SOCIETY FOR SCIENCE AND EDUCATION
UNITED KINGDOM
TMLAI TRANSACTIONS ON MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE
VOLUME 5, ISSUE 1
ISSN 2054-7390

Construction of Word Dictionary for Bangla Vowel Ended Roots and Its Verbal Inflexions in UNL Based Machine Translation Scheme

Md. Nawab Yousuf Ali[1], Md. Shamsujjoha[2], Golam Sorwar[3] and Shamim H Ripon[4]
[1,2,4]*Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh*
[3]*School of Business and Tourism, Southern Cross University, Gold Coast, Australia*
nawab@ewubd.edu, dishacse@yahoo.com, Golam.Sorwar@scu.edu.au, dshr@ewubd.edu

ABSTRACT

This paper focuses on the development of word dictionary of Bangla vowel ended roots and their verbal inflexions for an interlingua representation called Universal Networking Language (UNL) processors. A considerable amount of work has been done on the development of Bangla morphological analysis on verbs, nouns, prefixes and suffixes for machine translation. As far as the researchers are aware, no attempts, however, have been made to integrate the previous developments on Bangla vowel ended roots and their inflexions to a concrete computational output. This paper attempts to bridge the gap on Bangla vowel ended roots and inflexions in the framework of UNL system aiming to produce a Bangla word dictionary for UNL. The paper analyzes the Bangla vowel ended roots and verbal inflexions and develops their formats in the UNL structure. Dictionary entries of all vowel ended roots and their inflexions are developed in order to generate associated verbs for sentences. Following semantic rules these verbs can be used to convert Bangla native language sentences into UNL expressions, which are then converted into required native languages using the language specific generation rules. Conversion of a Bangla language sentence into UNL expression has also been shown in this paper.

Keywords: Verb Roots, Vowel Ended Roots, Verbal Inflexion, Bangla Word Dictionary, Universal Networking Language, and Universal Words.

1 Introduction

The Universal Networking Language (UNL) [1] is an artificial language, in the form of semantic network for computers to express and exchange various information across languages. The mission of the UNL project is to allow people to access information on the Internet in their own languages [2]. Hundreds of millions of people throughout the world, with various demographic backgrounds use Internet for information communication and sharing [3]. English is arguably, though, considered as a primary vehicle for the Internet based information, presentation and delivery, understandably not all Internet users are expected to have the necessary level of English language proficiency. Knowledge and information in different languages are scattered all over the world and remain inaccessible to mostly due to non-machine representation and language barrier [4]. Translation is the means of disseminating information; however, it demands extensive effort and cost directly and/or indirectly. Though nations are becoming more

DOI: 10.14738/tmlai.51.2479
Publication Date: 15th January, 2017
URL: http://dx.doi.org/10.14738/tmlai.51.2479

interdependent and need to exchange information, language barrier hinders these progresses at individual, institutional and national levels. Knowledge sources are to be shared globally as much as possible to advance civilization [5]. To deal with the language barrier, United Nations University/Institute of Advanced Studies (UNU/IAS) conducted a review of all internationally available machine translation programs and started to devising an efficient and workable technique to develop a human language neutral meta-language for the Internet. The result of the project is Universal Networking Language (UNL) [1]. The aim of this internationally cooperative initiative is to eliminate the massive requirement of translation among languages and reduce language to language translation to one time conversion to UNL. Once information written in one language is converted into UNL, they can be shared by anyone with their own native languages [4]. In UNL framework, each native language sentence is converted into a UNL hypergraph by a tool called "Enconverter" [6] following analysis rules defined in [7]. These hypergraphs are then translated into any native language, using generation rules defined in [7], by another tool called "Deconverter" [8]. The development of language specific components, such as dictionary, analysis rules and generation rules used by Enconverter and Deconverter, are the research focus across the world.

