Independent Study: Computational Paninian Grammar **Spring 2013**

Lecture 1: January 21

Professor: Dr. Dipti Misra *Tags: CPG,Intro*

1.0.1 Introduction

The Karaka system serves as the basis for description of Panini's Syntax. It is a syntacito-semantic representation of the relations between the verb/its derivatives and the direct participants of the action in the sentence.

1.0.2 Definitions

Panini's work is explained, extended, commented and reinterpreted by many authors like kAtyayana, patanjali, bhartrhari and others. This section includes some of the definitions of the "kAraka".

- **Patanjali**, in his Mahabhashya defines "kAraka" as "karOti iti" ("The one that does")
- The author of **kAsika** explains it as being synonymous to "hEtu" and "nimitta" (Cause) - "kArakam hEtur ity anarthAntaram" (" Cause and kArakam are one and the same ")
- **Bhartrhari** uses the term "sAdhanam" to specify kAraka as the one capable of establishing action which is given the term "sAdhya".
- **NagEsa** defines kAraka as the one that producces the action.

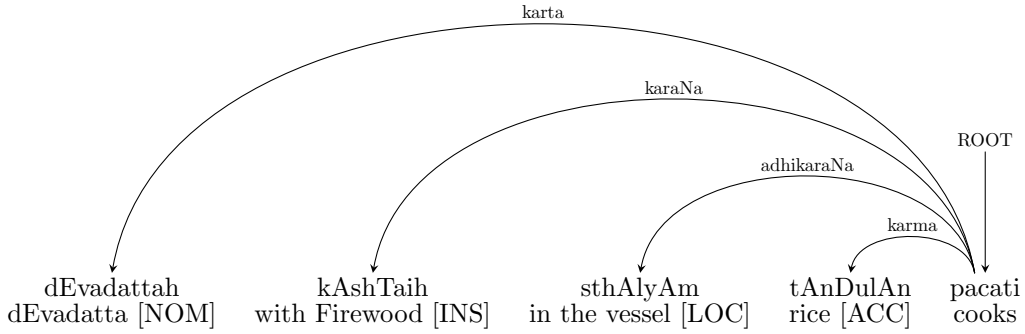
Therefore, we may say that kAraka is a animate/inanimate, passively/actively involved entity in the acomplishment of an action. The relations between the verb ("kriya") and the kAraka are of the type visheshaNa - visheshya (Modifier - Modified).

There are six kArakas. They are specified below briefly. (Written as per the order)

- **apAdAnam** : Defined as *"dhruvam apAye pAdAnam"* - The Entity which remains constant when seperation takes place
- **sampradAnam** : *"karmaNA yam abhipraiti sa sampradAnam"* - Is the entity for which the karma is intended.
- **karaNam** : Is defined as the most effective means of accomplishing the action - *''sAhakatamam karaNam"*
- **adhikaraNam** : *"AdhAro' dhikaraNam"* - Specifies the location an time of the activity.
- **karma** :
- **karta** : *"svatantrAh karta"* - This is the entity which is considered by the speaker as the most independent of all the other kArakAs in an activity.

1.0.3 Examples

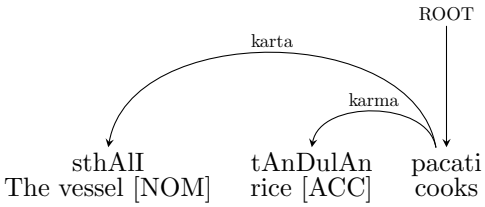
Consider the following sentence and its respective dependency relations.



"(1) dEvadatta cooks the rice with the firewood in the vessel "

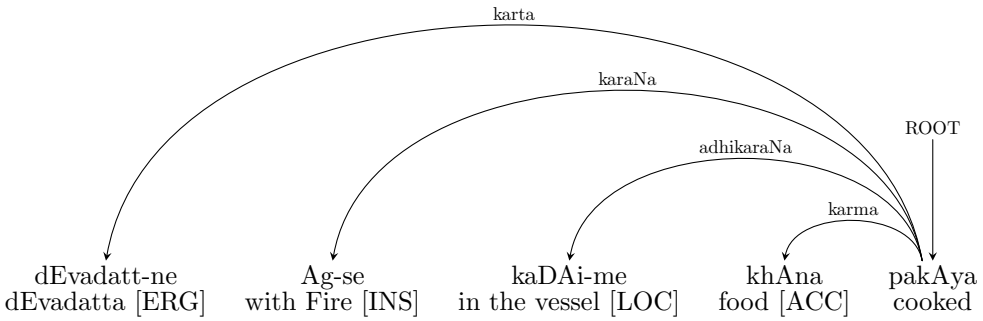
There are four dependency relations in the above sentence. They are karta (which now, is in the role of Agent), karma (which now, acts as the object), karaNa (Instrument), and adhikaraNa (The location).

