Valency Lexicon of Czech Verbs: Alternation-Based Model

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Abstract

The main objective of this paper is to introduce an alternation-based model of valency lexicon of Czech verbs VALLEX. Alternations describe regular changes in valency structure of verbs – they are seen as transformations taking one lexical unit and return a modified lexical unit as a result. We characterize and exemplify 'syntactically-based' and 'semantically-based' alternations and their effects on verb argument structure. The alternation-based model allows to distinguish a minimal form of lexicon, which provides compact characterization of valency structure of Czech verbs, and an expanded form of lexicon useful for some applications.

Introduction

The verb is traditionally considered to be the center of the sentence, and the description of syntactic and syntactic-semantic behavior of verbs is a substantial task for linguists. Theoretical aspects of valency are challenging. Moreover, valency information stored in a lexicon (as valency properties are diverse and cannot be described by general rules) belongs to the core information for any rule-based task of NLP (from lemmatization and morphological analysis through syntactic analysis to such complex tasks as e.g. machine translation).

There are tens of different theoretical approaches, tens of language resources and hundreds of publications related to the study of verbal valency in various natural languages. It goes far beyond the scope of this paper to give an exhaustive survey of all these efforts – Žabokrtský (2005) gives a survey and short characteristics of the most prominent projects (i.e. (Fillmore, 2002), (Babko-Malaya et al., 2004), (Erk et al., 2003) and (Mel'čuk and Zholkovsky, 1984)).

The present paper is structured as follows: in the first section the valency lexicon VALLEX is introduced. Section 2. deals with the concept of alternations – we present alternations as transformations that describe regular changes in the valency structure of verbs (and reduce lexicon redundancy). We characterize basic rules for their representation and exemplify basic types of alternations. Section 3. gives a brief sketch of minimal and expanded form of the lexicon.

1. Valency lexicon VALLEX

The valency lexicon VALLEX is a collection of linguistically annotated data and documentation, resulting from an attempt at a formal description of valency frames of roughly 4300 most frequent Czech verbs. It is closely related to Prague Dependency Treebank (PDT), see (Hajič, 2005).[1] VALLEX provides information on the valency structure of

verbs in their particular meanings / senses, possible morphological forms of their complementations and additional syntactic information, accompanied with glosses and examples (briefly described below; the theoretical background of Functional Generative Description of Czech is presented in (Sgall et al., 1986) and (Panevová, 1994), its application on VALLEX is specified in (Lopatková, 2003)). All verb entries in VALLEX are created manually; manual annotation and accent put on consistency of annotation are highly time consuming and limit the speed of quantitative growth, but allow for reaching desired quality.

VALLEX version 1.0 was publicly released in autumn 2003. The second version of the lexicon, VALLEX 2.0, which adopted the alternation-based model will be available this autumn (2006) at http://ufal.mff.cuni.cz/vallex/.

1.1. Structure of VALLEX

VALLEX can be seen as having two components, a data component and a grammar component.

Formally, the **data component** consists of word entries corresponding to verb lexemes. Lexeme is an abstract twofold data structure which associates lexical form(s) and lexical unit(s) (see Fig. 1).
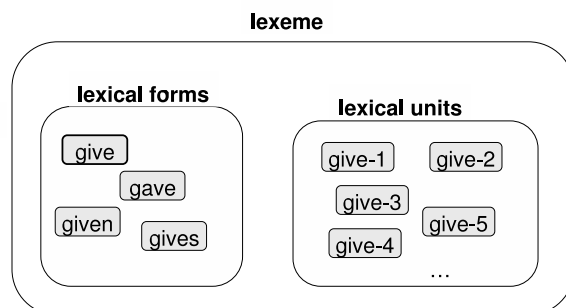

Figure 1: Lexeme, lexical form, and lexical unit.

Lexical forms are all possible manifestations of a lexeme in an utterance, as e.g. perfective, imperfective and iterative verb lemmas, all their morphological manifestations, reflexive and irreflexive forms etc. In the lexicon, all lexical

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[1] However, VALLEX is not to be confused with a bit larger valency lexicon PDT-VALLEX created during the annotation of PDT, see (Hajič et al., 2003). PDT-VALLEX has originated as a set of valency frames instantiated in PDT, whereas in the more complex and more elaborated VALLEX verbs are analyzed in all their complexity.

forms of a lexeme are represented by perfective, imperfective and iterative infinitive forms (if they exist), the so called **(headword) lemma(s)**.