The people in Bangladesh and three states (West Bengal, Tripura and Aaam) in India, which is about one sixth population of the world use Bangla as their first language. About one sixth population of the world is speaking in Bangla. Exchanging information and sharing knowledge globally, it is critically important to devise conversion technique(s) for Bangla language texts into UNL and vice versa. Machine translation (MT) is an approach to translating texts from one natural language to another automatically. Ali and Ali (2002) attempted to develop MT Bangla dictionaries that address the organization, contents and details of the information [9]. Saha (2005) developed low cost English to Bangla (E2B)-ANUBAD translating English text into Bangla text using both rule-based and transformation-based MT schemes along with three-level of parsing [10]. Another attempt by Uddin et. al. (2004) was to develop a statistical Bangla to English translation engine using only simple Bangla sentences that contain a subject, an object and a verb [11].

As a consequence, the development of these aspects is the major focus of this research. A rigorous study on Bangla language grammar [9-11, 13-15], verb and roots (vowel ended and consonant ended) [9-11] and morphological analysis [3, 16-20], based on their semantic structures, has also been conducted due to the relevancy with the study.

The paper extends the work on Bangla Vowel Ended Roots (VERs) for representing them into a computational approach. To prepare word dictionary of Bangla VERs and verbal inflexions (VIs), this study has conducted an in-depth analysis of various aspects, including UNL expression, UNL Attributes, Universal Words, UNL systems and specifications of EnConverter [1-8] of UNL. Among those, Universal Words and Attributes play an important role in the development of dictionary entries for any native language word. Alike any other languages, they are equally important for the development of Bangla word dictionary, enconversion and deconversion rules required for a conversion of a natural language sentence (here Bangla sentence) into a UNL expression.

The major components of this research touch upon: 1) analysis of Bangla vowel ended roots (VERs) and their verbal inflexions (VIs), 2) categorization of VERs considering the ways verbal inflexions are added with them to form verbs, 3) identification of alternative roots for them 4) outlining the formats of VERs, 5) dictionary entries of VERs, 6) outlining the formats of verbal inflexions, 7) Dictionary entries of verbal

inflexions and 8) Conversion of a Bangla text into UNL expressions. A preliminary version of the work has been published in [20].

The rest of the paper is organized as follows. Section 2 describes the structure of UNL and EnConverter. Format of UNL-Based Bangla word dictionary is presented in Section 3. Analysis of Bangla VERs and their Vis is elaborated in Section 4. This section also presents categorizations of VERs, their alternative roots and Vis and their alternative VERs. Section 5 outlines the format of word dictionary for Bangla VERs and their lexicons. Dictionary format of Vis and their lexicons are presented in Section 6. Conversion procedures of a Bangla sentence into UNL expression is shown in Section 7, while some concluding remarks and future directions are presented in Section 8.

2 Universal Networking Language (UNL)

The UNL has been defined as a digital meta-language for describing, summarizing, refining, storing and disseminating information in a machine independent and human language neutral form [1]. It represents information, i.e. meaning, sentence by sentence. Each sentence is represented as a hypergraph, where nodes and arcs represent concepts and their relations respectively. This hypergraph is also represented as a set of directed binary relations between a pair of concepts present in a sentence. Concepts are represented as character-strings called Universal Words (UWs). Knowledge in UNL document is expressed in the following three dimensions [8]:

2.1 Universal Words (UWs)

UWs, which are language independent, are used to express word knowledge. UWs constitute the UNL vocabulary and the syntactic and semantic units, which are combined according to the UNL laws to form UNL expressions. They are tagged using restrictions describing the sense of a word in a current context. For example, drink(icl>liquor) denotes a sense of drink, as a noun- restricting the sense to a type of liquor. Here, icl stands for inclusion forming an is-a relation as in semantic nets

2.2 Relation Labels (RL)

Conceptual knowledge is captured by the relationship between UWs through a set of UNL relations. For example, Human affects the environment is described in UNL expression as:

agt (affect(icl>do).@present.@entry:01,human(icl>animal).@pl)

obj(affect(icl>do).@present.@entry:01,environment (icl>abstract

thing).@pl)

where, agt and obj refer agent and object relations respectively. The terms affect(icl>do), human(icl>animal) and environment(icl>abstract thing) are the UWs denoting concepts.

