Towards Automating the Generation of Derivative Nouns in Sanskrit by Simulating Pāṇini

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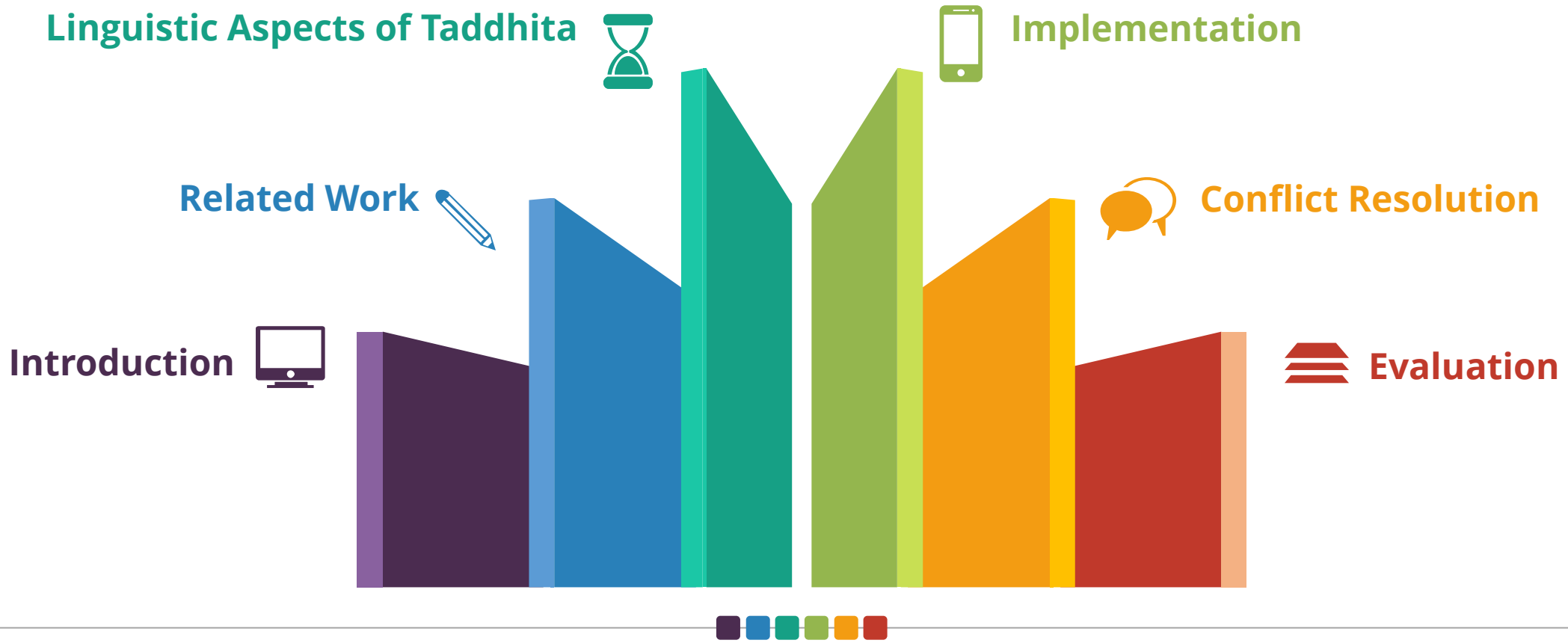
OVERVIEW

Nouns derived from other nouns by affixation

Prātipadikam - nouns & adjectives
Taddhita - Non-category changing

Aṣṭādhyāyī - Grammar of 4000 rules, completely describes Sanskrit

Attempt to automate the rule triggering for affixation


Linguistic Aspects of Taddhita
Implementation
Related Work
Conflict Resolution
Introduction
Evaluation

Objective

AFFIXATION

- Scheme for automation of Taddhita section
- Simulate the affixation process by triggering of rules
- How affix polysemy homonymy and synonymy are handled.

RULE SELECTION

- Methods for rule selection, conflict resolution and blocking of rules
- Effectiveness in Taddhita section and in other general cases.

STORAGE OF LINGUISTIC FEATURES

- Linguistic features obtained by the entities participating in derivation
- How it can be used for later derivations and analysis.

Motivation

Praises from domain experts in the fields of Linguistics, Mathematics and Computer science, for the deep computational insights it carries

Preserve etymological information of nouns so formed

Supplementary information to lexical databases like IndoWordnet

Pedagogy tool for learning

TIMELINE

1965 - 1989

Formalizing rules on grammar

- George Cardona.
  - 1965. On translating and formalizing pāṇinian rules. In Journal of the Oriental Institute of Baroda, volume 14, pages 306--14.
  - 1969. Studies in indian grammarians I: The method of description reflected in the śivasūtras. In Transactions of the American Philosophical Society, pages 3--48. JSTOR.

- J. Frits Staal. 1965. Context-sensitive rules in pāṇini. In Foundations of Language , pages 63--72.

1984 - 2007

Linguistic aspects in Aṣṭādhyāyī.

- Saroja Bhate. 1989. *Panini's Taddhita rules*. University of Poona, Pune.
- SD Joshi and Saroja Bhate. 1984. The fundamentals of anuvritti pune: University, Publications of the Centre of Advanced Study

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- George Cardona. 1997. Panini: His work and its traditions vol 1. In Background and Introduction. 2nd ed. Motilal Banarsidass.
- Rama Nath Sharma. 2002. the Aṣṭādhyāyi of Pāṇini - Vol.1 : Introduction to the Aṣṭādhyāyi as a Grammatical Device. Munshiram Manoharlal Publishers Pvt. Ltd., New Delhi.
- Ashwini Deo. 2007. Derivational morphology in inheritance-based lexica: Insights from pāṇini. In Lingua, volume 117.1, pages 175--201. Elsevier.

reflected in the śivasūtras. In *Transactions of the American Philosophical Society*, pages 3--48. JSTOR.

