

Semantic processing in Pāṇini's *kāra*ka system

Girish Nath Jha¹, Sudhir K Mishra²

¹Special Center for Sanskrit Studies, J.N.U. New Delhi-110067
girishj@mail.jnu.ac.in

²CDAC Pune (Applied AI Group), Pune-411005
sudhirkumarmishra@gmail.com

Abstract

Pāṇini's grammar is widely known for its formal treatment of the Sanskrit language. Many scholars have earlier (Jha 2004) taken a systemic view of Pāṇini and have argued for easy implementation aspects of Pāṇini. However, on a closer look, several complications arise specially in Pāṇini's recourse to semantics in many of the *vidhi* and *saṃjñā* rules. This seems to happen more in the *kāra*ka *prakaraṇa* than in other components. The authors of this paper have focused on some of the semantic aspects of Pāṇini's *kāra*ka system and have highlighted the challenges in implementing these rules. For example, the semantic conditions to the definitions of some *kāra*kas like *karma* (*karturīpsitatamam* [most desired by kartā] *karma*), *karaṇa* (*sādhakatamam* [most instrumental/helpful] *karaṇam*), *sampradāna* (*karmaṇā yamabhipraiti* [*karma*'s *abhiprāya*], *rucyarthānām prīyamāṇaḥ* [in the sense of taste..]) etc. are difficult to formalize. The paper also looks at possible strategies to handle such situations, and presents pseudo-code like translations of some *kāra*ka rules.

Key words: *vārtika*, *kāra*ka, *vibhakti*, *upapada vibhakti*, *karma*pravacanīya, semantics, *śiva-sūtra*, *ṛgveda*, *nirukta*, *brāhmaṇa*, *śikṣā*, *prātiśākhya*, *kartṛ*, *karma*, *karaṇa*, *sampradāna*, *apādāna*, *adhikaraṇa*, *prathamā*, *dvitīyā*, *trītiyā*, *caturthī*, *pañcamī*, *ṣaṣṭhī*, *saptamī*, *ākāṅkṣā*, *yogyatā*, *vivakṣā*

1. Indian linguistic tradition: emphasis on semantics

Semantics and phonetics have been the basis of all linguistic analysis in the Sanskrit tradition before during and after Pāṇini. According to Nayar (2002), 'it was always held that all linguistic analysis is a step-by-step progress from sound to sense involving a series of contextualizations'. The *vyākaraṇa vedāṅga* which culminated in Pāṇini, provided steps for semantic interpretation through carefully crafted morpho-syntactic procedures often bordering on semantic conditions. Compared to earlier generative linguistics where semantics was given a lesser or no role, the Indian tradition has emphasized on a logical movement from sound to meaning. An utterance is contextualized, and the context is considered to be a playfield of semantics. We will do a quick survey of some relevant literature since *ṛgveda* to ascertain the role for semantic studies in the Indian linguistic tradition -

1.1 *ṛgveda*

ṛgveda is probably the earliest documentation on language. It emphasizes on the correctness of speech and refers to it in the following terms –

- source of happiness
- means of attaining desired ends
- revealer of true knowledge
- permeates every aspect of life
- nothing exists beyond language
- good speech is original and creative

and has many similar references at many places. The most appropriate references to language however are in the famous *vāk sūkta* (X.125). Let us look at some of its references to language below (Kapoor 93) -

- language is everywhere
- it is a cognitive instrument
- a source of power
- a social force
- the very basis of existence

vāk sūkta seems to be emphasizing on the social function of language the very basis of which is the correct interpretation

1.2 Yāska (*nirukta*)

Scholars like Kapoor (93) have argued that the very basis of Yāska's treatise on etymology was to prove that the vedas were indeed meaningful and could still be understood.

1.3 *brāhmaṇa* texts

Among the various *brāhmaṇa* texts, the *kauśītakī brāhmaṇa* praises the *kuru pāñcāla* speech. It eulogizes this speech as the abode of *vāk*. While clarifying the relation between speech and mind it says that speech is impossible without mind, that speech is preceded by mind, it expresses mind (*pañcaviṃśa brāhmaṇa*), that speech is the canal of mind (*jaiminīya brāhmaṇa*), that the mind is limited, speech is less comprehensive than mind (*śatapatha brāhmaṇa*).

1.4 *upaniṣadas*

They emphasize on the importance of correct speech and its social value. Among them, *praśnopaniṣad*, *māṇḍūkya*, *ṛhadāranyaka*, *kenopaniṣad*, *chāndogya* elaborate on the physics and metaphysics of speech in this context

1.5 śikṣā- prātiśākhya texts

The *vājasaneyī prātiśākhya* (also called *śukla yajurveda prātiśākhya*) emphasizes the importance of *samyak pāṭha*. *pāṇini-śikṣā* emphasizes the *śabdārtha* as the goal of phonetics

प्रसिद्धमपि शब्दार्थमविज्ञातमबुद्धिभिः
पुनर्व्यक्तीकरिष्यामि वाच उच्चारणे विधिम्

*prasiddhamapi shabdārthamavijñātamabuddhibhiḥ
punarvyaktīkariṣyāmi vāca uccāraṇe vidhim* (PS.2)

1.6 Patañjali

Patañjali states that one of the goals of linguistic study in Indian tradition was *rakṣā* (defense of scriptures). It could be done through grammar by explaining the meaning of scriptures to those who thought it was meaningless. He also emphasizes on the *samyak jñāna* (right knowledge) and *suṣṭhu prayoga* (precise usage) of a word.

1.7 Semantic roadblocks in Pāṇini

A complete computer simulation of Pāṇini has semantic hurdles to cross. This is due to the fact that the very basis of Pāṇini's processing is semantics. Cardona (2004) has also pointed to semantics being the basis of all derivations in Pāṇini. Ramanujam (2002) while describing his Desika application has expressed his frustration at semantic issues in Pāṇini – ‘there are quite a few issues which have no satisfactory method of handling at the moment. These obviously pertain to the semantics covered/sought to be conveyed by different word categories, as described by sage Pāṇini.’ Pāṇini's morpho-syntactic rules as seen in inflectional morphology (*subanta*, *tiṅanta*), derivational morphology (*kṛdanta*, *taddhita*, *strī pratyaya*, *samāsa*) and syntactico-semantic rules (*kāraka*) heavily depend on semantic conditions thereby making their implementation difficult.

