the specifications given in the lexical entry for the verb, and then applies general 'case functions' associated with the peripheral cases to the remaining arguments. If all the arguments can be legally assigned case roles, then the clause is considered well-formed. Otherwise, the rule is deemed to have failed, and an alternative frame processor is tried.

Case frames are also used in transfer, primarily to order the constituents and assign them appropriate syntactic function markers. Sometimes, if a case is 'marked', there might also be a change in syntactic form, most often (presumably) from noun-phrase to prepositional phrase or vice versa.

Lack of space prevents us from looking closely at the list of cases used. The list of central roles more or less reflects the consensus view. In addition, fully 25 major and additional peripheral roles of a rather less abstract nature are proposed.

Of interest in the documentation describing the case roles is that some of them are exemplified in noun frames rather than verb frames (see below). More bizarre perhaps is that although these roles are allegedly typically peripheral, many of the examples given show them being used as 'obligatory' arguments, somewhat undermining the central-peripheral distinction. This leads us to our most important comment on the METAL system, with regard to the central-peripheral distinction. There is a serious problem, if we admit the possibility of using these cases also for 'obligatory' roles, of conflict between these more specific and the slightly more general central cases. For example, there is an Material case, as in (10a), which would however also seem a good alternative candidate to Target (=Patient) for the surface object of use in (10b).

(10a)   John built the wall out of bricks.
(10b)   John used bricks to build the wall.

My own proposals will show how this kind of problem might be addressed, in particular by making a stricter distinction between 'central' and 'peripheral' cases, though allowing the latter as 'secondary' labels attaching to the former where necessary.

6. Valency and Case in MT

In this section I wish to present a synthesised view of the use of Valency and Case in MT, taking into account the points raised above. In the following discussion, I assume a transfer- rather than interlingua-based approach, in keeping with current views on this dichotomy.

Remembering the necessity to keep transfer as small as possible, we can see the motivation for introducing the degree of shallow semantics offered by Case. We saw in Section 2 the problems associated with transfer based solely on labels distinguishing only between complements and adjuncts. We have also seen in Section 5 how the additional information

carried by case labels simplifies the mapping of arguments in transfer. We should also take into consideration the fact (cf. Somers, in press) that all the traditionally proposed cases (with the exception of Patient) can occur both as complements and adjuncts, even simultaneously. It seems therefore that the key to transfer is a label indicating both a case relation and the valency-binding of that element, so that each constituent is uniquely identifiable. We also seek to incorporate the additional valency-binding values (integral, middle and extra-peripheral) introduced in Section 3.

For guidance as regards the choice of a set of cases, I would like to propose an adaptation of the approach found in METAL (discussed above), where there is a strict distinction between the cases used for central and peripheral roles. We saw in our discussion above that some uneasiness results from the combination of general and specific cases, since often both a general (traditional) and a specific case assignment seems appropriate. The approach I wish to propose here involves the definition of a relatively small set of traditional cases which are associated primarily with complements. The notion 'relatively small' must of course be expanded. The cases in this set will be rather abstract in the manner of traditional cases. Because they are to be used essentially to distinguish valency-bound elements, and because the maximum possible valency for any verb is probably four, we could argue for having only that many of these 'inner cases'. However, we also want to take advantage of the mnemonic value of the case names, so as to make assignment of case labels (by humans, perhaps in relatively independent research groups) as easy as possible. The number and exact values of these cases is to be fixed by some preliminary research, and is not in my view an issue of import. The important point is that this set be fixed, i.e. forming a closed set, so that one of the cases can be used quite explicitly as a 'wastebasket' or neutral case (cf. Mellema, 1974) for those instances where there is no obvious case assignment. Judicious and motivated elaboration of the case-set will reduce such instances to a minimum.