- J. Frits Staal. 1965. Context-sensitive rules in pāṇini. In *Foundations of Language* , pages 63--72.

2003-2015

Automation Attempts

In *Sanskrit Computational Linguistics, First and Second International Symposia, Rocquencourt, France*

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In Sanskrit Computational Linguistics, First and Second International Symposia, Rocquencourt, France

- Pawan Goyal, Amba Kulkarni, and Laxmidhar Behera. 2009. Computer simulation of aṣṭādhyāyī: Some insights.
- Malcolm D. Hyman. 2009. From pāṇinian sandhi to finite state calculus.
- Anand Mishra. 2009. Simulating the pāṇinian system of sanskrit grammar.
- Sridhar Subbanna and Shrinivasa Varakhedi. 2009. Computational structure of the aṣṭādhyāyī and conflict resolution techniques.

- Pawankumar Satuluri and Amba Kulkarni. 2014. Extra linguistic information needed for automatic generation of sanskrit compounds: A study. In recent developments in Sanskrit Computational Linguistics', at SALA-30, Hyderabad.
- Peter Scharf, Pawan Goyal, Anuja Ajotika, and Tanuja Ajotikar. 2015. Voice, preverb, and transitivity restrictions in sanskrit verb use. In Sanskrit Syntax, Selected papers presented at the seminar on sanskrit syntax and discourse structures

Linguistic Aspects of Taddhita

1
2
3 TADDHITA
4
5
6
7

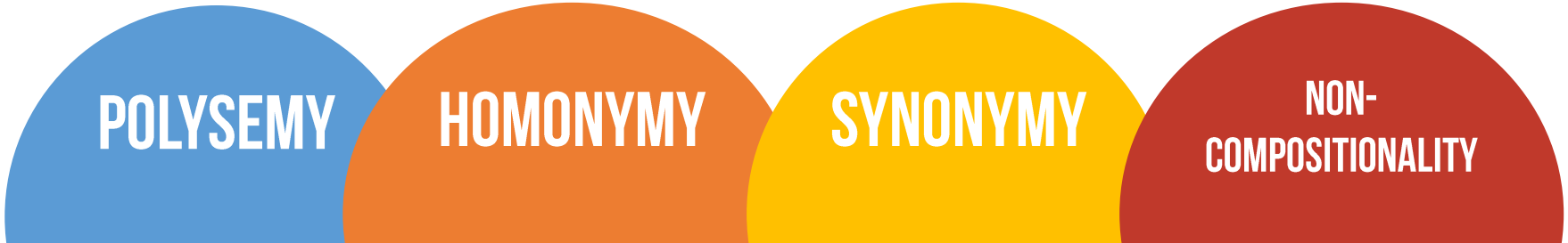
INDIAN – INDIA
ITALIAN – ITALY
KERALITE - KERALA
GRAMMARIAN - GRAMMAR
LIBRARIAN - LIBRARY

Stem

m:n

affix

माथुरा - मथुर
औपगव - उपगु
आश्वलायन - अश्वल
नैपुण - निपुण
स्थाण्डिला - स्थण्डिल



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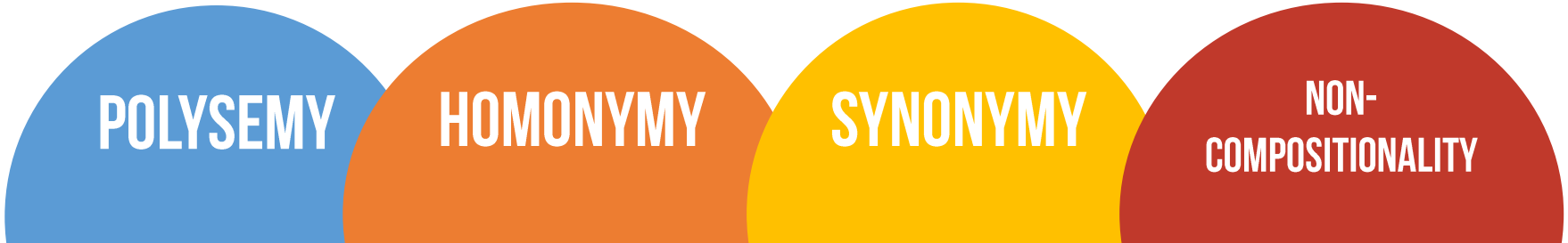

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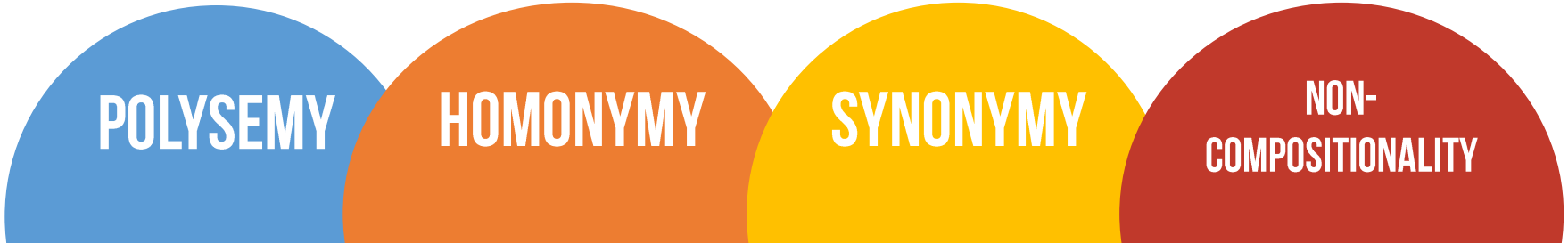