Concerning **lexical units (LUs)**, the concept introduced in (Cruse, 1986) has been adopted: LUs are "form-meaning complexes with (relatively) stable and discrete semantic properties". Particular lexical unit is specified by particular meaning / sense, loosely speaking,'given word in the given sense'.[2] Each lexical unit is characterized by a **gloss** (i.e. a verb or a paraphrase roughly synonymous with the given meaning / sense) and by **example(s)** (i.e. sentence fragment(s) containing the given verb used with the given valency frame). The core valency information is encoded in the **valency frame** consisting of a set of **valency members / slots**. Each of these valency members corresponds to an individual – either required or specifically permitted – complementation of the given verb (assigned with its possible morphological forms and a flag for obligatoriness). In addition to this obligatory information, also optional attributes may appear in each LU: a flag for idiom, information on control, affiliation to a syntactic-semantic class and a list of alternations that can be applied to this LU (accompanied by examples as illustrated below), see Fig. 2.

The **grammar component** consists of a set of transformations that can be applied to particular LUs (as specified in the data component) to obtain derived LUs and thus an expanded form of the lexicon. These transformations explicitly cover possible alternation constructions for individual verb forms (they are described in more details in Section 2.2.).

1.2. Basic quantitative characteristics of VALLEX

VALLEX 2.0 contains almost 2100 lexemes. Valency frames of around 6350 LUs are stored in the lexicon. From the other point of view, it describes roughly 4300 verbs (counting perfective forms (ca 1950 verbs), imperfective forms (2250 verbs) as well as biaspectual forms (96 verbs); in addition to these numbers, VALLEX contain also 335 iterative verbs).

2. Alternations

When studying the valency of Czech verbs, it proves to be fruitful to exploit the concept of Levin's alternations (Levin, 1993) and to adapt it for Czech. Levin's alternations describe different changes in argument structure of lexical units. Though our main goal is rather different from that of Levin (Levin builds semantically coherent classes from verbs which undergo particular sets of alternations), the concept of alternations enables us to systematically describe regular changes in argument structure of verbs. Levin recognizes around 45 alternations for English (some of them with more variants). Similar behavior of verbs can be detected in Czech in spite of the typological character of this inflective language. Several of these alternations are described in Czech linguistic works, e.g. in (Daneš, 1985), (Mlu, 1987), (Panevová, 1999), but no Czech lexicon has reflected this model yet.

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[2]This concept of LU corresponds to the Filipec's 'monosemic lexeme' as specified in (Filipec, 1994).
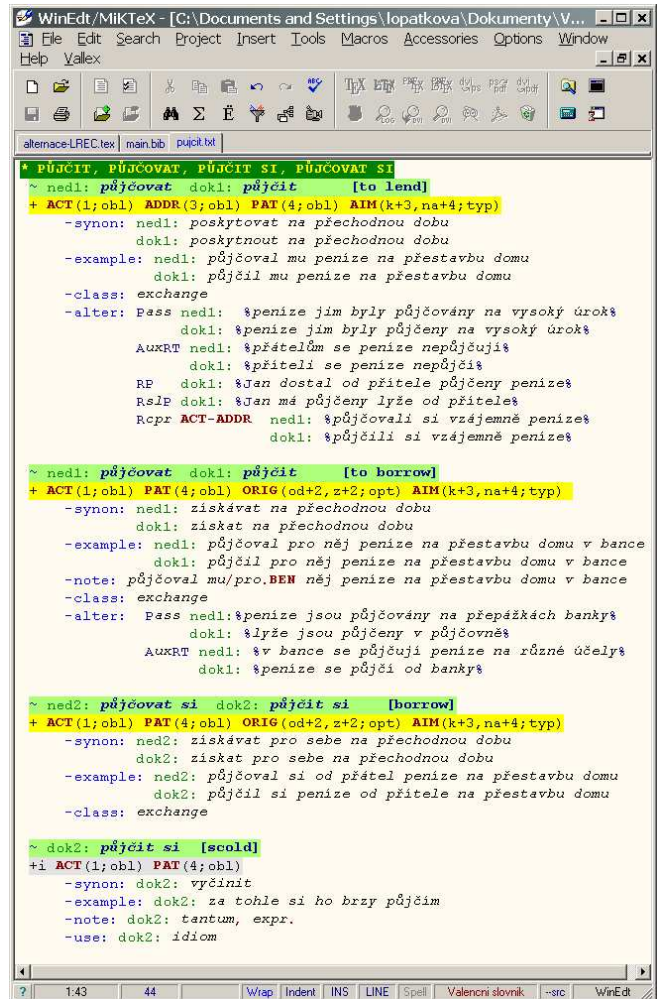

Figure 2: VALLEX lexeme for the lemma *půjčit/půjčovat/půjčit si/půjčovat si* [to lend / to borrow]. The highlighting mode in WinEdt text editor, the annotation tool for VALLEX.