2. Pāṇini's *kāraka-vibhakti* system

Etymologically *kāraka* is the name given to the relation between a noun and a verb in a sentence. It means ‘that which brings about’ or ‘doer’. Pāṇini (*kārake* 1.4.23) introduces *kāraḥ* probably as *adhikāra*. Normally technical terms are introduced in the nominative case but in 1.4.23, the term *kārake* is introduced in the locative case. Pāṇini discusses the entire gamut of *kāraka-vibhakti* relations in three sections of Aṣṭādhyāyī

- *kāraka sūtra* (1.4.23 – 1.4.55)
 - 33 *kāraka-sūtras* in the following sequence- *apādāna*, *saṃpradāna*, *kāraṇa*, *adhikāraṇa*, *karman* and *karṭṛ*
- *vibhakti sūtra* (2.3.1 - 2.3.73)

- *karma-pravacanīya* (1.4.82 – 1.4.97)

Patañjali defines it as ‘*karoti iti kārakam*’ (that which brings out or accomplishes action). Kātyāyana takes *kārake* as a *sañjñā sūtra*. Bhartṛhari (Bhatta 92) argues that *kāraka* is the capacity to produce an action. Nāgeśa interprets *kāraka* to be something having the capacity to accomplish an action. Jagadīśa (Bhatta 92) in his *śabdaśaktiprakāśikā* states that the meaning expressed by the particular post-nominal affix becomes the *kāraka*, if such a meaning to be related with the action expressed by the verb. Giridhara (*Vibhaktyarthanirṇaya*) adds some constraints to the theory of *kāraka* outlined by Jagadīśa. According to him the meaning of the post-nominal affixes can be regarded as *kāraka* provided that

- they are invariably related to an action
- they are never related to the meaning of any nominal stem
- they are not referred to by the post-nominal affixes that are added to a noun on account of the presence of another word.

Siddhānta Kaumudī’s section on cases is called *vibhaktyartha prakaraṇa* (the section dealing with the semantics of *vibhaktis*) by many scholars. Cardona (2004) describes it ‘participants in actions’. In the words of Ghildiyal (1962), ‘*Kāraḥ* are the meanings of *vibhaktis*. *Kāraḥ* are meanings and *vibhaktis* are their markers. There are three kinds of *vibhaktis* - *kāraka*, *upapada* and special cases.

- *kāraka vibhaktis* - *kartā*, *karma* etc
- *upapada vibhaktis* – those required by some padas for example - *dvitīyā vibhakti* is ordained in the case of following *upapada* - *abhītaḥ*, *parītaḥ*, *samayā*, *nikaṣā*
- special case *vibhaktis* – in the context of special meanings of some words, for example – in the *sūtra kālādhvanoratyantasamyoge* - *dvitīyā vibhakti* is ordained in the case of *kāla* and *adhva* meaning words if the activity is understood to be continuous.

3. Formalizing Pāṇini’s *kāraka* rules

The following sections attempt an algorithmic representation of the *kāraka sūtras*. The boldfaced words in Devanagari and Roman characters are the semantic conditions difficult to formalize and compute. The formulation of *karṭṛ kāraka* related rules are as follows

3.1 *karṭṛ kāraka*

Rule	1.4.54 : स्वतन्त्रः	कर्ता
Condition	<i>kāraka</i> independent of others	
Result	<i>karṭṛ kāraka</i>	
Code	{ कर्ता ([स्वतन्त्र]) }	

karṭṛ as *samradāna* –

Rule	1.4.40 : प्रत्याङ्भ्यां श्रुवः पूर्वस्य कर्ता
Condition	<i>śru</i> is used with prefix <i>prati</i> or <i>ān</i>
Result	<i>kartṛ</i> of prior act becomes <i>sampradāna</i>
Code	{ सम्प्रदान (कर्ता [पूर्व क्रिया (प्रति /आङ् + श्रु धातु)]) }
Example	विप्राय गां प्रतिशृणोति आशृणोति वा

Rule	1.4.41 : अनुप्रतिगृणश्च
Condition	<i>gṛ</i> is used with prefix <i>anu</i> or <i>prati</i>
Result	<i>kartṛ</i> of prior act becomes <i>sampradāna</i>
Code	{ सम्प्रदान (कर्ता [पूर्व क्रिया (अनु /प्रति + गृ धातु)]) }
Example	होत्रे अनुगृणाति प्रतिगृणाति वा

kartṛ as *karma* -

Rule	1.4.52: गतिबुद्धिप्रत्यवसानार्थं शब्दकर्माकर्मकाणामणिकर्ता स णौ
Condition	causative of the <i>gati</i> , <i>buddhi</i> , <i>prtyāvasāna</i> meaning verbs
Result	<i>kartṛ</i> becomes <i>karman</i>
Code	{ कर्म (कर्ता [णिजन्त (शब्दकर्मक गति , बुद्धि , प्रत्यवसानार्थक धातु , अकर्मक धातु)]) }
Example	शत्रून् अगमयत् स्वर्गम्

Some *vārtikas* –

Rule	<i>vārtika</i> : 1.4.52 : जल्पतिप्रभृत िनामुपसंख्यानम्
Condition	<i>kartṛ</i> of causative <i>jalp</i> or <i>bhāṣ</i>
Result	<i>karman kāraka</i> .
Code	{ कर्म (कर्ता [णिजन्त जल्प , भाष्]) }

Rule	<i>vārtika</i> : 1.4.52 : दृशेश्च
Condition	<i>kartṛ</i> of causative <i>dṛś</i> is used
Result	it becomes <i>karman kāraka</i> .
Code	{ कर्म (कर्ता [णिजन्त दृश्]) }

Vārtika : *kartṛ* as *karaṇa kāraka* -

Rule	<i>vārtika</i> : 1.4.52 : नीवहोर्न
Condition	<i>kartṛ</i> of causative <i>nī</i> or <i>vah</i> is used
Result	becomes <i>karaṇa</i> .
Code	{ करण (कर्ता [णिजन्त नी , वह्]) }
Example	नाययति वाहयति वा भारं भृत्येन

