PDT-VALLEX: Creating a Large-coverage Valency Lexicon for Treebank Annotation

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1   The Prague Dependency Treebank

The valency theory as a part of the theory of Functional Generative Description ([16]) of language meaning has been around for some time ([14]). However, it is for the first time that a large-scale corpus (the Prague Dependency Treebank (PDT, [4]) has been fully annotated with valency information based on this theory, i.e., with fully referenced valency lexicon at each relevant verb, noun or adjective. [1]

The PDT is a long-term research project, whose main aim is a complex manual annotation of (roughly) a one-million-word part of the Czech National Corpus. [2] It is being annotated on three layers.

On the lowest, **morphological layer** the lexical entry (usually represented by a lemma) and values of morphological categories (person, number, tense, gender, voice, aspect, . . .) are assigned to each word.

At the **analytical layer**, a sentence is represented as a dependency tree. Nodes of the tree represent tokens (i.e. word forms and punctuation marks) as they are found in the original sentence. No node is added or deleted. Edges usually (where it makes sense) represent relation of formal dependency. In addition, an **analytical function** capturing the type of dependency relation between the child and its parent is added.

The highest (or, "deepest" depending on the point of view) layer is the **tectogrammatical layer** ([7]). It captures the deep (underlying) structure of a sentence. Nodes represent only autosemantic words; synsemantic (i.e., auxiliary) words and punctuation marks are not represented by nodes, they may only affect values of attributes of the autosemantic words which they are attached to. At this layer, several attributes are assigned to each node, one of the most important ones

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[2]http://ucnk.ff.cuni.cz

being the **(deep) functor** capturing the tectogrammatical function of a dependent relative to its governor.

2 Valency in the Functional Generative Description

Some functors are "bound" to certain governing lexical units (heads) more than other functors by **valency**. The notion of valency is one of the crucial points for the theoretical description of language as well as for any NLP system. However, the description and understanding of valency differs form one theoretical background to another. Our valency approach is based on the Functional Generative Description (FGD; again, see [16], [14]), where the dependency-based underlying syntactic structure is not only defined per se, but it is also mapped onto the corresponding morphemic representation. The labels for the syntactic relations belong to the deep (underlying) syntactic units, the morphosyntactic information (string of morphemic forms: case endings, prepositions with case endings, subordinated conjunctions) represents the surface form of the sentence. The verb with its valency members is considered to be a core of the sentence. However, some clear criteria must be used for the determination which members constitute the core of the sentence, i.e. which have a valency character.

The set of syntactic relations (i.e., functors) considered in FGD was classified according the following criteria:

(aa) could the given relation be repeated with a single verb?

(ab) could the given relation occur only once with a single verb?

(ba) could the given relation be combined with any verb?

(bb) could the given relation occur with the limited class of verbs, which can be listed?

The empirical analysis has shown, that the syntactic relations fulfilling the criterion (aa) fulfills also the criterion (ba), while the relations fulfilling (ab) fulfills also (bb). The former are called **free adverbials** (FA). The latter are called **inner participants** (IP). Five types of relations enter the class of inner participants: ACT(or), PAT(ient), ADDR(essee), ORIG(in), EFF(ect). They are either obligatory (the omitting of them mostly leads to an ungrammatical sentence,[3] see (1)) or they are optional (they can be omitted without loosing grammaticality (see (2)).

(1) *Chlapec dal učitelce květiny.* (Lit. *The-boy gave to-the-teacher flowers.*)

     – **Chlapec dal.* (Lit. *The-boy gave.*)

     – **Chlapec dal květiny.* (Lit. *The-boy gave flowers.*)

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[3]Unless in a specific discourse position, such as in spoken dialog.