The problem is that many verbs can be used in different contexts in the same or only slightly different meanings, which can be accompanied by small changes in their syntactic properties. When describing valency really explicitly, such changes imply introduction of new LUs, which is rather unintuitive and causes problems in building a lexicon (it is a substantial source of inconsistency during annotation, it causes redundancy in the lexicon). As an illustration:

(1) *Martin.ACT nastříkal barvu.PAT na zeď.DIR3*
     Martin sprayed paint on the wall.

(2) *Martin.ACT nastříkal zeď.PAT barvou.MEANS*
     Martin sprayed the wall with paint.

Clearly, different frames (containing different functors, i.e. labels of 'deep roles')[3] are instantiated in both pairs. Thus we have to have two LUs for these two utterances of verb

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[3]Here the labels ACT and PAT stand for inner participants Actor/Bearer and Patient, respectively, the labels DIR3 and MEANS stand for free modifications Direction-where and Means.

despite the similarity of their meanings. The point here is that instead of having two unrelated LUs in the lexicon, it is more economical (less redundant) to store only one of them (considered as a basic LU) accompanied with information about particular alternation(s) that is/are applicable on this LU (and a derived LU can be generated 'on demand').

2.1. Threefold effect of alternations

In our approach, alternations are seen as transformations that take one LU as an argument and return another LU as a result. The effect of alternations is manifested by (at least one of) the following ways:

- change in **(complex) verb form**,

- change in **valency frame**, i.e.

  - changes in list of valency members,

  - changes in obligatorness of particular members,

  - changes in the sets of possible morphological forms of particular complementations,

- change in **lexical meaning** (with a possible change in the syntactic-semantic class).

Each alternation should be applicable on a whole group of LUs and its manifestation must be completely regular – all the changes (in form, in valency frame as well as in meaning) must be predictable from the input LU and the type of alternation.

2.2. Alternations as transformations

According to the alternation-based model, LUs are grouped into **LU clusters**, as is sketched in Fig. 3. Each cluster contains a **basic LU**, which has to be physically stored in the lexicon, and possibly a number of **derived LUs**, which are present only virtually in the lexicon – these derived LUs are obtained as results of transformations (for alternations applicable on the basic LU).

As the effects of alternations are completely regular, each alternation can be described in the grammar component of the lexicon as **set(s) of transformation rules** that can be applied on a basic LU. These transformations cover all changes in a LU relevant for a particular alternation.

Let us stress here that some alternations can be composed. Thus the LU cluster (see Fig. 3) can be seen as an oriented graph with one distinguished node (basic LU), from which there is an oriented path to all remaining nodes.

Concerning the choice of the basic LU, linguists do not offer in general any simple and explicit solution. Practically, this choice depends on the list of alternations introduced in the lexicon, so it is arbitrary to some extent (only the formal criterion that all other LUs are reachable from the chosen one must be fulfilled). Therefore certain conventions were adopted, some of them more obvious (as e.g. active construction is considered as the basic structure and particular passive constructions as the derived ones), other more arbitrary (as e.g. choice of basic LU for 'cause co-occurrence' alternation, see examples (5)-(6)).
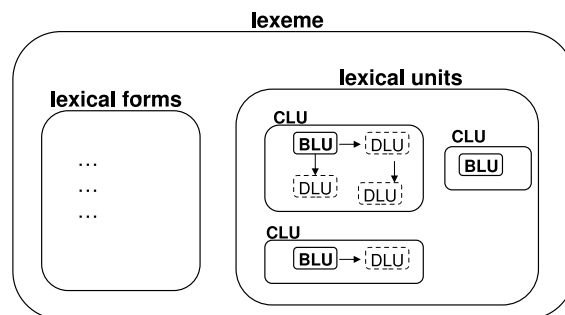

Figure 3: Basic and derived LUs (BLUs and DLUs) forming clusters of LUs (CLU).

Since some alternations can be combined the transformation rules must specify also changes in the list of alternations applicable to the output LU (see below, examples (3)-(4) and (5)-(6)).