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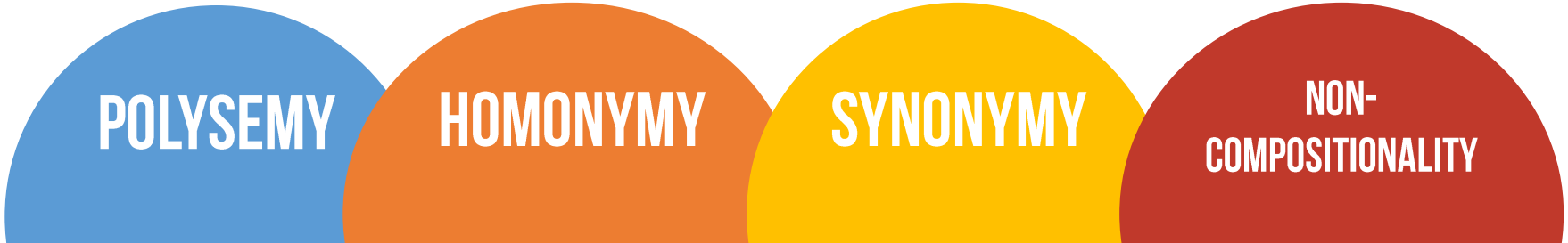

Linguistic Aspects of Taddhita

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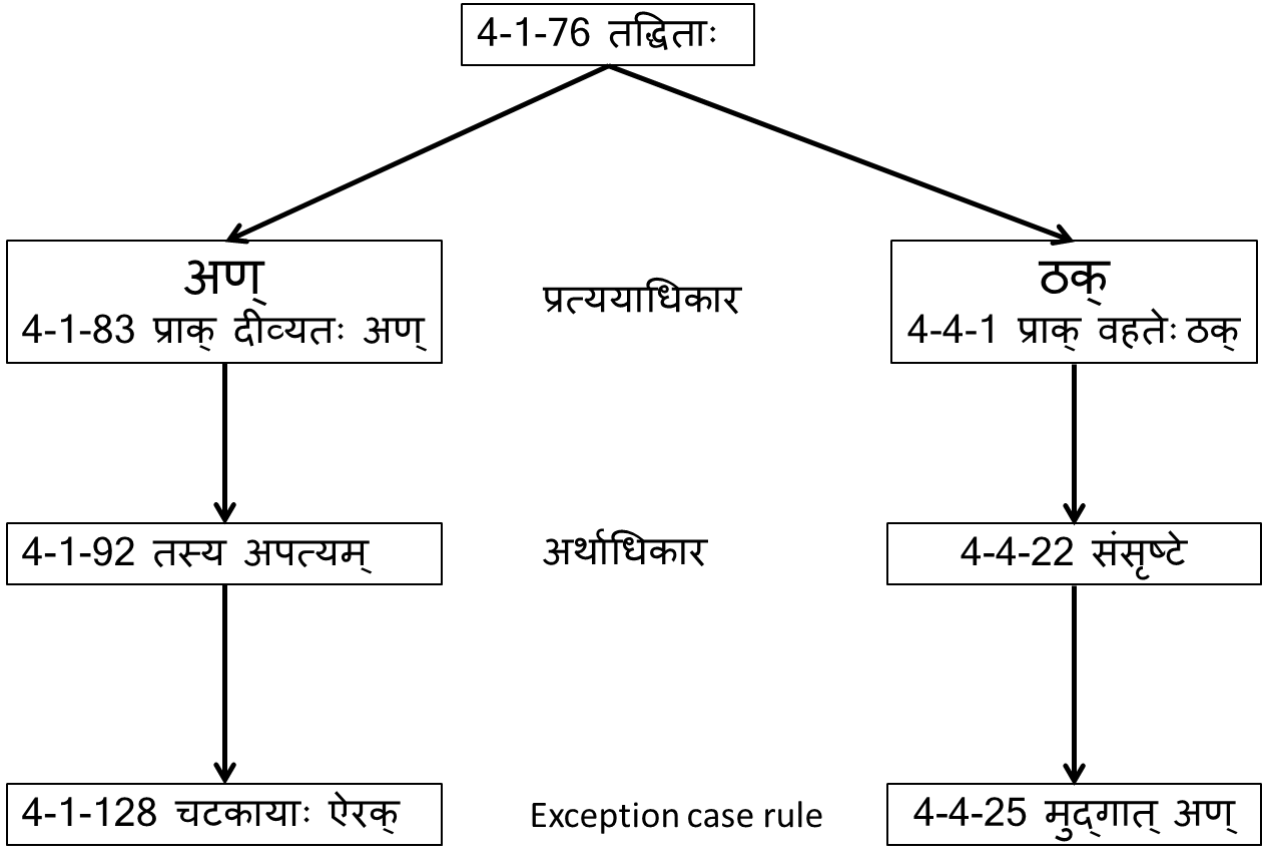
1115 Rules from sūtra A.4.1.76 to A.5.4.160

300 Semantic relations : arthādhikāra rules

5 Default affix rules : pratyayādhikāra rules

2 Types of affixation
Prātipadika + Taddhita-affix
Prātipadika + Taddhita-affix + strī-affix



An instance of inheritance hierarchy in Taddhita section

Anuvṛtti and Adhikāra

1
2
3 TADDHITA
4
5
6
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1-3-2 उपदेशे अच् अनुना सकः इत्
1-3-3 हल् अन्त्यम्
1-3-4 न वभक्तौ तुस्माः
1-3-5 आदिः ञटुडवः
1-3-6 षः प्रत्ययस्य आदिः
1-3-7 चुटू
1-3-8 लशकु अत ङ्घते

3.3.1 प्रत्ययः (Head)
4.1.76 त ङ्घताः (Head)
4.1.83 प्राक् दीव्यतः अण् (Head, Default affix Rule)
4.1.92 तस्य अपत्यम् (Default semantic rule)
4.1.123 शुभ्रादिभ्यः च (Exception Rule)

INHERITANCE NETWORK

CONSTRAINED SEPARATIONISM

NO MULTIPLE INHERITANCE

ADHIKĀRA & ANUVṚTTI
MODELLED USING MULTILEVEL INHERITANCE

Ashwini Deo. 2007. Derivational morphology in inheritance-based lexica: Insights from pāṇini. In Lingua, volume 117.1, pages 175--201. Elsevier.
Saroja Bhate. 1989. Panini's Taddhita rules. University of Poona, Pune.