Rule	<i>vārtika</i> : 1.4.52: नियन्तृकर्तृकस्य वहेरनिषेधः
Condition	<i>kartṛ</i> of causative <i>vah</i> is also governing or restricting

Result	<i>karman kāraka</i> not <i>karaṇa kāraka</i> .
Code	कर्म { कर्ता (नियन्ता [गिजन्त वह]) }
Example	वाहयति रथं वाहान् सूतः

3.2 *karman kāraka*

Rule	1.4.49 : कर्तुरीप्सिततमं कर्म
Condition	most sought by <i>karṭṛ</i>
Result	<i>karman kāraka</i>
Code	{ कर्म (ईप्सिततम् [कर्ता]) }

Rule	1.4.50 : तथायुक्तं चानीप्सितम्
Condition	something not most sought by <i>karṭṛ</i>
Result	<i>Karman</i>
Code	{ कर्म (अनीप्सितम् [कर्ता]) }

two exceptions -

Rule	1.4.36 : स्पृहेरीप्सितः
Condition	most desired by <i>karṭṛ</i> with verbal base <i>sprh</i>
Result	<i>sampradāna kāraka</i> .
Code	{ सम्प्रदान (ईप्सित [स्पृह ईप्सायाम् धातु]) }

Rule	1.4.27 : वारणार्थानामीप्सितः
Condition	item desired by <i>karṭṛ</i> with verbal bases having the meaning of <i>vāraṇa</i>
Result	<i>apādāna kāraka</i> .
Code	{ अपादान (ईप्सित [वारणार्थक धातु]) }

Rule	1.4.38 : क्रुधदुहोरुपसृष्टयोः कर्मः
Condition	person towards whom anger is directed when the verb bases <i>krudha</i> (to be angry) and <i>druh</i> (to harm) are used with a preverb.
Result	<i>karman kāraka</i>
Code	{ कर्म (जिसके प्रति कोप हो [उपसर्ग युक्त क्रुध , दुह धातु]) }

3.3 *karaṇa kāraka*

Rule	1.4.42 : साधकतमं करणम्
Condition	The factor most effective in the accomplishment of the action
Result	<i>karaṇa kāraka</i> .
Code	[करण (साधकतम)]

3.4 *sampradāna kāraka*

Rule	1.4.32 : कर्मणा यमभिप्रेति स सम्प्रदानम्
Condition	That which the agent wants to connect with the object of the action of giving
Result	<i>dāna kāraka</i> .
Code	{ सम्प्रदान (यमभिप्रेति [कर्म द्वारा]) }
Rule	1.4.33 : रुच्यर्थानां प्रीयमाणः
Condition	in the sense of <i>ruc</i> the one who is pleased
Result	<i>sampradāna kāraka</i> .
Code	{ सम्प्रदान (प्रीयमाण [अभिलाषार्थक धातु]) }
Rule	1.4.34 : श्लाघहुङ्स्थ ाशपां जीप्स्यमानः
Condition	The person who is desired to be cognizant of the praise when verbal roots <i>ślāgha</i> (to praise), <i>hnuñ</i> (to hide), <i>sthā</i> (to stay) and <i>śapa</i> (to swear) are used.
Result	<i>sampradāna kāraka</i>
Code	{ सम्प्रदान (जीप्स्यमान [श्लाघ , हुङ् , इ , स्था , शप धातु]) }
Rule	1.4.35 : धारेरुत्तमर्णः
Condition	In the case of the use of the causal of <i>dhṛñ</i> (owe), the creditor
Result	<i>sampradāna kāraka</i> .
Code	{ सम्प्रदान (उत्तमर्ण [णिजन्त धृञ् धातु]) }
Rule	1.4.37 : कृधदुहेष्यासूयार्थानां यं प प्रति कोपः
Condition	To whom anger is directed when verb roots having the signification of <i>krudha</i> (to be angry), <i>druha</i> (to wish harm to), <i>īṛya</i> (not to tolerate) and <i>asūya</i> (to invent fault) are used
Result	<i>sampradāna kāraka</i> .
Code	{ सम्प्रदान (यं प्रति कोप ः [कृध , दुह , ईर्ष्य , असूयार्थक धातु]) }
Rule No.	1.4.39
Rule	राधीक्षचोर्यस्य विप्रश्नः
Condition	To whom many enquiries are made when verbal roots <i>rādha</i> (to prophesy) or <i>īkṣa</i> (observe) are used.
Result	<i>sampradāna kāraka</i>
Code	{ सम्प्रदान (विप्रश्न णः [राध , ईक्ष धातु]) }

3.5 *apādāna kāraka*

Rule	1.4.24 : ध्रुवमपायेऽपादानम्
Condition	The fixed point in relation to moving away
Result	<i>apādāna kāraka</i> .

Code	{ अपादान (ध्रुव [अपाय]) }
Rule	1.4.25 : भीत्रार्थानां भयहेतुः
Condition	in the sense of <i>bhī</i> (fearing) or <i>trā</i> (protecting), the item which causes fear
Result	<i>apādāna kāraka</i> .
Code	{ अपादान (कारण [भय , त्राणार्थक धातु]) }
Rule	1.4.26 : पराजेरसोढः
Condition	The item which is unbearable when verb base <i>ji</i> (to win) is used with the preverb <i>prā</i> .
Result	<i>apādāna kāraka</i>
Code	{ अपादान (असोढ [परा + जि धातु]) }
Rule	1.4.28 : अन्तर्धीं येनादर्शनमिच्छितः
Condition	The person by whom one wishes not to be seen through the use of something which comes in between
Result	<i>apādāna kāraka</i> .
Code	{ अपादान (जिससे छुपना [अन्तर्धान]) }
Rule No.	1.4.29
Rule	आख्यातोपयोगे
Condition	The person who relates is termed <i>apādāna kāraka</i> when regular instruction is denoted.
Code	{ अपादान (आख्याता [उपयोग]) }
Rule No.	1.4.30
Rule	जनिकर्तुः प्रकृतिः
Condition	The material cause from which the agent of the verbal base <i>jan</i> (to originate from) arises is called <i>apādāna kāraka</i> .
Code	अपादान { कारण (कर्ता [जन धातु]) }
Rule No.	1.4.31
Rule	भुवः प्रभवः
Condition	The place of origin for the agent of verb base <i>bhu</i> (to be, become) is called <i>apādāna kāraka</i> .
Code	अपादान { प्रभव (कर्ता [भू धातु]) }
Rule No.	<i>vārtika</i> for 2.3.28
Rule	जुगुप्साविरामप्रमादार्थानामुपसंख्यानम्
Condition	The factor most effective in the accomplishment of the action is termed <i>karaṇa kāraka</i> .
Code	{ अपादान (विषय [जुगुप्सा , विराम , प्रमादार्थक धातु]) }