– *Chlapec dal učitelce. (Lit. *The-boy gave the-teacher.*)

(2) *Jan prodal (Pavlovi) auto.* (Lit. *Jan sold (to-Pavel) a-car.*)

– *Jan prodal auto.* (Lit. *Jan sold a-car.*)

The rest of the dependency relations (temporal, local, directional, causal, manner etc.; see Tables 1 and 2 for a list of functors relevant for valency) belongs to the class of free adverbials. They can be freely combined with any verb,[4] however they are obligatory with some particular verbs (such as Direction with the verb *směřovat* (*to_head_to_sw*), Local with the verb *rozkládat_se* (*to_be_situated*), TWHEN (Time-WHEN; temporal) with the verb *trvat* (*to_last*). The sentences with such verbs are ungrammatical[5] and incomplete without them, so that they must be understood as their valency members. There are of course cases where the obligatory valency elements (from the point of view of the underlying syntactic layer), are not expressed on the surface (see (3), (4)):

(3) *Přátelé už přijeli.* (Lit. *The-friends already came.*)

(4) *Jeho obě děti už čtou.* (Lit. *His both children already read.*)

In (3) and (4) the surface zero position has an underlying counterpart according to the criterion of semantic completeness, which can be tested by the **dialog test**: The question "Where?" after the utterance (3) in a dialog is a kind of deviation and it cannot be answered by the speaker "I don't know" (the same is valid with the question "What?" after (4)). This test demonstrates that the directional relation for the verb *přijet* (*to_arrive*) is an obligatory valency member on the layer of underlying representation.

Any autosemantic lexical unit has its particular valency frame[6], which is constituted in accordance with the criteria of their classification given above in a way reflected in Table 3.

Table 3 shows that all inner participants (both obligatory and optional) can enter a valency frame. The free adverbials become a slot in the valency frame only when they are obligatory (from the point of view of the tectogrammatical, underlying layer). In other cases they are optional and they need not be listed in the valency frames as a part of lexicon.

If the verb has one or two valency slots, their labels are determined according the language patterning (the first slot with a verb *to_open* is structured in the same way in (5) as in (6), so that *janitor* in (5) and *key* in (6) are labeled as Actors).

(5) *Vrátný otvírá dveře klíčem.* (Lit. *The-janitor opens the-door with-a-key.*)

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[4]For simplicity, we talk here about verbs, but in principle, all what is said here about verbs applies to nouns and adjectives, too; see Sect. 6 for more details.

[5]With the usual caution what "ungrammatical" means.

[6]Which can be empty with verbs as Czech *pršet* (*to_rain*), nouns as *stul* (*table*), *slunce* (*sun*), adverbs as *rychle* (*quickly*) etc.

Type	Functor	Description	Example(s) of annotation
Inner part-icipants	ACT	Actor	She(ACT) saw a car.
	PAT	Patient	She saw a car(PAT).
	ADDR	Addressee	He gave a book to Mary(ADDR).
	EFF	Effect	... went down to 2.2 percent(EFF).
	ORIG	Origin	He made a toy out of wood(ORIG).
Time	TWHEN	When (general)	She came yesterday(TWHEN).
	TFHL	For how long	He worked for hours(TFHL).
	THL	How long	It takes two hours(THL).
	THO	How often	... twice(THO) a day.
	TOWH	For what time	... contracts for next year(TOWH).
	TPAR	During	... while on the train(TPAR).
	TSIN	Since when	Rates increase from Nov. 1(TSIN).
	TTILL	Till when	Until now(TTILL), there was ...
Location	LOC	Where (gen.)	We are in Sweden(LOC) now.
	DIR1	From where	She came from London(DIR1).
	DIR2	Through where	She came through customs(DIR2).
	DIR3	To where	He goes home(DIR3).
Manner and similar	MANN	Manner, gen.	... finished successfully(MANN).
	EXT	Extent	... a bit(EXT) premature.
	REG	Regard	... with relation to her(REG)
	ACMP	Accompaniment	He traveled with the dog(ACMP).
	ATT	Attitude	She aptly(ATT) noted ...
	MEANS	Means	... killed by a gun(MEANS).
	CRIT	Criterion	According to NYT(CRIT), ...
	BEN	Benefactive	... has read for him(BEN).
	RESTR	Except	...except for her(RESTR).
Causal and other rel.	CAUS	Causative	..., because he did(CAUS) ...
	COND	Condition	If it works(COND), ...
	COND	Condition	If it works(COND), ...
	AIM	Aim	... designed to deliver(AIM) ...
	CONFR	Confrontation	..., whereas I forgot(CONFR).
	CTERF	Counterfactual	If he were(CTERF) here, ...
	RESL	Result	... tanned brown(RESL).
	CPR	Comparison	... better than that(CPR).
	NORM	Normative	According to Sect.(NORM) II.4, ...
Other	SUBS	Substitution	Instead of Paul(SUBS), ...
	DPHR	Phraseme	to kick the bucket(DPHR)
	CPHR	Phraseme class	to give a speech(CPHR)
	INTT	Intention	He sent him shopping(INTT) for ...
	COMPL	Complement	... saw him barefoot(COMPL).