Overview

1
2
3
4 IMPLEMENTATION
5
6
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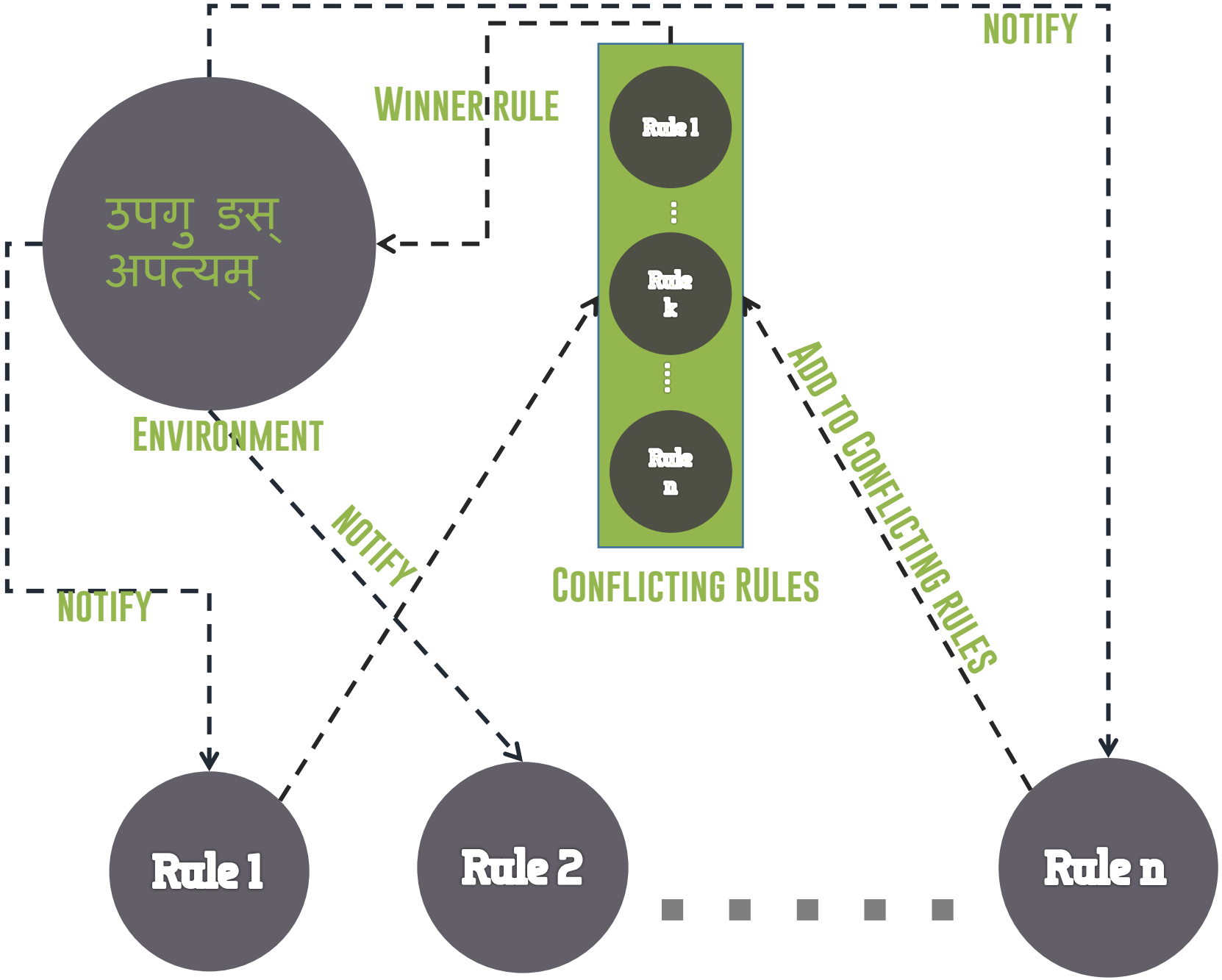
Each rule is a class (with single instance)

Environment notifies the rules when modified.