Now, it is the nature of the natural language that it allows its speaker to focus some actors/participants and decrease the relative importance of the others. In that context, the above situation can also be expressed using the following sentence.

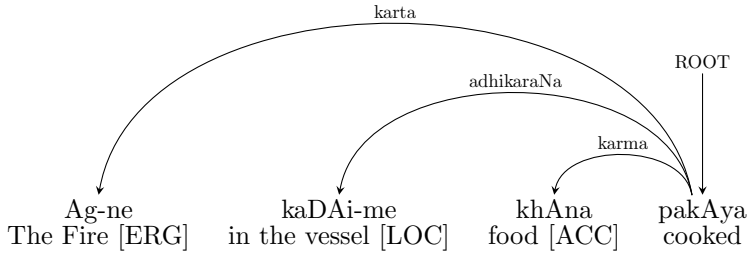


"(2) The vessel cooks the rice "

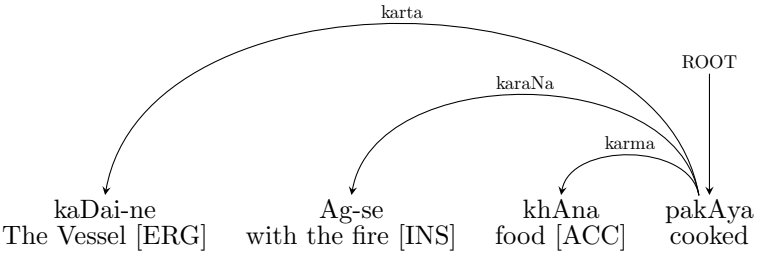
In this sentence (2), the speaker emphasizes upon "sthAli" (the vessel) making it the most independent entity of all other participants in the sentence thus, making it the "karta", the predominantly important participant in any sentence. Here, the vessel is raised to the level of karta in the absence of "dEvadatta", so as to give importance to the vessel. Similarly, any other participants (*) may be raised to the level of karta. To Illustrate this, consider the following sentences in Hindi.



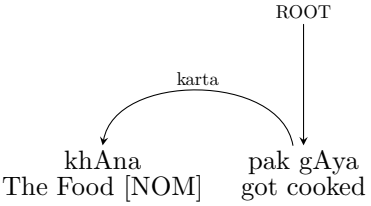
"(3) dEvadatta cooked the rice with the fire in the vessel "



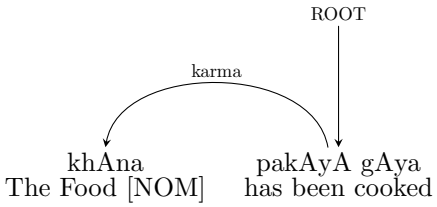
"(4) The fire cooked the rice in the vessel "



"(5) The vessel cooked the rice with the fire "