Table 1: Functors (general use, most frequent)

Functor	Description	Example(s) of annotation
APP	Appurtenance	roof of the house(APP)
ID	Identity	the ship Titanic(ID)
MAT	Partitive	a cup of tea(MAT)
RSTR	Restrictive	green(RSTR) ball
VOC	Vocative	Peter(VOC), bring us *sth*

Table 2: Functors (for nouns only)

Slot presence	Inner participant	Free adverbials
obligatory	+	+
optional	+	-

Table 3: Valency slot presence possibilities

(6) *Klíč otvírá dveře.* (Lit. *The-key opens the-door.*)

We are of course aware of the fact that the semantic nature of the key is instrumentality in both cases, however it follows from its lexical semantics and not from its (deep) syntactic role. We speak here about the shift of participant (instrument was shifted onto the position of Actor). In the same way an Addressee in (7) is shifted onto the place of Patient, being a second slot of the verb *oslovit* (*to_address*):

(7) *Řečník(ACT) oslovil posluchače(PAT).* (Lit. *The-speaker addressed listeners.*)

If the verb has three or more valency slots, semantics starts to play a role. In (8) and (9)[7] the distinction between Effect and Origin is based on their semantics, while the second slot (*canoe* in (8) and *log* in (9)) is classified in accordance with the principle of shifting as a Patient. For comparison to a different handling of semantics vs. syntax in valency frames, see ([3]).

(8) *He(ACT) made a canoe(PAT) from the log(ORIG).*

(9) *He(ACT) made a log(PAT) into the canoe(EFF).*

In other words, the first two slots (if they are inner participants) are defined largely syntactically and thus always Actor and Patient, while the other (up to three, if they exist) get their label based on their semantics.

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[7]English-only examples are given here since none of these cases behaves the same way for the same verb in Czech and English.

Word /	Valency Frame				
Sense	$Slot_1$	$Slot_2$	$Slot_3$	...	$Slot_n$
dát	ACT_{obl}(Nom)	PAT_{obl}(Acc)	$ADDR_{obl}$(Dat)		
dopis	ACT_{obl}(Poss/Gen)	$ADDR_{obl}$(Dat)			
plný	PAT_{obl}(Gen)				

Figure 1: Example of valency frames for *dát* (*to_give*), *dopis* (*a_letter*) and *plný* (*full*).

3 The Valency Lexicon

Without a proper valency lexicon that stores for each autosemantic, valency-capable word its valency information it would be hard to say at annotation time what are the proper slots to be filled for that word: in general, any slot filler can be left out in the surface form of a sentence, regardless how "obligatory" it is.

Therefore, we have to have a valency lexicon entry (see Fig. 1) for each sense of a word ([semantic] verb, noun, adjective) that can be referred to from the annotated corpus, and with which the annotation is consistent. Based on the theory presented in the previous section, each headword entry consists of one or more *valency frames* ((almost always) one for each sense of the headword), that in turn contain a fixed number of *slots*. Each slot is labeled by a name of the dependency relation (i.e., the *functor*), such as ACT, PAT, LOC etc., with each slot marked as obligatory or optional.[8]

Every slot includes also the appropriate (allowed) *form* of the slot filler in an utterance. In principle, it is a (underspecified) surface dependency syntax representation as used at the analytical layer of annotation. We use a shorthand notation to pinpoint the relevant constraints on the form (in the examples in Fig. 1, they are enclosed in parentheses right after the slot's functor name). See ([6], in this volume) for the principles and more detailed description of the relation between the valency frame and its surface syntactic representation.