Candidate rules trigger, winner is selected



Multilevel Inheritance & Observer Design Pattern

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4 IMPLEMENTATION
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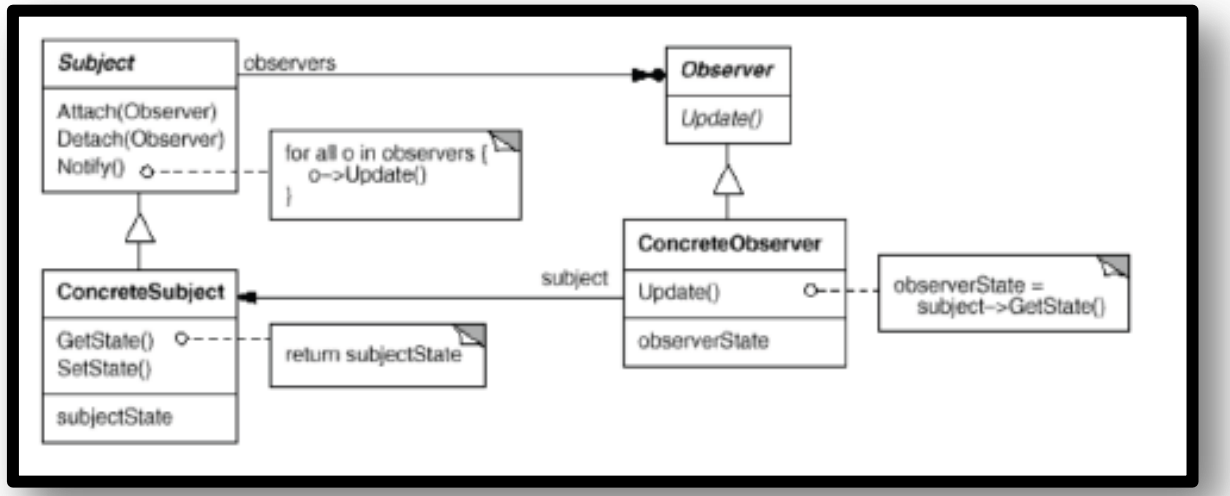
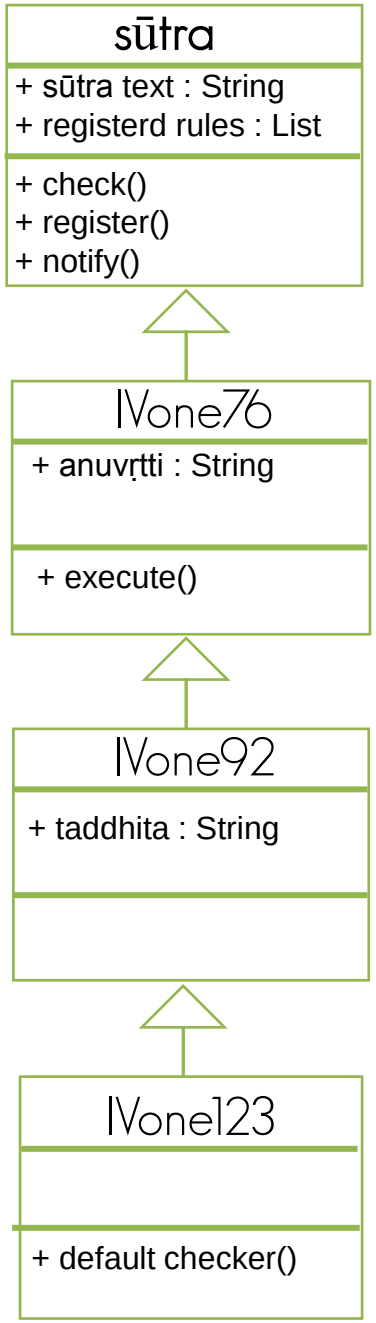


Observer Design Pattern (UML)

Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides. 1994. Design Patterns: Elements of Reusable Object-Oriented Software. Addison Wesley.



Multilevel Inheritance (UML)

Rule Triggering Hierarchy

1
2
3
4 IMPLEMENTATION
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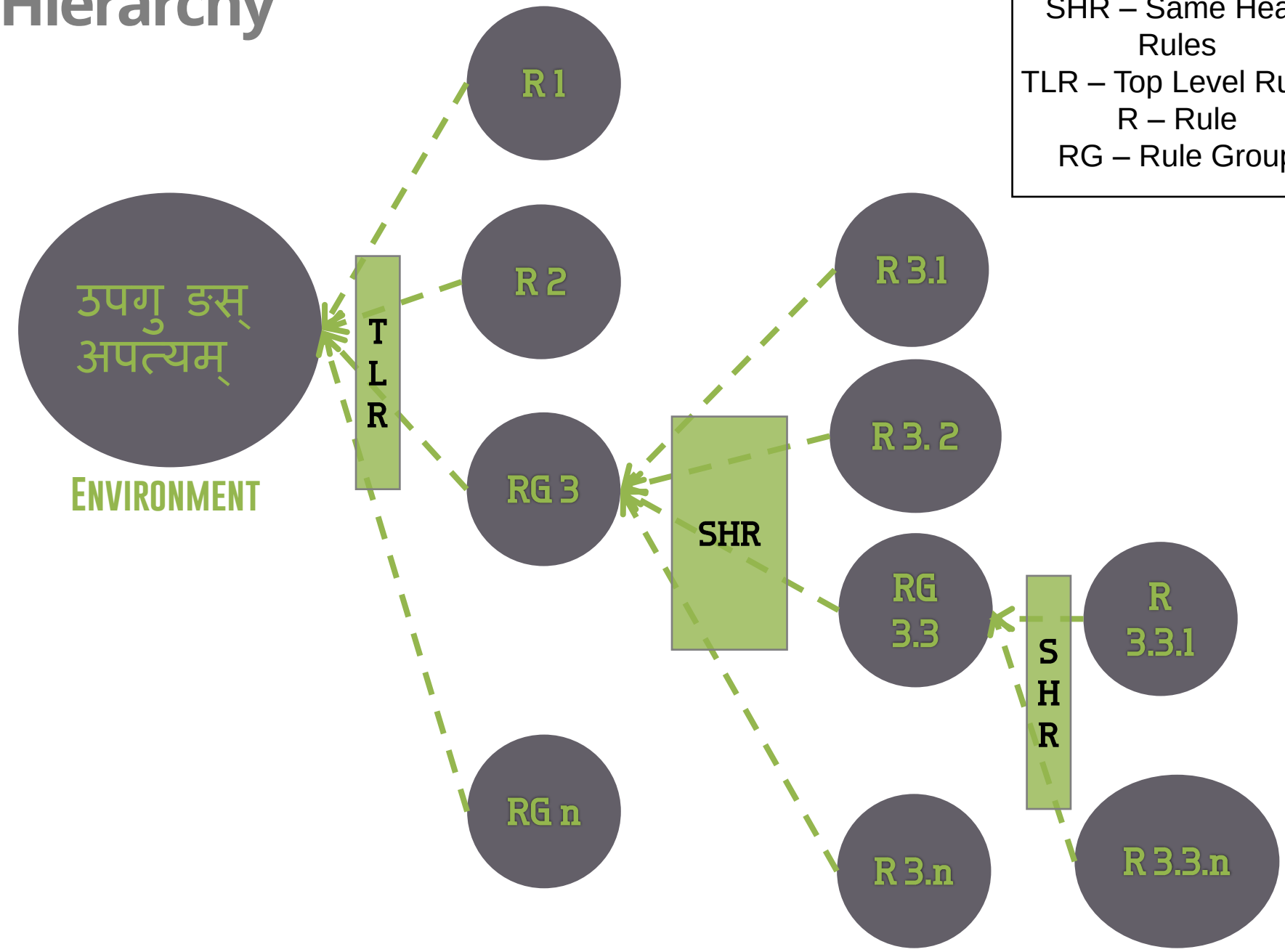
Top level rules observe the environment