3.6 *adhikaraṇa kāraka*

Rule No.	1.4.45
Rule	आधारोऽधिकरणम्
Condition	The locus of action is called <i>adhikaraṇa kāraka</i> .
Code	(अधिकरण [आधार])
Rule No.	1.4.46
Rule	अधीशोऽस्थासं कर्म
Condition	The locus is called <i>karman kāraka</i> when <i>śīn</i> (to recline), <i>sthā</i> (to stand) and <i>ās</i> (to sit) are used with the pre-verb <i>adhi</i> .
Code	{ कर्म (आधार [अधि + शीङ् , स्था , आस्]) }
Rule No.	1.4.47
Rule	अभिनिविशथ
Condition	The locus is called <i>karman kāraka</i> when <i>viś</i> (to enter) is used with the pre-verb <i>abhini</i> .
Code	{ कर्म (आधार [अभि + नि + विश्]) }
Rule No.	1.4.48
Rule	उपान्वध्याड्वसः
Condition	The locus is called <i>karman kāraka</i> when verbal base <i>vas</i> (to dwell) is used with the pre-verbs <i>upa</i> , <i>anu</i> , <i>adhi</i> or <i>ān</i> .
Code	{ कर्म (आधार [उप /अनु /अधि /आड् + वस्]) }
Rule No.	<i>vārtika</i> for 1.4.48
Rule	अभुक्त्यर्थस्य न
Condition	The factor most effective in the accomplishment of the action is termed <i>adhikaraṇa kāraka</i> .
Code	{ अधिकरण (आधार [उप + उपवासार्थक वस्]) }

Generally *saptamī vibhakti* (2.3.36) is used in *adhikaraṇa kāraka* but along with it *ṛtīyā* (2.3.44), *pañcamī* (2.3.42) and *ṣaṣṭhī* (2.3.38) *vibhaktis* are also used in *adhikaraṇa kāraka* which are thoroughly described in the *vibhakti* section

3.7 optional *kāraka*

There are three *kāraka sūtras* (and one *vārtika*) where more than *kāra*kas are possible. Pāṇini has a *sūtra* when *karṭṛ kāraka* is realized as *karman* or *karaṇa kāraka* optionally as follows-

Rule No.	1.4.53
Rule	हक्रोरन्यतरस्याम्
Condition	If <i>hṛ</i> or <i>kṛ dhātu</i> are used in causative forms then <i>karṭṛ</i> of the verb is termed optionally <i>karman</i> or <i>karaṇa kāraka</i> .
Code	{ कर्म /करण (कर्ता [णिजन्त ह , कृ धातु]) }

Kātyāyana added one *vārtika* in the above *sūtra* as a modification when *karṭṛ kāraka* is realized as *karman* or *karaṇa kāraka* optionally as follows

Rule No.	<i>vārtika</i> of 1.4.53
----------	--------------------------

Rule	अभिवादिदृशोरात्मनेपदे	वेति	वाच्यम्
Condition	If <i>karṭṛ</i> becomes <i>karman</i> or <i>karaṇa kāraka</i> .		
Code	{ कर्म /करण (कर्ता [अभि उपसर्ग + णिजन्त एवं आत्मनेपदीय वद् एवं दृश् धातु]) }		

Pāṇini makes provision for *karman* and *karaṇa kāraka* optionally in the next *sūtra* as follows

Rule No.	1.4.43
Rule	दिवः कर्म च
Condition	The most effective factor in the gambling is considered as <i>karman</i> or <i>karaṇa kāraka</i> .
Code	{ कर्म /करण (साधकतम [दिव धातु]) }

Pāṇini makes provision of *sampradāna* and *karaṇa kāraka* optionally in the next *sūtra* as follows

Rule No.	1.4.44
Rule	परिक्रयणे सम्प्रदानमन्यतरस्याम्
Condition	The most effective factor in effecting <i>parikrayaṇa</i> (hiring on stipulated wages) is optionally treated as <i>sampradāna</i> or <i>karaṇa kāraka</i> .
Code	{ सम्प्रदान /करण (साधकतम [परिक्रयण]) }

Pāṇini makes provision for *karman* and other *kāraḥ* optionally in the next *sūtra* as follows

Rule No.	1.4.51
Rule	अकथितं च
Condition	That <i>kāraka</i> which has not yet been mentioned is called <i>karman kāraka</i> .
Code	{ कर्म (कर्ता /कर्म /करण /सम्प्रदान /अपादान /अधिकरण [अकथित]) }

4. Formalizing Pāṇini's *vibhakti* rules

The following sections attempt a formal representation of the *vibhakti* rules of Pāṇini

4.1 *prathamā vibhakti*

Rule No.	2.3.46
Rule	प्रातिपदिकार्थलिङ्गपरिमाणवचनमात्रे प्रथमा
Condition	The <i>prathamā vibhakti</i> is used when <i>prātipadikārtha</i> (nominal stem meaning), <i>liṅga</i> (gender), <i>parimāṇa</i> (measure) or <i>vacana</i> (number) is to be expressed.
Code	{ प्रथमा (प्रातिपदिका थं [जाति , व्यक्ति] , लिङ्ग , परिमाण , वचन) }
Rule No.	2.3.47
Rule	सम्बोधने च

Condition	The <i>prathamā vibhakti</i> is used when <i>sambodhana</i> (address) is to be expressed.
Code	{ प्रथमा (सम्बोधन) }