4 PDT-VALLEX Contents

After the first pass annotation of the tectogrammatical layer of the PDT (about 55,000 sentences, dubbed "version 2.0") has been completed, we ended up with about 10,200 entries (see Tab. 4) in the valency lexicon. Verbs had already contained one or more valency frames as entered by the annotators during the annotation process; most nouns and adjectives, however, had not yet been in the lexicon[9].

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[8]More detailed information is contained in a smaller, but more thoroughly researched valency lexicon, called VALLEX, that is (indeed) PDT-VALLEX-compatible and currently contains about 1,450 verbs but no nouns and adjectives ([12], [11]).

[9]This is due to the fact that verb valency have been studied extensively in the past and therefore more or less consistent guidelines exist for a valency entry definition (albeit incomplete and not very

Word type (part of speech)	# of words	# of occurrences
Verbs	5,262	104,598
Nouns	4,090	121,073
Adjectives	831	13,905

Table 4: Valency lexicon size and token count

The valency lexicon is kept separately from the annotation (with references pointing from the annotated corpus to the lexicon entries) in a XML file, allowing for easy online and offline lexicon maintenance as well as use in applications.

5   Creating PDT-VALLEX

The annotation and lexicon-creation process is closely related, and we use a single software tool called `TrEd` ([5]) for both. It allows for interactive, graphical annotation off preprocessed data, online processing of the data as needed, search in the already annotated data and full access to the valency lexicon (viewing and editing). For certain tasks, the valency lexicon can also be edited separately.

We proceed in the following steps:

- Basic lexicon preparation: all verbs that have been theoretically studied are inserted into the valency lexicon manually, before the annotation starts (as an "inspiration" for the first pass annotation).

- First pass annotation: every verb is inserted or changed in the valency lexicon by the annotator, and an appropriate reference is inserted to the word being annotated, and elided nodes are inserted (such as general actors, dropped subjects, etc.). Nouns are inserted only if they are regular verbal derivatives. However, noun complements already present in the annotation trees are labeled "correctly" (as if their valency lexicon entry exists).

- All verbs are manually checked and corrected (by a single person, for consistency reasons) based on examples extracted from the corpus, independent research in the Czech National Corpus (as generalized in the VALLEX lexicon), and annotator comments and temporary lexicon entries. See Fig. 2 for an idea what is being done at this phase; the tool also allows for full search capability in the annotated treebank data.

- In parallel with the previous step, all nouns and adjectives that have been annotated at least once with a valency-related complement are extracted and merged with nouns and adjectives already in the lexicon, together with the