Rules grouped by the notion of topicality

Rules with topics or conditions as anuvṛtti forms head

Confict resolution at each rule group

SHR – Same Head Rules
TLR – Top Level Rules
R – Rule
RG – Rule Group



Rule triggering schema

Rule Triggering

1
2
3
4 IMPLEMENTATION
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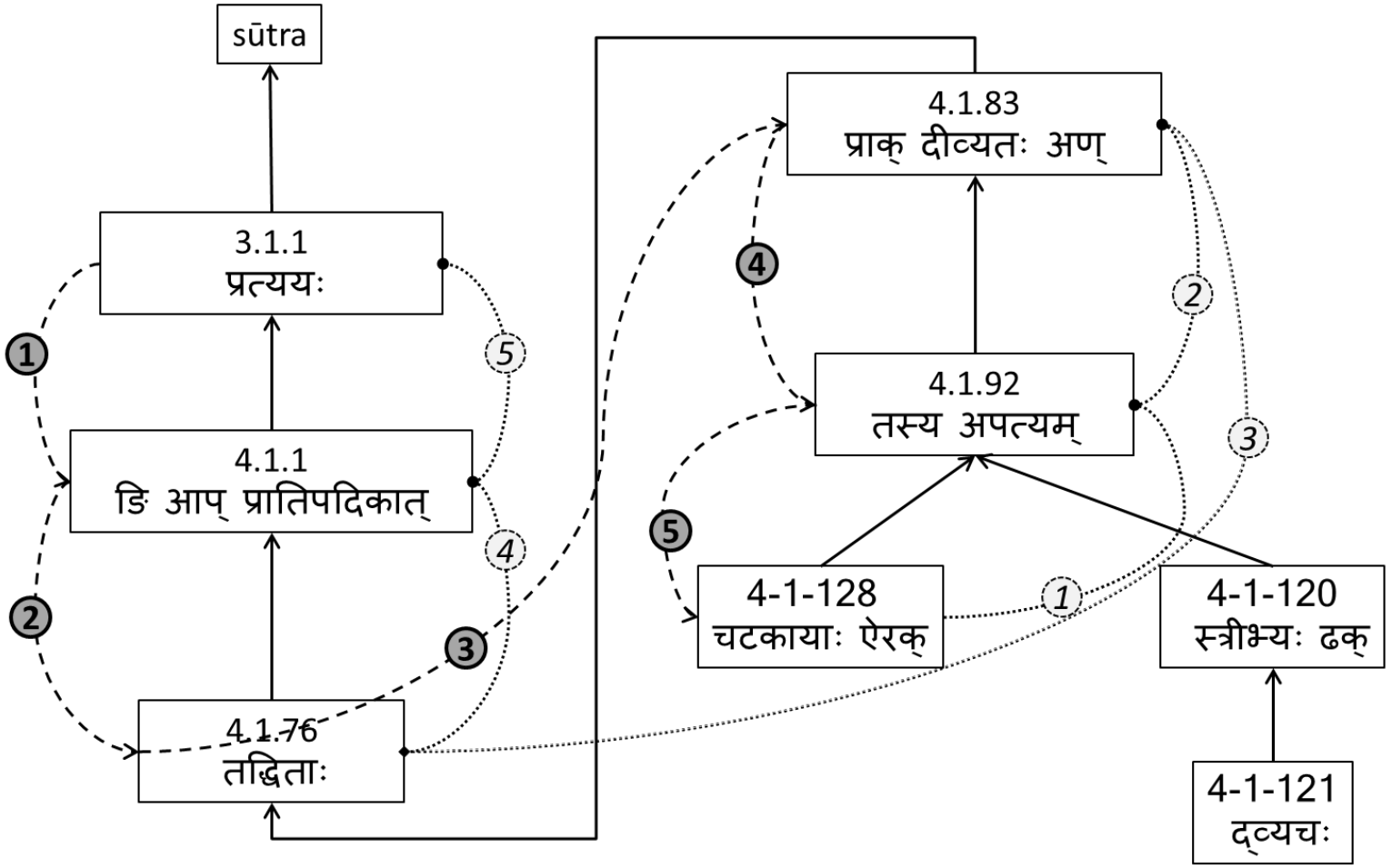
Input - चटका ङस् अपत्यम्