2.3 Attribute Labels (AL)

Speaker's view, aspect, time of event, etc. are captured by UNL attributes. For instance, in the above example, the attribute @entry denotes the main predicate of the sentence, @present denotes the present tense, @pl is the plural number and :01 is the scope ID.

UNL expressions provide the meaning of the text. Hence, search could be carried out considering the meaning rather than the text. This contributes to the development of a novel kind of search engine technology allowing information in one language can be stored in multiple languages. To convert Bangla

sentences into UNL form, we use EnConverter (EnCo) [1], a universal converter system provided by the UNL project shown in Figure 1. It is a language independent parser; a multi-headed Turing Machine [21] provides synchronously a framework for morphological, syntactic and semantic analysis. Natural language texts are analyzed sentence by sentence using a knowledge rich lexicon and by interpreting analysis rules. It scans an input string from left to right.

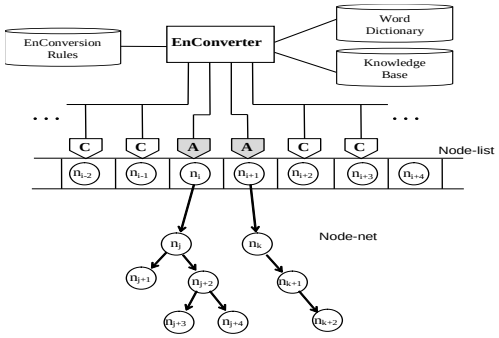

Figure 1. Structure of EnConverter ("A" indicates an Analysis Window, "C" indicates a Condition Window, and "nn" indicates an Analysis Node).

Moreover, when an input string is scanned all matched morphemes with the same string characters are retrieved from the dictionary and become the candidate morphemes according to the priority rule in order to build a syntactic tree and the semantic network for the sentence. The left character string is scanned from the beginning according to the applied rule. It moves back and forth over the Node List, which contains words of the input sentence. In the figure, "A", "C" and "n" indicate an Analysis Windows (AW), Condition Windows (CW) and "nn" indicates an Analysis Node respectively. The machine traverses the input sentence back and forth, retrieves the relevant dictionary entry from the Word Dictionary (Lexicon) depending on the attributes of the nodes under the AWs and those surrounding the CWs. It then generates the semantic relations between the UWs and /or attaches speech act attributes to them. As a result a set of UNL expressions is made equivalent of UNL graph [22]. EnCo is driven by a set of analysis rules to analyze a sentence using Word Dictionary and Knowledge Base. The enconversion rules have been described in [6]. Morphological analyses are performed by the left and right composition rules. This type of rule is used primarily for creating a syntactic tree with two nodes on the Analysis Windows. The semantic analyses are accomplished by either the left or right modification rules. They are used to create semantic relations between the words in a sentence [6].

3 Bangla Word Dictionary

The Word Dictionary is a collection of word dictionary entries. Each entry consists of three elements: Headword (HW), Universal Word (UW) and Grammatical Attribute (GA). A HW is a notation/surface of a native language word composing the input sentence. It is used as a trigger in obtaining equivalent UWs from a Word Dictionary in enconversion process. An UW expresses the meaning of a word which is used in creating UNL networks (i. e., UNL expressions) of output. GAs are the information on how words behave in a sentence and are used in enconversion rules. Each dictionary entry has the following format associating with any native language word [1, 6].