formal); the same cannot be said about nouns and adjectives which are still under development that is indeed based, i.a., on a feedback from the corpus annotation.
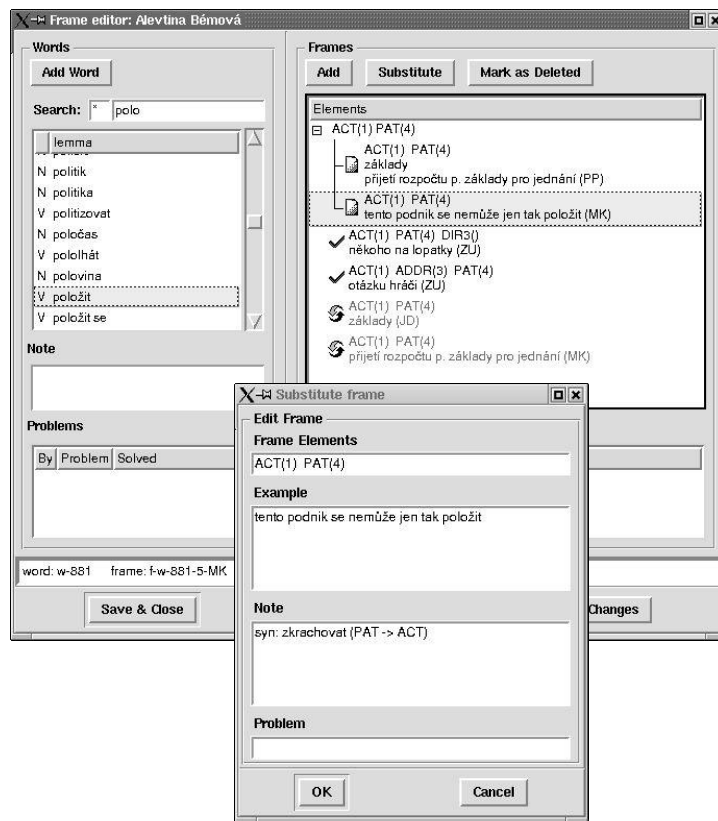
Figure 2: Editing window(s) for PDT-VALLEX

valency frame fragments as found in the annotated trees. Subsequently they are merged, checked and corrected, again by a single person to insure maximum consistency.

- After the valency lexicon is considered complete and correct, a second manual pass checks and/or corrects all occurrences of verbs, nouns and adjectives in the corpus, aided by a tool minimizing the amount of manual work.

- Finally, a full check is run automatically through the whole corpus to see if the dependents of such words are consistent with the referenced valency frames, and any errors are corrected.

In the end, every token in the treebank that corresponds to a word that has an entry in the valency lexicon contains a reference to the appropriate valency frame in the lexicon as selected by the annotator. Moreover, the annotation of the dependents is valency-consistent; it includes the annotation of inserted nodes (for dropped, elided or controlled actors, patients, and other obligatory slot fillers).

6 Verb vs. Noun and Adjective Valency

One of the interesting aspects of including nouns and adjectives in the valency dictionary is that for many of them (the deverbal ones), their underlying verb's valency is preserved together with its form after certain transformations ([15], [13]). For example, in a prototypical example of a transitive verb with an Actor in nominative and Patient in accusative, the derived noun's valency frame has also an Actor and a Patient, but Actor's form is either genitive, instrumental or a possessive adjective or pronoun, and Patient's form is genitive. Such (relatively) regular transformations apply both to regularly derived deverbal nouns (corresponding to English gerundive nominals) as well as to non-productive (irregular) derivations (corresponding to English derived nominals, cf. [2], p. 60, [1], pp. 1-9).

Whereas the derived nouns and adjectives mostly share the valency frames of their respective sources, however, the primary nouns and adjectives may have their own valency frames given by their lexical meanings and syntactic properties. In this case, the set of their specific valency complements must be studied: For the (primary) nouns the two specific functors (valency relations) have been added:

- obligatory Appurtenance with the nouns as *bratr* (*brother*), *povrch* (*surface*), *tvar* (*shape*)

- Material (obligatory with the nouns as *skupina* (*group*), *tucet* (*dozen*), optional with other (*sklenice* (*glass*), *košík* (*basket*), *šálek* (*cup*))

The same criteria as for the determination of the obligatoreness and optionality of the valency members with verbs were used here (the so-called dialog test, [14], and also Sect. 2). However, there are some open theoretical questions: the nouns as *glass*, *basket*, *cup* etc. could be considered as ambiguous with one meaning (a container) having an obligatory slot for Material, and the second meaning (an object) with an empty valency frame. However, the difference between these two meanings is too vague to be reflected in the lexicon, therefore a single lexical item for *glass*, *basket*, *cup* etc. will be introduced in the lexicon with an optional slot for potential valency with a value Material. Similar solution seems to be satisfactory for some cases of valency of primary adjectives: *Hrdý*, *pyšný* (*proud*), *nervózní*, *zoufalý* (*nervous, helpless*) may be used either as an "absolute" quality as in (10) and (11) below, or with their respective valency complements as in (12) a (13)

(10) *Je to hrdý člověk.* (Lit. *He is a proud person.*)

(11) *Matka je nervózní.* (Lit. *My mother is nervous.*)

(12) *Otec je pyšný na svou dceru.* (Lit. *Father is proud of his daughter.*)

(13) *Je nervózní ze zkoušek.* (Lit. *She is nervous because of the exam.*)

A single lexical item will be introduced for them with a slot for an optional Patient.