Affixation under patronymic relation for चटका

Output - चटका ङस् ऐरक्

Śabdarūpa Representation

1
2
3
4 IMPLEMENTATION
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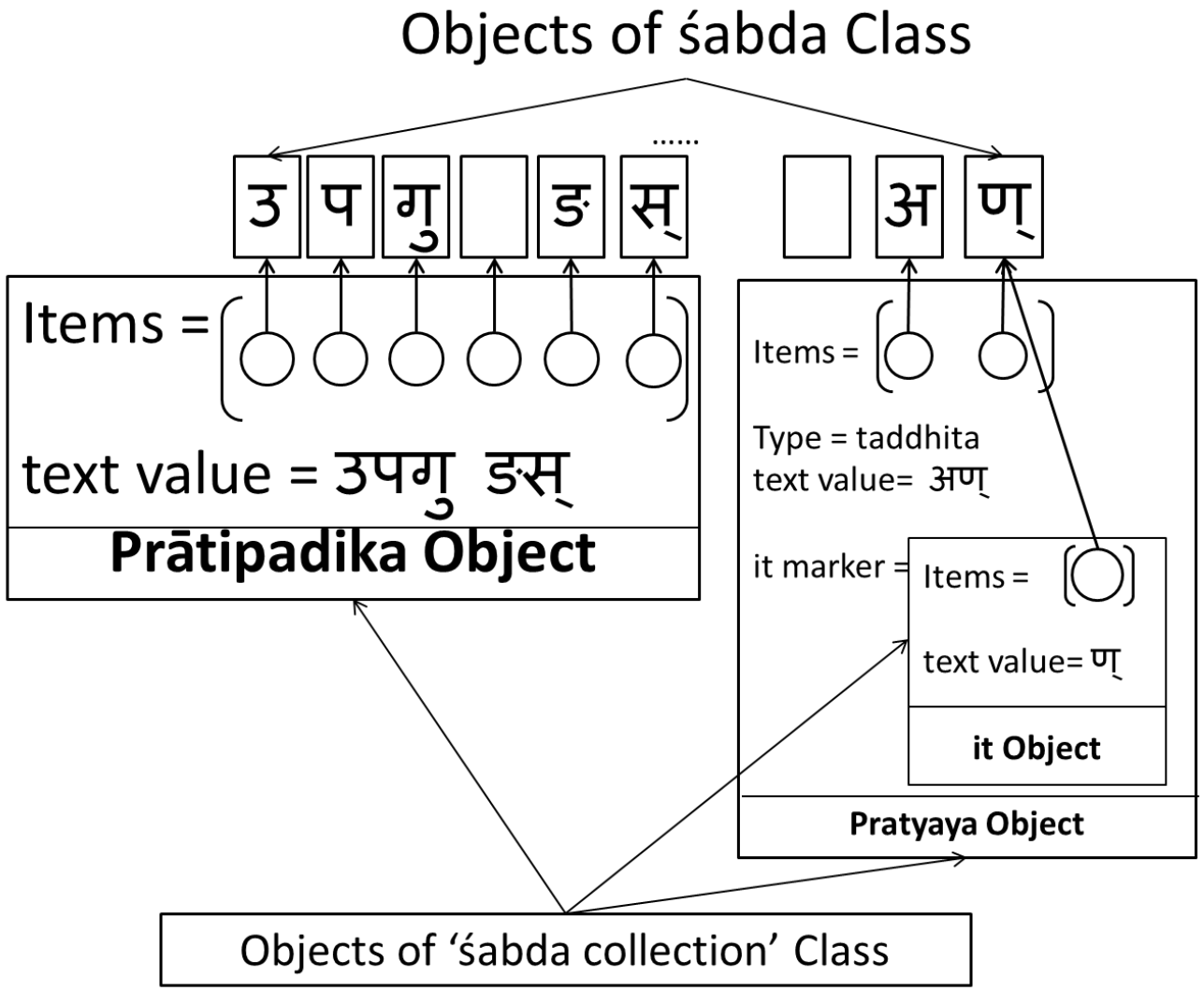
Attain technical terms during derivation -> Operational rules trigger

Rich linguistic features get stored. -> Useful for new derivations

Individual entity property remains with itself like the 'it' marker

Helps in forming relation between nouns



Conflict Resolution and Rule Triggering

1
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3
4
5 CONFLICT RESOLUTION
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- Aṣṭādhyāyi provides limited information about conflict resolution
- No general consensus among scholars
- Implemented as a pluggable entity in the system

Utsarga-Apavada	Antaraṅga - Bahiraṅga	Nitya – Anitya	Para – Pūrva
General – Exception case	Bracketing	Obligatory rule wins	Later rule emerges as the winner
The inheritance network captures this notion	Internal is preferred	A.6.1.77 wins over A.6.1.8	The triggering by default enables pūrva
A.4.1.128 wins over A.4.1.92	A.3.4.86 wins over A.6.1.77		Internalizes the concept of A.1.4.2

Specificity Hierarchy

1
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3
4
5 CONFLICT RESOLUTION
6
7