4.1.1 optional *prathamā vibhakti*

Kātyāyana adds two *vārtika* related to *prathamā vibhakti* where it is used optionally as follows

Rule No.	<i>vārtika</i> for 1.4.31
Rule	तद्युक्तादध्वनः प्रथमासप्तम्यो
Condition	The space or distance measured from the point takes either <i>prathamā</i> or <i>saptamī vibhakti</i> .
Code	{ प्रथमा , सप्तमी (मार्गवाची शब्द [तद्युक्त]) }
Rule No.	<i>vārtika</i> for 2.3.27
Rule	निमित्तपर्यायप्रयोगे सर्वासां प्रायदर्शनम्
Condition	All <i>vibhaktis</i> are used in synonyms of word <i>nimitta</i> such as <i>hetu</i> , <i>kāraṇa</i> , <i>prayojana</i> etc. But words other than the pronoun do not take <i>prathamā</i> or <i>dviṭīyā vibhakti</i> .
Code	{ प्रथमा , द्वितीया , तृतीया , चतुर्थी , पञ्चमी , षष्ठी , सप्तमी (सर्वनाम + निमित्तार्थक शब्द) }

4.2 *dviṭīyā vibhakti*

Rule No.	2.3.4
Rule	अन्तराऽन्तरेण युक्ते
Condition	The <i>dviṭīyā vibhakti</i> is added when <i>antarā</i> (between) and <i>antareṇa</i> (without) are in use.
Code	{ द्वितीया (सम्बन्ध [अन्तरा , अन्तरेण]) }
Rule No.	2.3.5
Rule	कालाध्वनोरत्यन्तसंयोगे
Condition	If <i>atyantasamyoga</i> (continuous connection) is signified then <i>dviṭīyā vibhakti</i> is used in words which are denoting <i>kāla</i> (time) and <i>mārga</i> (path) with some <i>kriyā</i> (action), <i>dravya</i> (thing) or <i>guṇa</i> (quality) is denoted.
Code	{ द्वितीया (कालवाचक , मार्गवाचक शब्द [संयोग]) }
Rule No.	2.3.8
Rule	कर्मप्रवचनीययुक्ते द्वितीया
Condition	A word in construction with a <i>karmapravacanīya</i> takes <i>dviṭīyā vibhakti</i> .
Code	{ द्वितीया (कर्मप्रवचनीय) }

Kātyāyana adds two *vārtikas* related to *dviṭīyā vibhakti* which are as follows

Rule No.	<i>vārtika</i> for 1.4.48
Rule	उभसर्वतसोः कार्या धिगुपर्यादिषु त्रिषु द्वितीयामेडितान्तेषु ततोऽन्यत्रापि दृश्यंते
Condition	The <i>dvitīyā vibhakti</i> is used after words in composition with <i>ubhayataḥ, sarvataḥ, dhik, upari-upari, adhyadhi</i> and <i>adho'dhaḥ</i> .
Code	{ द्वितीया (सम्बन्ध [उभयतः , सर्वतः , धिक् , उपर्युपरि , अद्यधि , अधोऽधः]) }

Rule No.	<i>vārtika</i> for 1.4.48
Rule	अभितः परितः समयानिकषा हा प्रतियोगेऽपि
Condition	The <i>dvitīyā vibhakti</i> is used after words in composition with <i>abhitaḥ, paritaḥ, samayā, nikaṣā, hā</i> and <i>prati</i> .
Code	{ द्वितीया (सम्बन्ध [अभितः , परितः , समया , निकषा , हा , प्रति]) }

4.2.1 optional *dvitīyā vibhakti*

Pāṇini makes provision of *dvitīyā* and *ṣaṣṭhī vibhakti* optionally in the following *sūtra*

Rule No.	2.3.31
Rule	एनपा द्वितीया
Condition	The <i>dvitīyā</i> and <i>ṣaṣṭhī vibhakti</i> is optionally used in conjunction with another stem which ends in affix <i>enap</i> (5.3.35).
Code	{ द्वितीया , षष्ठी (सम्बन्ध [एनप् प्रत्ययान्त]) }

Pāṇini makes provision of *dvitīyā, tṛtīyā* and *pañcamī vibhakti* optionally in the following two *sūtra*-

Rule No.	2.3.32
Rule	पृथग्विनानानाभिस्तृतीयान्यतरस्याम्
Condition	The <i>dvitīyā, tṛtīyā</i> and <i>pañcamī vibhakti</i> is optionally used after a stem in conjunction with <i>pṛthak</i> (a part from), <i>vinā</i> (excluding) or <i>nānā</i> (different from).
Code	{ द्वितीया , तृतीया , पञ्चमी (सम्बन्ध [पृथक् , विना , नाना]) }

Rule No.	2.3.35
Rule	दूरान्तिकार्थेभ्यो द्वित्तीयया च
Condition	A <i>dvitīyā, tṛtīyā</i> and <i>pañcamī vibhakti</i> is optionally occurs after <i>dūra</i> (far), <i>antika</i> (near) or their synonyms.
Code	{ द्वितीया , तृतीया , पञ्चमी (सम्बन्ध [दूरार्थक , अन्तिकार्थक शब्द]) }

4.3 *tṛtīyā vibhakti*

Pāṇini describes *ṛtīyā vibhakti* in five *sūtras* and in other five *sūtras*, the *ṛtīyā vibhakti* becomes optional. There are three suffixes [P4.1.2] in *ṛtīyā vibhakti* as *ṛā*, *bhyām* and *bhis*. They are used to express respectively for *ekavacana*, *dvivacana* and *bahuvacana*[P1.4.21-22]. The formulation of *ṛtīyā vibhakti* related rules are as follows

Rule No.	2.3.6
Rule	अपवर्गे तृतीया
Condition	A <i>dviṛīyā</i> , <i>ṛtīyā</i> and <i>pañcamī vibhakti</i> is optionally occurs after <i>dūra</i> (far), <i>antika</i> (near) or their synonyms.
Code	{ तृतीया (सम्बन्ध [दूरार्थक , अन्तिकार्थक शब्द]) }

5. *karmapravacanīyas*

The following sections present a formalization of the *karmapravacanīya* related *sūtras*