The concept of transformations is described in detail on the 'recipient passive' alternation and 'cause co-occurrence' alternation in the following sections.

2.2.1. 'Recipient passive' alternation

The 'recipient passive' alternation can be exemplified on the sentences (3)-(4).

(3) *Pojišt'ovna.ACT zaplatila výrobcům.ADDR ztráty.PAT*
[insurance_company$_{Nom}$-covered-(to)producers$_{Dat}$-losses$_{Acc}$]
The insurance company covered losses to the producers.

(4) *Výrobci.ADDR dostali od pojišt'ovny.ACT zaplaceny ztráty.PAT*
[producers$_{Nom}$-got-from-insurance_company$_{Gen}$-covered-losses$_{Acc}$]
The producers have got covered their losses from the insurance company.

The active construction of a meaningful verb (here the verb *zaplatit* [to cover / to pay]) is considered as the basic LU, and thus it is contained in the VALLEX lexicon, see LU in Fig. 4. The set of applicable alternations (together with the examples) is listed in the atribute 'alter'.

It is specified in the grammar component, that the 'recipient passive' construction (marked RP in VALLEX) consists of the finite form of the verb *dostat* [to get] plus passive participle of the meaningful verb. The passive participle has either the form for neuter gender, or it agrees with the noun in accusative case (we draw on the description proposed in (Daneš, 1985) and (Mlu, 1987)).

Clearly, the 'recipient passive' construction has the same valency frame (i.e. the same set of valency complementations) as the active construction. However, the possible morphological forms are different – in active sentence, ACTor is in Nominative and ADDRessee in Dative case; in recipient passive, ACTor is either in Instrumental, or it is realized as a prepositional group *od* [from]+Genitive and ADDRessee is in Nominative (PATient is in Accusative case in both sentences).

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ZAPLATIT
 ∼ pf: zaplatit [to cover / to pay]
   + ACT(1;obl) ADDR(3;opt) PAT(4;obl)
    -gloss: uhradit [to cover / to pay]
    -example: zaplatit mechanikovi opravu
            [to pay the repair to a mechanic]
    -class: exchange
    -alter: Pass %oprava byla zaplacena v eurech%
            [the repair was paid in euros]
          AuxRT %oprava se zaplatila v eurech%
            [the repair was paid in euros]
          RP %opravu dostali zaplacenu v eurech%
            [they have got the repair covered in euros]
          RslP %rodiče měli dovolenou zaplacenu %
            [parents have the holidays paid]
          Rcpr    ACT-ADDR
            %zaplatili si (navzájem) všechny pohledávky%
            [they covered their claims each to other]
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Figure 4: The basic LU for the particular sense of the verb *zaplatit* [to cover / to pay] in the annotation format.

In VALLEX, a transformation notation developed by Petr Pajas (originally used for consistency checking of valency frames in PDT) was adopted for describing different types of alternations. Informally, the set of rules for RP alternation looks as follows:

- change in verb form:
  ⇒ +*dostat* [to get], finite form
  active ⇒ passive participle
  (neuter gender | agreement with the noun in Accusative)
- changes in valency frame :
  not applicable (NA in the sequel)
- changes of possible morphological forms:
  ACT(1) ⇒ − ACT(1), +ACT(7), +ACT(od+2)
  ADDR(3) ⇒ − ADDR(3), +ADDR(1)[4]
- change of syntactic-semantic class:
  NA
- change in the list of applicable alternations:
  ⇒ − Pass
  ⇒ − AuxRT
  ⇒ − RP
  ⇒ − RslP
  ⇒ − Rcpr

As a result of this transformation rule (applied to the basic LU for the verb *zaplatit* [to cover / to pay]), the derived LU for the 'recipient passive' construction is obtained, see Fig. 5 (the example is copied from the relevant alter attribute of the basic LU).

2.2.2. 'Cause co-occurrence' alternation

The 'cause co-occurrence' alternation concerns a group of verbs that express putting things / substances into containers or putting them on surface (for Czech described in (Daneš, 1985), for English see (Levin, 1993), Section 2.3).

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[4]This is interpreted as: concerning ACT, remove Nominative case, add Instrumenal and prepositional group *od*+Genitive; concerning ADDR, remove Dative case and add Nominative.