Specificity Hierarchy

Priority wise ordering from the most concrete to most abstract

1
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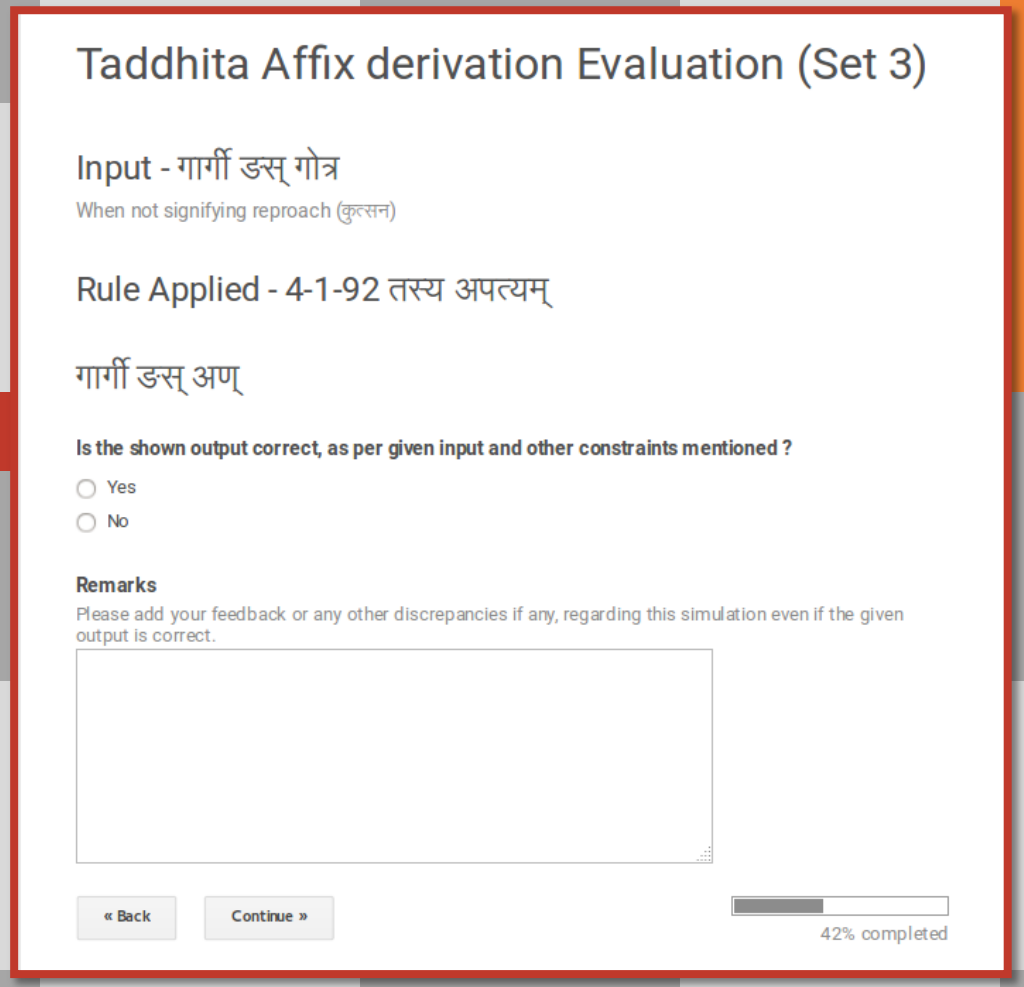
4
5
6 EVALUATION
7



Taddhita Affix derivation Evaluation (Set 3)

Input - गार्गी ङस् गोत्र

When not signifying reproach (कुत्सन)

Rule Applied - 4-1-92 तस्य अपत्यम्

गार्गी ङस् अण्

Is the shown output correct, as per given input and other constraints mentioned ?

- Yes
- No

Remarks

Please add your feedback or any other discrepancies if any, regarding this simulation even if the given output is correct.

« Back Continue »

42% completed

IMPLEMENTED APATYA SECTION - RULES FROM A.4.1.83 TO A.4.176

5 EXPERTS

3 SETS – 20 CASES PER SYSTEM

60 INPUT CASES

1
2
3
4
5
6 EVALUATION
7

EVALUATION	ACCURACY	ERROR
WITH NO EXTERNAL CONFLICT RESOLUTION METHOD	83.33	16.67
WITH SPECIFICITY HIERARCHY	93.33	6.67

50

CORRECT CASES WITHOUT ANY EXTERNAL CONFLICT RESOLUTION

4

WRONG CASES AFTER IMPLEMENTING SPECIFICITY HIERARCH

INCORRECT CASES RESOLVED - 6

1
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4
5
6 EVALUATION
7

Resolved Cases

गर्ग ङस् गोत्र, क प ङस् गोत्र

Rules applied
A.4.1.151 and A.4.1.122
Desired rules
A.4.1.105 and A.4.1.107
Resolved
by specificity hierarchy
(refinement inside semantic class)

उत्स ङस् अपत्यम्,
दिति ङस् अपत्यम्

Rules applied
A.4.1.95 and A.4.1.122
Desired rules
A.4.1.86 and A.4.1.85
Resolved
by specificity hierarchy

Instances requiring extra information

Rule A.4.1.122,

Need to know of stems with 'इञ्' pratyaya beforehand

Another application of our representation, which stores this information

पतृष्वसृ ङस् अपत्यम्

Multiple rules to be applied
A.4.1.133
Talks of elision with an affix as condition

The Schema as a General Schema for Modelling Aṣṭādhyāyī

1
2
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7 DISCUSSION

1. SIMPLE BLOCKING

2. OVERLAPPING DOMAINS

3. OVERLAPPING DOMAINS : FAILED CASE

Principles used in the system like Anuvṛtti, Adhikāra, Conflict resolution techniques etc. are Applicable to entire Aṣṭādhyāyī

Examples based on Scharf's paper

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Examples based on Scharf's paper

Bottlenecks

1
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7 DISCUSSION

Linguistic Features

- Panini uses rich linguistic features (Phonetic to Semantic)
- Intention of the speaker is one of them
- A.**4-1-147** गो□ि□याः कु□नेण च

Specificity Hierarchy

- Multiple entities with different specificity
- Specificity for entitles in anuvritti
- Semantic entity in A.4.1.86

Metarules

- Like Vipratishedha, other metarules
- System Internalized them

Conclusion

1
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6
7 DISCUSSION

Generation of Correct forms, Sequence of rules

Preserve Etymological Information.
Pedagogy Tool.
Supplementary Information to Lexical Databases

Rule Selection, Conflict Resolution

Handling Affix Synonymy, Homonymy and other features

Preserve rich linguistic features along with the noun object

Relevant Citations

1
2
3
4
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Ashwini Deo. 2007. Derivational morphology in inheritance-based lexica: Insights from pāṇini. In Lingua, volume 117.1, pages 175--201. Elsevier.

Peter M Scharf. 2010. Rule selection in the aṣṭādhyāyī, or is pāṇini's grammar mechanistic? In Studies in Sanskrit Grammars: Proceedings of the Vyakarana Section of the 14th World Sanskrit Conference.

Rama Nath Sharma. 2002 The Aṣṭādhyāyi of Pāṇini - Vol.1 : Introduction to the Aṣṭādhyāyi as a Grammatical Device. Munshiram Manoharlal Publishers Pvt. Ltd., New Delhi.

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George Cardona. 1997. Panini: His work and its traditions vol 1. In Background and Introduction. 2nd ed. Motilal Banarsidass.

THANK YOU