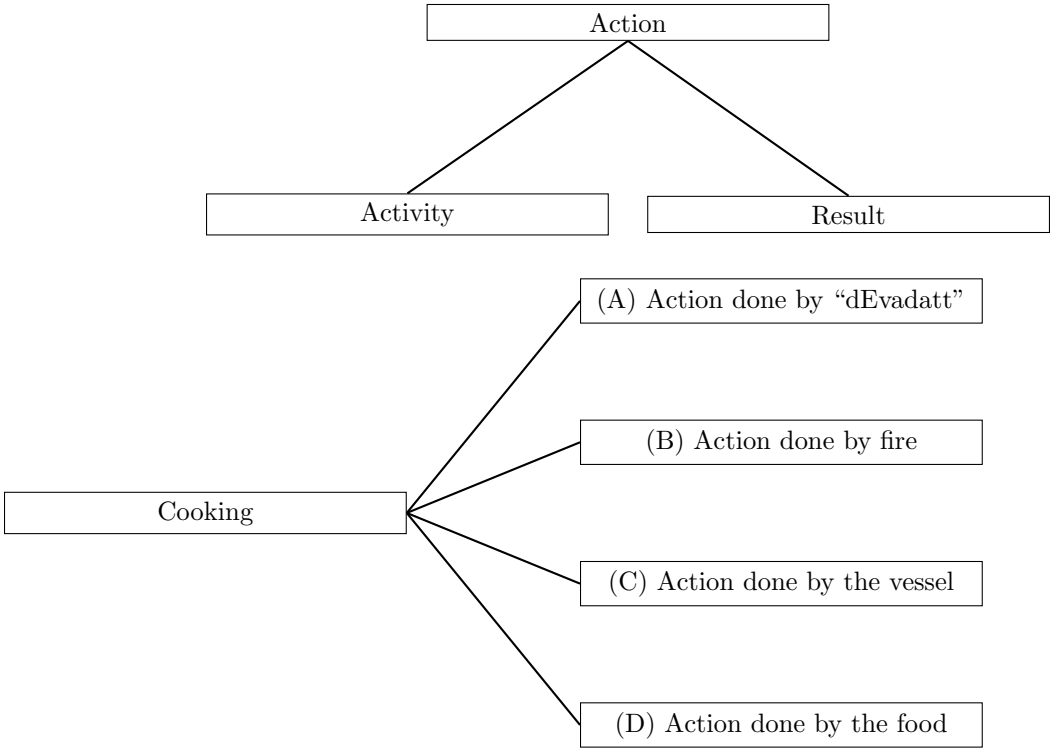
"(6) The rice got cooked "



"(7) The rice has been cooked "

In the above sentences, we can see that different participants can be elevated to the level of karta if the speker wishes to emphasize on that particular participant and make it indenpendent among the others. At this stage we state that, each action comprises of an "Activity" and a "Result". We then define the "karta" as the locus of the activity and "karma" as the locus of the result. The accomplishment of an action requires other participants and these are the actors of a series of subactions that complete it.

Therefore, the act of cooking comprises the subactions performed by "dEvadatt" (Say, putting the vessel on the fire), the action performed by the fire (Heating), the vessel (Transmission of the heat) and the food (Getting cooked).



Given this, the verb form may be transformed to represent any of the above activities. So, the sentences (3),(4),(5),(6) can be explained as follows.

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From the sentences (3) and (4)

1.1 Some theorems and stuff

We now delve right into the proof.

Lemma 1.1 *This is the first lemma of the lecture.*

Proof: The proof is by induction on .... For fun, we throw in a figure.

Figure 1.1: A Fun Figure

This is the end of the proof, which is marked with a little box. ■

1.1.1 A few items of note

Here is an itemized list:

- this is the first item;
- this is the second item.

Here is an enumerated list:

1. this is the first item;
2. this is the second item.

Here is an exercise:

Exercise: Show that P $\neq$ NP.

Here is how to define things in the proper mathematical style. Let f_k be the $AND - OR$ function, defined by

$$f_k(x_1, x_2, \ldots, x_{2^k}) = \begin{cases} x_1 & \text{if } k = 0; \\ AND(f_{k-1}(x_1, \ldots, x_{2^{k-1}}), f_{k-1}(x_{2^{k-1}+1}, \ldots, x_{2^k})) & \text{if } k \text{ is even;} \\ OR(f_{k-1}(x_1, \ldots, x_{2^{k-1}}), f_{k-1}(x_{2^{k-1}+1}, \ldots, x_{2^k})) & \text{otherwise.} \end{cases}$$

Theorem 1.2 *This is the first theorem.*

Proof: This is the proof of the first theorem. We show how to write pseudo-code now.

Consider a comparison between x and y:

if x or y or both are in S **then**
    answer accordingly
else
    Make the element with the larger score (say x) win the comparison
    if $F(x) + F(y) < \frac{n}{t-1}$ **then**
        $F(x) \leftarrow F(x) + F(y)$
        $F(y) \leftarrow 0$
    else
        $S \leftarrow S \cup \{x\}$
        $r \leftarrow r + 1$
    endif
endif

This concludes the proof. ■

1.2 Next topic

Here is a citation, just for fun [CW87].

References

[CW87] D. Coppersmith and S. Winograd, "Matrix multiplication via arithmetic progressions," *Proceedings of the 19th ACM Symposium on Theory of Computing*, 1987, pp. 1–6.

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