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 ∼ pf: zaplatit [to cover / to pay]
   + ACT(7,od+2;obl) ADDR(1;opt) PAT(4;obl)
    -gloss: uhradit [to cover / to pay]
    -example: opravu dostali zaplacenu v eurech
            [they have got the repair covered in euros]
    -class: exchange
```

Figure 5: The derived LU for the 'recipient passive' construction for the verb *zaplatit* [to cover / to pay].

(5) *Dělníci.ACT naložili vagony.PAT uhlím.MEANS*
     The workers loaded the wagons with coal.

(6) *Dělníci.ACT naložili uhlí.PAT do vagonů.DIR3*
     The workers loaded coal on the wagons.

Sentences (5)-(6) show two possible underlying syntactic structures that these verbs can create, see Table 1.

	agens / causator	container / surface	thing / substance
ex. (5)	ACT	PAT	MEANS
ex. (6)	ACT	DIR3	PAT

Table 1: Two possible underlying syntactic structures for the 'cause co-occurrence' alternation.

In VALLEX, the syntactic structure realized in the sentence (5) is considered as the primary one – thus the basic LU for the relevant sense of the verb *nakládat / naložit* [to load] is such as in Fig. 6 ('CCo' labels 'cause co-occurrence' alternation). All alternations applicable to this verb sense are presented here just to illustrate the possibility of alternations to compose.

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NAKLÁDAT, NALOŽIT
 ∼ impf: nakládat pf: naložit [to load]
   + ACT(1;obl) PAT(4;obl) MEANS(;typ)
    -gloss: impf: plnit pf: naplnit [to load]
    -example: impf: nakládat vůz senem
              pf: naložit vůz senem
              [to load a wagon with hay]
    -class: providing
    -alter:
          Pass impf: %vozy byly nakládány dřevem po okraj%
              pf: %vozy byly naloženy dřevem po okraj%
              [wagons were loaded with timber to the brim]
          AuxRT impf: %vozy se nakládaly dřevem po okraj%
              pf: %vozy se naložily dřevem po okraj%
              [wagons were loaded with timber to the brim]
          RslP pf: %mít vůz naložený dřevem po okraj%
              [to have wagon loaded with timber to the brim]
          CCo impf: %nakládat seno na vůz%
              pf: %naložit seno na vůz%
              [to load hay on wagon]
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Figure 6: The basic LU for the particular sense of the verb *nakládat / naložit* [to load].

The transformation rule in the grammar component of VALLEX specifies the way how to obtain a derived LU for particular alternations. Concerning CCo, the following changes are relevant:

- change in verb form:
  NA
- changes in valency frame (list of complementations as well as obligatoriness of particular members):
  MEANS ⇒ – MEANS
  ⇒ +DIR3(;obl)
- changes of possible morphological forms:
  NA
- change of syntactic-semantic class:
  providing ⇒ location
- change in list of applicable alternations:
  ⇒ – CCo

The result of the CCo transformation rule applied to the appropriate basic LU for the verb *nakládat / naložit* [to load] is shown in Fig. 7.

NAKLÁDAT, NALOŽIT
  ∼ impf: *nakládat* pf: *naložit* [to load]
    + ACT(1;obl) PAT(4;obl) DIR3(;obl)
    -gloss: impf: *plnit* pf: *naplnit* [to load]
    -example: impf: *nakládat seno na vůz*
          pf: *naložit seno na vůz*
          [to load hay on wagon]
    -class: *location*
    -alter: Pass
        AuxRT
        RslP

Figure 7: The derived LU for the 'cause co-occurrence' alternation for the verb *nakládat / naložit* [to load].

As the lists of alternations applicable to derived LU's are gained from the transformation rules in the grammar component (not from the data component), there cannot be examples of their instantiations in derived LUs (we minimize this minus by ordering alternations, see Section 2.3.).

2.3. Typology of alternations

Basically, we distinguish two groups of alternations, tentatively characterized as 'syntactically-based' alternations and 'semantically-based' ones.

2.3.1. 'Syntactically-based' alternations

A group of 'syntactically-based' alternations primarily consists of different types of 'diathesis' (in the narrow sense) in Czech. Further, reciprocal alternations are ranged with this type and also some additional (more sparse) constructions. These alternations are characterized by changes in the verb form.

We have exemplified some of these alternations in the previous section in Figures 4 and 6, where label Pass stands for passive voice, AuxRT for reflexive passive, RP and RslP for recipient and resultative passive with *dostat* [to get] and *mít* [to have], respectively, plus passive participle constructions. We take into account also, e.g., alternations for constructions like *dát / nechat* plus infinitive (as in *dává /*

nechává si vyprat špinavé košile [he has/gets his dirty shirts washed]). Label Rcpr (see Fig. 4) is used for reciprocal constructions described for Czech in (Panevová, 1999).