A further range of less abstract cases will serve for the remaining degrees of valency-binding – middles, adjuncts and extra-peripherals. These will typically be more specific, and their character determined by particular translation problems as they arise during the development stage of the system. Some suggestions of candidates for this list can be found in the METAL documentation. Given the existence of these specific cases, it would be quite acceptable to use them as secondary labels in conjunction with the traditional cases (particularly, perhaps, the neutral case), again as and where necessary or helpful, though their presence would not typically be a requirement for transfer. They might, for example, be found to be of assistance in choosing appropriate surface structures in generation for some target language, though not for another.

There remains the problem of the roles of arguments in non-verbal constituents, since these too have a dependency structure. Furthermore, the recognition of the nature of these relationships is often essential in translation. Compare the noun groups in (11), all of which have a similar syntactic structure, but which represent different translation patterns in French, depending on the relationship

between the modifier and the head.

(11a) a steam train   un train à vapeur
(11b) a football pitch   un terrain de foot
(11c) a cotton shirt   une chemise en coton
(11d) the baby linen   le linge pour bébé

Although it could be argued that these noun-phrases could be treated as individual compound lexical items, the type of construction they exemplify is typical, widespread, and such 'compounds' occur freely in novel combinations, often involving a larger number of elements (12):

(12a) the Geneva peace talks
(12b) SDP election campaign promises
(12c) North Sea oil field offshore rig administration

These pose considerable problems when they are translated into languages in which such opaque compounds cannot be formed and where the relationships between the elements are made more explicit. Therefore, these relationships must be represented at input to transfer. Indeed this has been recognised as a problem in translation (human or mechanical), and Case suggested as a descriptive mechanism for such structures (e.g. Bauer, 1978; Mackenzie, 1983). My own approach would be to propose that the case set be supplemented by a number of relations specifically suited to noun groups: these would be compatible with the cases already established, with as large an overlap as possible. Clearly, in the case of complex noun groups whose head is derived from a verb, either as a direct nominalisation (13a), as a cognate form (14a) or even perhaps when the link is essentially semantic (15a), there is no reason why the range of cases (and valency bindings) that would apply in the corresponding verbal predications (13b, 14b, 15b) could not be employed within the noun group.

(13a) the possible future dismissal of teachers for incompetence
(13b) Teachers will possibly be dismissed in future for incompetence.

(14a) my mother's temporary loss of memory
(14b) My mother has temporarily lost her memory.

(15a) Everton's recent 6-1 home victory over Arsenal
(15b) Everton recently beat Arsenal by 6-1 at home.

By the same token, nouns not so related to verbs must be seen as heads with arguments in some relation. Work on nominal valency (e.g. Sommerfeldt & Schreiber, 1977; Teubert, 1979) has recognised that many nouns can be attributed 'valency patterns', and Pitha (1980) and Mackenzie (1983) have taken a Case approach to the problem. Among their findings is the observation that while almost no nouns take obligatory complements, many noun modifiers can be regarded as valency-bound (e.g. the noun book has complements indicating author, subject and contents, signalled by by, about and of respectively). Furthermore, there are a number of case-like relations that are appropriate for noun modifiers, among them almost certainly an essentially neutral one, for use – in the context of MT – when there turns out to be no need to compute the relationship: attributive adjectives may be an example of this.

It is not my intention here to establish, discuss and

justify such a set of relations. In any case, only by extensive research and experimentation with a working system could one expect to be able to discover the range of relations needed.

7. Conclusion

It has been the intention of this paper to make a statement about the proper approach to the use of case and Valency in MT. On the one hand, I have presented a proposal to abandon the old two-term Valency system in favour of a new six-term system, and have explored the consequences of such a change. In connection with this, I have tried to show where Case fits in. What this research perhaps lacks at this point in time is empirical evidence that such an approach is valid, and an accompanying set of case names for the various relations. It could be argued that the latter is a prerequisite for the former, though I would prefer to claim that the demonstration of the validity of the approach and the elaboration of a 'comfortable' set of cases form an essentially unified research task. This paper, then, has explained the theoretical background to such a task.

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