Data Format:

[HW]{ID}"UW"(Attribute1, Attribute2,...)<FLG, FRE, PRI>

Here,

HW ← Head Word (Bangla word)

ID ← Identification of Head Word (omissible)

UW ← Universal Word

ATTRIBUTE ← Attribute of the HW

FLG ← Language Flag

FRE ← Frequency of Head Word

PRI ← Priority of Head Word

Attributes denote the grammatical, semantic and morphological properties of a word. Some example entries of dictionary for Bangla language are given below:

[আপনি]{} "you(icl>person)" (PRON, HPRON, RES,SG,P2)

[ওরা]{} "they(icl>person)" (PRON, HPRON, PL,GEN, P3)

[আমি]{} "i(icl>person)" (PRON, HPRON, PL,RES, P3)

[তুই]{} "you(icl>person)" (SUB, PRON, HPRON, SG,NEG, P2)

where, PRON refers to Pronoun, HPRON to Human Pronoun, GEN to General, NEG to Neglect, RES to Respect, SUB for subject, SG to singular, PL to plural, CL to conversation language, LL to literature language, P1, P2, and P3 to first person, second and third persons respectively.

4 Analysis of Bangla Vowel Ended Roots and Verbal Inflexion

The root of a verb plays important role in forming verb of a sentence in any natural language. In order to analyze roots systematically, we have meticulously studied Bangla language grammars [12-17], verb and roots (vowel ended and consonant ended) [12-14] and morphological analysis [3, 18-21], based on their semantic structure. For an appropriate morphological analysis and designing verb root template, verb roots are divided, according to tenses and persons, into two broad categories: vowel ended group (VEG) and consonant ended group (CEG); each of them is then again divided into sub-groups. This paper focuses on only vowel ended groups. To date, 25 vowel ended roots have been identified in Bangla language [16, 20]. Through an extensive analysis of these roots we have categorized them into 11 subgroups: VEG1, VEG2, VEG3, VEG4, VEG5, VEG6, VEG7, VEG8, VEG9, VEG10 and VEG11 based on how verbal inflexions are added with them to form verbs. In categorization, the behavior of verbal inflexions with various kinds of persons (1st, 2nd and 3rd) and tenses (present, past and future) have been taken into consideration. For example: 'আমি বিশ্ববিদ্যালয়ে যাই', aami bishabiddaloye jai means "I go to university". Here, verb is 'যাই', jai. In this verb, root 'যা' is a vowel ended root (VER) and 'ই' is verbal inflexion (VI). If the above sentence is written in the present continuous form, it will be, 'আমি বিশ্ববিদ্যালয়ে যাচ্ছি', aami bishabiddaloye jachhi meaning "I am going to university". Although the root is same in both cases, the verbal inflexion for the later case is 'চ্ছি'. The present perfect form of this sentence is, 'আমি বিশ্ববিদ্যালয়ে গিয়েছি', Ammi bishabiddaloye

giechhi meaning "I have gone to university". In this case, the original root 'যা' is changes its form to 'গি', gi' in generating verb 'গিয়েছি', 'giechhi', where, 'য়েছি', 'echhi' is the verbal inflexion. Similar changes have been observed in different roots with different tenses. Bangla VERs have been further classified into the following three distinctive categorizes based on them.

4.1 Vowel Ended Roots and Their Verbal Inflexion for First Person

Tables 1, 2, and 3 present the subgroups of VEG1, VEG2, VEG3, VEG4, VEG5, VEG6, VEG7, VEG8, VEG9, VEG10 and VEG11 along with their alternatives and inflexions respectively. The tables show the roots with their corresponding tenses for first person as a subject.

In Table 1, roots পা (pa) and খা (kha) fall into VEG1. They do not change in present indefinite, present continuous, past continuous and future indefinite tenses. However, they are changed from পা (pa) to পে (pe) and খা (kha) to খে (khe) in other tenses. Similarly, roots গা (ga), চা (cha), and ছা (chha) in VEG2 are changed to গে (ge), চে (che), and ছে (chhe) in present perfect and past perfect tenses respectively. Roots নি (ni), and দি (di) of VEG3 remain unchanged in all tenses, whereas root যা (ja) in VEG4 is changed to গি (gi) in present perfect and past perfect tenses, গে (ge) in past indefinite and যে (je) in past habitual tenses respectively.