The 'syntactically-based' alternations cover constructions described in details in Czech grammars, another 'diatheses' are regular enough to be covered by general rules (e.g. 'dispositional modality' or impersonal constructions), so it is redundant to store them in a lexicon (see esp. (Mlu, 1987) and (Daneš, 1985), and (Skoumalová, 2002)).

2.3.2. 'Semantically-based' alternations

Let us give here at least several examples to illustrate 'semantically-based' alternations. Levin stated that alternations are language dependent, though several of English examples have their Czech counterparts, e.g. 'cause co-occurrence' alternation (examples (1)-(2)) matches up with Levin's 2.3 alternations (see also (Cinková, 2006)). The following Table 2 shows some other examples of semantically-based alternations (examples marked with ⋆ are described in (Benešová, 2004)).

1.4	*vyjít kopec / vyjít na kopec*⋆
	[to climb the mountain / to climb up the mountain]
2.4	*chlapec roste v muže / z chlapce roste muž*
	[a boy grows into a man / a man grows from a boy]
1.1	*Slunce vyzařuje teplo / teplo vyzařuje ze slunce*
	[the Sun radiates heat / heat radiates from the Sun]
2.1	*poslat dopis mamince / poslat peníze do Indie*⋆
	[to send mamma a letter / to send money to India]
???	*soustředit se v centru města/ soustředit se do centra*⋆
	[to mass in the city center / to mass into the city center]

Table 2: Examples of corresponding Czech and English alternations (numbers in first column stand for Levin's types of alternations).

Distinguishing two basic groups of alternations is not an enterprize for its own sake – these two groups exhibit different behavior:

- Alternations belonging to the same group typically cannot be composed (with the rare exception of Rcpr alternation where subject is not involved – this case must be treated separately).
- Typically, alternations from different groups can be mutually composed.
- Though in general, alternations from different groups can be composed in any order, we have not found a single example where the order of composition is relevant. That means that the result of composition is the same regardless the order.

These observations result in an important constraint – it allows us to prescribe the order in which alternations can be composed: if two alternations are to be applied to any LU, then the 'semantically-based' one is (by convention) considered as the first one, the 'syntactically-based' one follows.

This constraint has both theoretical and practical impact. It guarantees the tree structure of LU clusters (compare Fig. 3 in Section 2.). From the practical point of view it ensures that 'semantically-based' alternations are exemplified in the

lexicon. Considering the exhaustive description of passive constructions in grammar books (and also description of other constructions which come under 'syntactically-based' alternations), it seems to be acceptable to have these types of alternations without examples in the expanded form of the lexicon.

3. Minimal and expanded form of the lexicon

The VALLEX lexicon (in its minimal form) contains only the basic LU with an associated list of applicable alternations. However, there are various tasks for which it could be useful to include the derived LUs to the lexicon (e.g. frame disambiguation, i.e. assigning LUs to verb occurrences in text). This requirement leads to distinguishing minimal and expanded form of valency lexicon VALLEX – the expanded one (containing all LUs covered either explicitly or implicitly in the lexicon) can be derived from the minimal one (containing only basic LUs) by a fully automatic procedure. The formal alternation-based model of VALLEX is described in details in (Žabokrtský, 2005), where also the main software components of the dictionary production system developed for VALLEX are outlined (including annotation format, www interface for searching the text format as well as XML data format).

Conclusions

Despite the variety of valency behavior of lexical units, in the valency lexicon of Czech verbs VALLEX the stress is laid on an adequate and consistent description of regular properties of verbs as lexical units. The alternation-based model gives a more powerful description of Czech verbs and shows regular changes in their argument structure. It makes it possible to decrease redundancy in the lexicon and to make the lexicon more consistent.

In future, we will especially focus on the 'semantically-based' alternations in Czech, the adequate description of which requires further linguistic research. We aim to empirically confirm the adequacy of tree-structure constraint on LU clusters. Depending on the progress in this field, we intend to involve newly specified alternations to the lexicon. We plan to extend VALLEX also in quantitative aspects.

The alternation-based model is a novelty in Czech computational lexicography. Though only a limited number of alternations has been practically implemented in VALLEX, its asset to adequate description of valency properties of verbs has been clearly proved.

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