5.1 *anu karmapravacanīya*

Pāṇini makes *karmapravacanīya samjñā* of *anu* in four semantic conditions and allows for *dviṛīyā vibhakti* [2.3.8]

Rule No.	1.4.84
Rule	अनुर्लक्षणे
Condition	when <i>anu</i> is denoting <i>lakṣaṇa</i> (characteristic mark's).
Rule No.	1.4.85
Rule	तृतीयार्थे
Condition	when <i>anu</i> is denoting the sense of <i>ṛtīyā</i> (third triplet of <i>sup</i>).
Rule No.	1.4.86
Rule	हीने
Condition	when <i>anu</i> is denoting <i>hīna</i> (less, inferior).
Rule No.	1.4.90
Rule	लक्षणेत्थम्भ्र ूताख्यानभागवीप्सासु प्रतिपर्यनवः
Condition	when <i>anu</i> is denoting <i>lakṣaṇa</i> (characteristic mark), <i>itthambhūtākhyāna</i> (characterizing a as b), <i>bhāga</i> (share) or <i>vīpsā</i> (pervasion).

Combined pseudo-code of the *sūtras* 1.4.84-86 and 1.4.90 can be given as follows-

```
{
  कर्मप्रवचनीय
  ( अनु
    [
      लक्षणार्थक
      सहभाव , साहित्यार्थक
      हीनार्थक
      लक्षणार्थक ,इत्थम्भ्रूताख्यान ,भाग , वीप्सार्थक
    ]
  )
}
```

}

5.2 *upa karmapravacanīya*

Pāṇini makes *karmapravacanīya samjñā* of *upa* in one semantic condition and allows for *saptamī vibhakti* [2.3.9] as follows

Rule No.	1.4.87
Rule	उपोऽधिके च
Condition	when <i>upa</i> is denoting <i>adhika</i> (more) or <i>hīna</i> (less, inferior)
Code	{ कर्मप्रवचनीय (उप [अधिक , हीन अर्थ]) }

5.3 *apa karmapravacanīya*

Pāṇini makes *karmapravacanīya samjñā* of *apa* in one semantic condition and allows for *pañcamī vibhakti* [2.3.10] as follows

Rule No.	1.4.88
Rule	अपपरी वर्जने
Condition	when <i>apa</i> is denoting <i>varjana</i> (exclusion)
Code	{ कर्मप्रवचनीय (अप [वर्जन]) }

5.4 *pari karmapravacanīya*

Pāṇini makes *karmapravacanīya samjñā* of *pari* in three semantic conditions with provisions for *pañcamī* [2.3.10] and *dviṭīyā* [2.3.8] *vibhaktis* as follows

Rule No.	1.4.88
Rule	अपपरी वर्जने
Condition	when <i>pari</i> is denoting <i>varjana</i> (exclusion)
Code	{ कर्मप्रवचनीय (परि [निषेधार्थक]) }

Rule No.	1.4.90
Rule	लक्षणेत्थम्भूताख्यानभागवीप्सासु प्रतिपर्यनवः
Condition	when <i>pari</i> is denoting <i>lakṣaṇa</i> (characteristic mark), <i>itthambhūtākhyāna</i> (characterizing a as b), <i>bhāga</i> (share) or <i>vīpsā</i> (pervasion).
Code	{ कर्मप्रवचनीय (परि [लक्षण , इत्थम्भूताख्यान , भाग , वीप्सार्थक]) }

Rule No.	1.4.93
Rule	अधिपरी अनर्थको
Condition	when <i>pari</i> is denoting <i>anarthaka</i> (<i>avidyamānārtha</i>).
Code	{ कर्मप्रवचनीय (परि [अनर्थक]) }

5.5 āñ karmappravacanīya

Pāṇini makes *karmappravacanīya samjñā* of *āñ* in one semantic condition and allows for *pañcamī vibhaktis* [2.3.10] as follows

Rule No.	1.4.89
Rule	आङ् मर्यादावचने
Condition	when <i>āñ</i> is denoting <i>maryādā</i> (extent spatial limit).
Code	{ कर्मप्रवचनीय (आङ् [मर्यादा एवं अभिविध्यार्थक]) }

4.6 prati karmappravacanīya

Pāṇini makes *karmappravacanīya samjñā* of *prati* in three semantic conditions and allows for *dviṭīyā* [2.3.8] and *pañcamī* [2.3.11] *vibhaktis* as follows

Rule No.	1.4.90
Rule	लक्षणेत्थम्भूताख्यानभागवीप्सासु प्रतिपर्यनवः
Condition	when <i>prati</i> is denoting <i>lakṣaṇa</i> (characteristic mark), <i>itthambhūtākhyāna</i> (characterizing a as b), <i>bhāga</i> (share) or <i>vīpsā</i> (pervasion).
Code	{ कर्मप्रवचनीय (प्रति [लक्षण , इत्थम्भूताख्यान , भाग , वीप्सार्थक]) }

Rule No.	1.4.92
Rule	प्रतिः प्रतिनिधिप्रतिदानयोः
Condition	when <i>prati</i> is denoting <i>pratinidhi</i> (representative, proxy) or <i>pratidāna</i> (exchange).
Code	{ कर्मप्रवचनीय (प्रति [प्रतिनिधि एवं प्रतिदानार्थक]) }

5.7 abhi karmappravacanīya

Pāṇini makes *karmappravacanīya samjñā* of *abhi* in one semantic condition and allows for *dviṭīyā* [2.3.8] *vibhakti* as follows

Rule No.	1.4.91
Rule	अभिरभागे
Condition	when <i>abhi</i> is denoting <i>lakṣaṇa</i> (characteristic mark), <i>itthambhūtākhyāna</i> (characterizing a as b) or <i>vīpsā</i> (pervasion).
Code	{ कर्मप्रवचनीय (अभि [लक्षण , इत्थम्भूताख्यान , वीप्सार्थक]) }

5.8 adhi karmappravacanīya

Pāṇini makes *karmappravacanīya samjñā* of *adhi* in three semantic conditions and allows for *dviṭīyā* [2.3.8] and *saptamī* [2.3.9] *vibhaktis* as follows