7 Valency and Surface Ellipsis

The importance of valency lexicon for the procedure of syntactic annotation was stressed above. However, the annotators faced very often the situation that an obligatory valency slot is missing in the input text (annotated sentence). Such surface zero elements must be restored in the tectogrammatical structure.

There are several reasons why a valency member might not be present on the surface:

- The omitted element can be easily understood and restored from the context, because its deletion is conditioned by the text structure (the first argument (Actor) is regularly omitted in pro-drop languages, the Patient and other participants are omitted e.g. in the text pattern "question - answer": *Přinesl listonoš noviny?* (Lit. *Did-bring mailman the-newspaper?*), *Přinesl* (Lit. *Did-bring*) (Actor, Patient deleted).

- An anaphoric element (known from the context) is deleted: *Přátelé už přijeli* (Lit. *Our friends have just arrived*): either *sem* (*here*) or *tam* (*there*) must be inserted in the annotation, reflected in the lexicon also as obligatory, but omittable on the surface. Similarly, there are *explanation (ACT) (ADDR) that he had lost the tickets* (cf. [8], pp. 284-285) two participants are missing (*who* explained to *whom*) and the appropriate nodes must be inserted into the annotation.

- The participant fitting an obligatory slot is generalized (what is reflected on the surface as a "zero"), e.g. *Na začátku věty se (ACT) píše velké písmeno* (Lit. *At the-beginning of-a-sentence is (ACT) written capital letter*). An annotator adds a new node with a proper functor.

- The position of obligatory participant is again empty, however, its lexical setting can be inferred from the context: *Vláda zítra projedná návrhy (ACT) (ADDR) na změny v sociálním pojištění* (Lit. *The-government tomorrow has-on-agenda proposals (ACT) (ADDR) for changes in social security*). The lexical setting of the obligatory slots of the noun *návrh* (*proposal*) is unspecified in the context, it could be only guessed. However, since these slots are given in the lexicon as obligatory, an annotator has to introduce new nodes marked "Unspecified" in the tectogrammatical structure with its proper functor.

8 Related Work, Future Work and Conclusions

As far as we know, the Prague Dependency Treebank will be one of the only two annotated corpora that are complemented by a valency lexicon, fully referenced from the nodes of the annotated dependency trees, with dependents' annotation

consistent with the selected valency frame[10]. The VALLEX lexicon with its 1,450 verbs with rich information has already been released ([12]) and is available from the Center for Computational Linguistics, and the PDT-VALLEX (with fully referenced corpus) will be released as part of the Prague Dependency Treebank, ver. 2.0, in the fall of 2004 (by the Linguistic Data Consortium in Philadelphia).

We expect to continue the development of the valency lexicon as further annotation in the future progresses (on top of PDT 2.0, there are business texts waiting to be annotated, and possibly some others), and eventually to have a fully specified valency dictionary (as rich as the current VALLEX) with consistent references from the annotated data (even though it might mean some re-annotation of the references or even the data if changes are inevitable). Also, we would like to continue in the direction of automatic valency frame extraction from both annotated and unannotated (or at least, not tectogrammatically annotated) corpora. We hope that such a broad coverage and rich lexicon can help an automatic tectogrammatical parser to learn and subsequently parse with high accuracy.

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[10]The other one being the so-called PropBank ([9], [10]), based on the Penn Treebank and annotated for predicate-argument structure (which is similar to our notion of valency). PropBank, however, does not annotate nouns nor adjectives with the predicate-argument structure, and it does not contain formally defined expression means (prepositions etc.) for every slot (argument).

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