In Table 2, roots ছুঁ (cchu), থু (thu), শু (shu), ধু (dhu), নু (no), দু (du), নু (nu), রু (ru) and লু (lo) of VEG5, VEG6, VEG7 and VEG8 remain unchanged in all tenses. In Table 3, roots ধা (dha), না (na) and বা (ba) in VEG10 are changed into ধে (dhe), নে (ne) and বে (be) in present perfect and past perfect tenses and into ধাই (dhai), নাই (nai) and বাই (bai) in past indefinite and past habitual tenses respectively. And roots ক (ko), ব (bo), র (ro) and ল (lo) in VEG11 are changed to কই (koi), বই (boi), রই (roi) and লই (loi) in past indefinite and past habitual tenses respectively.

Table 1. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG1 to VEG3 for First Person

Tenses	Vowel Ended Roots							
	পা (pa)	খা (kha)	গা (ga)	চা (cha)	ছা (ccha)	নি (ni)	দি (ni)	যা (ja)
Present Indefinite		ই	ই	ই	ই	ই	ই	ই
Present Continuous	ছি	ছি	ছি	ছি	ছি	ছি	ছি	ছি
Present Perfect	পা>পে য়েছি	খা>খে য়েছি	গা>গে য়েছি	চা>চে য়েছি	ছা>ছে য়েছি	য়েছি	য়েছি	যা>গি য়েছি
Past Indefinite	পা>পে লাম	খা>খে লাম	গা>গা ইলাম	চা>চা ইলাম	ছা>ছা ইলাম	লাম	লাম	যা>গে লাম
Past Habitual	পা>পে তাম	খা>খে তাম	গা>গাই তাম	চা>চাই তাম	ছা>ছাই তাম	তাম	তাম	যা>যে তাম
Past Continuous	ছিলাম	ছিলাম	ছিলাম	ছিলাম	ছিলাম	ছিলাম	ছিলাম	ছিলাম
Past Perfect	পা>পে য়েছিলাম	খা>খে য়েছিলাম	গা>গে য়েছিলাম	চা>চে য়েছিলাম	ছা>ছে য়েছিলাম	য়েছিলাম	য়েছিলাম	যা>গি য়েছিলাম
Future Indefinite	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব
	VEG1		VEG2			VEG3		VEG4

Table 2. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG5 to VEG8 for First Person

Tenses	Vowel Ended Roots								
	ছুঁ (chhu)	থু (thu)	শু (shu)	ধু (dhu)	ন (no)	দু (du)	নু (nu)	রু (ru)	ল (lo)
Present Indefinite	ই	ই	ই	ই	ই	ই	ই	ই	ই
Present Continuous	ছি	ছি	ছি	ছি		ছি	ছি	ছি	ছি
Present Perfect	য়েছি	য়েছি	য়েছি	য়েছি		য়েছি	য়েছি	য়েছি	য়েছি
Past Indefinite	লাম	লাম	লাম	লাম		লাম	লাম	লাম	লাম
Past Continuous	ছিলাম	ছিলাম	ছিলাম	ছিলাম		ছিলাম	ছিলাম	ছিলাম	ছিলাম
Past Perfect	য়েছিলাম	য়েছিলাম	য়েছিলাম	য়েছিলাম		য়েছিলাম	য়েছিলাম	য়েছিলাম	য়েছিলাম
Future Indefinite	ব	ব	ব	বো, ব		বো, ব	বো, ব	বো, ব	বো, ব
	VEG5				**VEG6**	**VEG7**			**VEG8**

Table 3. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG9 to VEG11 for First Person