Rule No.	1.4.93
Rule	अधिपरी अनर्थको
Condition	when <i>adhi</i> is denoting <i>anarthaka</i> (<i>avidyamānārtha</i>)
Code	{ कर्मप्रवचनीय (अधि [अनर्थक]) }
Rule No.	1.4.97
Rule	अधिरीश्वरे
Condition	when <i>adhi</i> is denoting <i>īśvar</i> (lord, master).
Code	{ कर्मप्रवचनीय (अधि [ईश्वरार्थक]) }
Rule No.	1.4.98
Rule	विभाषा कृञि
Condition	when <i>adhi</i> is used in sense of <i>īśvar</i> (lord, master) with verbal base <i>ḍukṛñ karāṇe</i> (to do, make).
Code	{ कर्मप्रवचनीय (अधि [ईश्वरार्थक अधि + कृञ् धातु]) }

5.9 *su karmappravacanīya*

Pāṇini makes *karmappravacanīya samjñā* of *su* in one semantic condition as follows

Rule No.	1.4.94
Rule	सुः पूजायाम्
Condition	when <i>su</i> is denoting <i>pūjā</i> (respect, praise)
Code	{ कर्मप्रवचनीय (सु [पूजार्थक]) }

5.10 *ati karmappravacanīya*

Pāṇini makes *karmappravacanīya samjñā* of *ati* in one semantic condition and allows for *dviṭīyā* [2.3.8] *vibhakti* as follows

Rule No.	1.4.95
Rule	अतिरतिक्रमणे च
Condition	when <i>ati</i> is denoting <i>atikramaṇa</i> (excelling) or <i>pūjā</i> (respect, praise)
Code	{ कर्मप्रवचनीय (अति [अतिक्रमण एवं पूजार्थक]) }

5.11 *api karmappravacanīya*

Pāṇini makes *karmappravacanīya samjñā* of *api* in one semantic condition as follows

Rule No.	1.4.96
Rule	अपिः पदार्थसम्भावनान्ववसर्गगर्हासमुच्चयेषु

Condition	when <i>api</i> is denoting <i>padārtha</i> , <i>sambhāvana</i> , <i>anvavasarga</i> , <i>garhā</i> and <i>samuccaya</i> .
Code	{ कर्मप्रवचनीय (अपि [पदार्थ , स म्भावन , अन्ववसर्ग , गर्हा एवं समुच्चयार्थक]) }

6. *kāraka* and *vibhakti* mapping

Pāṇini discusses the entire gamut of *kāraka-vibhakti* relations in three sections of Aṣṭādhyāyī –

- *kāraka sūtra* (1.4.23 – 1.4.55) → 33 *sūtras*
- *vibhakti sūtra* (2.3.1 - 2.3.73) → 73 *sūtras*
- *karma-pravacanīya* (1.4.82 – 1.4.97) → 16 *sūtras*

These rules have been explained in a tabular form as follows

<i>kāraka</i>	<i>sūtra</i>	Explanation	<i>vibhakti/s</i>
<i>karṭṛ</i>	P 1.4.54	One which is independent (the most important source) in any action and executes the action	P 2.3.46 → <i>prathamā</i>
			P 2.3.18 → <i>ṭṛtīyā</i>
			P 2.3.65 → <i>ṣaṣṭhī</i>
<i>karman</i>	P 1.4.49	which is most desired of agent through his action	P 2.3.2 → <i>dviṭīyā</i>
			P 3.4.69 → <i>prathamā</i>
			P 2.3.12 → <i>caturthī</i>
			P 2.3.65 → <i>ṣaṣṭhī</i>
<i>karaṇa</i>	P 1.4.42	that which is most instrumental in accomplishment of an action	P 2.3.18 → <i>ṭṛtīyā</i>
			P 1.4.43 → <i>dviṭīyā</i>
<i>sampradāna</i>	P 1.4.32	whosoever the agent approaches for the object of the act of giving/benefit	P 2.3.13 → <i>caturthī</i>
			P 2.3.12 → <i>dviṭīyā</i>
			P 1.4.44 → <i>ṭṛtīyā</i>
<i>apādāna</i>	P 1.4.24	that from which/where separation/departure is meant	P 2.3.28 → <i>pañcamī</i>
			P 2.3.35 → <i>ṭṛtīyā</i>
			P 2.3.32 → <i>dviṭīyā</i>
<i>adhikaraṇa</i>	P 1.4.45	that which is the locus/ substratum of the action	P 2.3.36 → <i>saptamī</i>
			P 2.3.38 → <i>ṣaṣṭhī</i>
			P 2.3.42 → <i>pañcamī</i>
			P 2.3.44 → <i>ṭṛtīyā</i>

7. Problems in implementation

The implementation issues with respect to *kāra*kas can be classified in three categories as follows –

- *vivakṣā* dependent operations
- *vārtikas* limiting/extending rules
- Semantic conditions to a rule implementation

Some of these may be difficult to implement with the current state of computing algorithms and technologies. Let us see each one of them –

7.1 *vivakṣā* dependent operations

Application of many *kāra*ka rules depend on the speaker *vivakṣā* (Cardona 2004),

In the example स्थाल्या पचति , स्थाली should be Location as it is the आधार (आधारोऽधिकरणम्) but it is करण by rule साधकतमं करणम् because the speaker thinks it is the most instrumental (साधकतम (प्रकृष्ट उपकारक)) and therefore prefers instrumental case

कर्मणा यमभिप्रेति स सम्प्रदानम् prescribes Dative for the receiver of gift, but *vārtika* अशिष्टव्यवहारे दाणः प्रयोगे चतुर्थ्यर्थे तृतीया prohibits it if the gift was **intended** for deriving some benefit (sexual favor in this case)

7.2 *vārtikas*

- *vārtikas* extend, limit Pāṇinian rules

example - नी -वहोर्न (नाययति वाहयति वा भारं भृत्येन) allows *karā*na if the verb is नी or वह् . It thus limits गतिबुद्धिप्रत्यवसानार्थशब्दकर्माकर्मकाणामणि कर्ता स णौ which allows karma

- *vārtikas* limit themselves

नियन्तृकर्तृकस्य वहेरनिषेधः (if the *kartā* is *sārathi* or any of its synonyms then नी -वहोर्न does not apply → वाहयति रथं वाहान् सूतः (karma by Pāṇini's गतिबुद्धि ... *sūtra*)

7.3 Semantic conditions

Semantic conditions such as follows are hard to implement. Some possible solutions have been provided in the section 8

- स्वातंत्र्य
- ईप्सित /ईप्सिततम्
- साधकतम्
- अभिप्रेति (to be अभिमुख - approach someone for gift)
- प्रीयमाणः (one who gets pleased - रूच्यर्थानां प्रीयमाणः) -
हरये रोचते भक्तिः
- ध्रुव (fixed point) अपाय (path of separation) ध्रुव पायेऽपादानम्
- धावतः अथात् पतति (is अथात् an आधार or ध्रुव ?)
- आधारोऽधिकरणम् (आधारः किम् ?)