Tenses	Vowel Ended Roots						
	হ (ha)	**ধা** (dha)	**না** (na)	**বা** (ba)	**ক** (ko)	**ব** (bo)	**র** (ro)
Present Indefinite	ই	ই	ই	ই	ই	ই	ই
Present Continuous	ছি	ছি	ছি	ছি	ছি	ছি	ছি
Present Perfect	য়েছি	ধা>ধে য়েছি	না>নে য়েছি	বা>বে য়েছি	য়েছি	য়েছি	য়েছি
Past Indefinite	লাম	ধা>ধাই লাম	না>নাই লাম	বা>বাই লাম	ক>কই লাম	ব>বই লাম	র>লাম
Past Habitual	তাম	ধা>ধাই তাম	না>নাই তাম	বা>বাই তাম	ক>কই তাম	ব>বই তাম	র>রই তাম
Past Continuous	ছিলাম	ছিলাম	ছিলাম	ছিলাম	ছিলাম	ছিলাম	ছিলাম
Past Perfect	য়েছিলাম	ধা>ধে য়েছিলাম	না>নে য়েছিলাম	বা>বে য়েছিলাম	য়েছিলাম	য়েছিলাম	য়েছিলাম
Future Indefinite	ব	ব	ব	ব	বো, ব	বো, ব	বো, ব
	VEG9	**VEG10**			**VEG11**		

4.2 Vowel Ended Roots and Their Verbal Inflexion for Second Person

Tables 4-to-11 present the subgroups of VEG1-to-VEG10 along with their inflexions respectively. The tables show the roots with their corresponding tenses for second person as a subject. In Table 4, roots পা (pa) and খা (kha) in VEG1 are changed into পে (pe) and খে (khe) in present perfect, past indefinite, past habitual and past perfect tenses respectively. পা (pa) and খা (kha) are also changed into পে (pe) and খে (khe) for imperative in general (GEN) case. In Table 5, the roots গা (ga), চা (cha) and ছা (chha) in VEG2 are changed into গে (ge), চে (che) and ছে (chhe) in present perfect and past perfect tenses and into গাই (gai), চাই (chai) and ছাই (chhai) in past indefinite and past habitual tenses respectively. গা (ga), চা (cha) and ছা (chha) are also changed into গে (ge), চে (che) and ছে (chhe) in general form of second person for imperative tense.

Table 4. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG1 for Second Person

	Vowel Ended Roots					
	পা (pa)			খা (kha)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	ও	স	ন
Present Continuous	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন
Present Perfect	পা>পে য়েছ	পা>পে য়েছিস	পা>পে য়েছেন	খা>খে য়েছ	খা>খে য়েছিস	খা>খে য়েছেন
Imperative	ও	*	ন	ও	*	ন
Past Indefinite	পা>পে লে	পা>পে লি	পা>পে লেন	খা>খে লে	খা>খে লি	খা>খে লেন
Past Habitual	পা>পে তে	পা>পে তি	পা>পে তেন	খা>খে তে	খা>খে তি	খা>খে তেন
Past Continuous	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন
Past Perfect	পা>পে য়েছিলে	পা>পে য়েছিলি	পা>পে য়েছিলেন	খা>খে য়েছিলে	খা>খে য়েছিলি	খা>খে য়েছিলেন
Future Indefinite	বে	বি	বেন	বে	বি	বেন
Imperative	পা>পেও	স	*	খা>খেও	স	*
	VEG1					

Table 5. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG2 for Second Person