8. Possible Solutions

- Build a database of all the *kāraka* rules, special conditions, exceptions, *vārtikas*, examples etc. The authors have developed such a database
- Synonymy lexicon – *amarakośa*
 - Rules having ‘in the sense of’ (वाची / अर्थक) etc can be handled by a synonymy lexicon like *amarakośa* (<http://sanskrit.jnu.ac.in/amara/index.jsp>)
- Semantic classification of verbs according to *kāraka*
 - <http://sanskrit.jnu.ac.in/tinanta/tinanta.jsp>
 - [dhatupatha.txt](http://sanskrit.jnu.ac.in/dhatupatha.txt)
- Build basic concepts centered on verb classes – just a thought
 - We can take semantic primitives as taken by Jackendoff, Dorr and use them for Sanskrit verb classes incorporating *kāraka* information as well
 - This model then can be extended to other Indian languages

9. Model for *Kāraka* identification

A tentative model for *kāraka* marking has been done and partial implementation has been done at <http://sanskrit.jnu.ac.in/karaka/analyzer.jsp> . Of the eight modules, six have been developed. Modules 5,6,7 are under development as of now –

- [1] VERB ID
- [2] VERB ANALYSIS
- [3] NON—VERB ID
- [4] SUBANTA ANALYSIS
- *[5] AKANKSHA CHECK
- *[6] KARAKA RULES
- *[7] SPECIAL CONDITIONS
- [8] KARAKA ASSIGNMENT

The module names prefixed with ‘*’ are under development currently

10. Conclusion

The authors in this paper have tried to present a case for deeper analysis of semantic conditions in rule writing of Pāṇini, and highlighted the fact that a complete implementation of the system of Pāṇini will not be possible without formalizing all karaka rules as per the semantic conditions put forth by Pāṇini. This may also necessitate a proper understanding of *vivaḥṣā* and its formalization. The authors have also put forth a *kāraka* analyzer system consisting of several modules many of which have been developed. Finally, the authors have suggested several solutions for a complete *kāraka* analysis module.

References

1. BHATTA, V.P. 1992, Epistemology, Logic and Grammar in the analysis of sentence-meaning, South Asia Books
2. CARDONA, GEORGE, 1967, *Pāṇini's syntactic categories*, Journal of the Oriental Institute, Baroda (JOIB) 16: 201-15
3. CARDONA, GEORGE, 1988, *Panini: his work and its tradition (vol.1)*, Motilal Banarasidas, Delhi,
4. CARDONA, GEORGE, 2004, *Some questions on Pāṇini's derivational system*, Proceedings of International Conference on Speech and Language Technology, Vol1, New Delhi, Tata McGraw Hill
5. GHILDIYAL SHRIDHARANAND, 1962, *Vaiyākaraṇa Siddhānta Kaumudī - Hindi Vyākhyā Sahita Vibhaktiyartha (kāraka prakaraṇa)*, Motilal Banarasidas, Delhi
6. ISHVARCHAND PT., 2004, *Aṣṭādhyāyī, vol 1-2*, Chaukhamba Surabharati Prakashan, Delhi
7. JHA GIRISH NATH. 2004, *The system of Pāṇini*, In *Language in India*, vol 4:2
8. JHA, GIRISH N. et al., 2006, *Towards a Computational analysis system for Sanskrit*, Proc. of *first National symposium on Modeling and Shallow parsing of Indian Languages* at Indian Institute of Technology Bombay, pp 25-34
9. KAPOOR KAPIL, 1993, *Text and Interpretation: The Indian Tradition*, D.K. Printworld, Delhi.
10. MISHRA SUDHIR K., JHA, GIRISH N., 2004, *Identifying Verb Inflections in Sanskrit morphology*, In proc. of SIMPLE 04, IIT Kharagpur, pp. 79-81.
11. MISHRA VISHVANATH ACHARYA, 1997, *Paribhāṣenduśekhara*, Chaukhamba Surabharati Prakashan, Delhi
12. MISHRA, SUDHIR K, JHA, GIRISH N, 2004, *Sanskrit Kāraka Analyzer for Machine Translation*, In SPLASH proc. of iSTRANS, Tata McGraw-Hill, New Delhi, pp. 224-225.
13. NARAYAN MISHRA, 1996, (ed). *Kāśikā of Pt. Vāmana and Jayāditya*, Chaukhamba Sanskrit Sansthan, Varanasi

14. NAYAR V.R.P., 2003, *Logical Structure of kārakas*, in *Aspects of Pāṇinian Semantics*, Sahitya Academy, New Delhi
15. RAJENDRAN C., 2003, *Aspects of Pāṇinian Semantics*, Sahitya Academy, New Delhi
16. RAMANUJAM, 2003, *Semantic problems in the computation of Pāṇinian rules*, in *Aspects of Pāṇinian Semantics*, Sahitya Academy, New Delhi
17. SHARMA, RAMA NATH, 2003, *The Aṣṭādhyāyī of Pāṇini*, Munshiram Manoharlal Publishers Pvt. Ltd., Delhi.
18. SHASTRI, BHEEMSEN, *Laghusiddhāntakaumudī (1st part)*, Bhaimee Prakashan, 537, Lajapatrai Market, New Delhi
19. WHITNEY, W.D., 2002, *History of Sanskrit Grammar*, Sanjay Prakashan, Delhi.