	Vowel Ended Roots								
	গা (ga)			**চা** (cha)			**ছা** (chha)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	ও	স	ন	ও	স	ন
Present Continuous	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন
Present Perfect	গা>গে য়েছ	গা>গে য়েছিস	গা>গে য়েছেন	চা>চে য়েছ	চা>চে য়েছিস	চা>চে য়েছেন	ছা>ছে য়েছ	ছা>ছে য়েছিস	ছা>ছে য়েছেন
Imperative	ও	*	ন	ও	*	ন	ও	*	ন
Past Indefinite	গা>গাইলে	গা>গাইলি	গা>গাইলেন	চা>চাইলে	চা>চাইলি	চা>চাইলেন	ছা>ছাইলে	ছা>ছাইলি	ছা>ছাইলেন
Past Habitual	গা>গাই তে	গা>গাই তি	গা>গাই তেন	চা>চাই তে	চা>চাই তি	চা>চাই তেন	ছা>ছাই তে	ছা>ছাই তি	ছা>ছাই তেন
Past Continuous	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন
Past Perfect	গা>গে য়েছিলে	গা>গে য়েছিলি	গা>গে য়েছিলেন	চা>চে য়েছিলে	চা>চে য়েছিলি	চা>চে য়েছিলেন	ছা>ছে য়েছিলে	ছা>ছে য়েছিলি	ছা>ছে য়েছিলেন
Future Indefinite	বে	বি	বেন	বে	বি	বেন	বে	বি	বেন
Imperative	গা>গে ও	স	*	চা>চে ও	স	*	ছা>ছে ও	স	*
	VEG2								

Table 6 shows the changes of root নি (ni) to না (na) and নে, root দি (di) to দা (da) and দে (de) in present indefinite, imparative and funture indefinite tenses and root যা (ja) to গি (gi) গে (ge) and যে (je) for present perfect, past indifinite, past habitual and past perfect recpectively. Roots ছুঁ (chhu), থু (thu), শু (shu) and ধু (dhu) are changed into ছো (chho), থো (tho), শো (sho) and ধো (dho) respectively in Table 7. In addition, Table

8 focuses the changes of roots দু (du) to দো (dho), নু (nu) to নো (no) and রু (ru) to রো (ro) in present indefinite and imperative tenses and also roots দু (du) to দুই (dui), নু (nu) to নই (noi) and রু (ru) to রুই (rui) in past indefinite tenses respectively.

Table 6. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG3 and VEG4 for Second Person

	Vowel Ended Roots								
	নি (ni)			**দি** (di)			**যা** (ja)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	নি>না ও	নি>নে	নি>নে ন	দি>দা ও	দি>দে	দি>দে ন	ও	যা	ন
Present Continuous	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন
Present Perfect	য়েছ	য়েছিস	য়েছেন	য়েছ	য়েছিস	য়েছেন	যা>গি য়েছ	যা>গি য়েছিস	যা>গি য়েছেন
Imperative	নি>না ও	নি>নে এ	নি>নে ন	দে>দা ও	দে>দ এ	দি>দে ন	ও	*	ন
Past Indefinite	লে	লি	লেন	লে	লি	লেন	যা>গে লে	যা>গে লি	যা>গে লেন
Past Habitual	তে	তি	তেন	তে	তি	তেন	যা>যে তে	যা>যে তি	যা>যে তেন
Past Continuous	ছিলে	ছিলি	ছিলেন	ছিলে	ছিলি	ছিলেন	ছিলে	ছিলি	ছিলেন
Past Perfect	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন	যা>গি য়েছিলে	যা>গি য়েছিলি	যা>গি য়েছিলেন
Future Indefinite	নি>নে বে	বি	নি>নে বেন	দি>দে বে	বি	দি>দে বেন	বে	বি	বেন
Imperative	ও	স	*	ও	স	*	এও	স	*
	VEG3						**VEG4**		

Table 7. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG5 for Second Person

	Vowel Ended Roots											
	ছুঁ (chhu)			**থু** (thu)			**শু** (shu)			**ধু** (dhu)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ছুঁ> ছোও	ছুঁ> ছোস	ছুঁ> ছোন	থু> থোও	থু> থোস	থু> থোন	শু> শোও	শু> শোস	শু> শোন	ধু> ধোও	ধু> ধোস	ধু> ধোন
Present Continuous	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন
Present Perfect	য়েছ	য়েছিস	য়েছেন	য়েছ	য়েছিস	য়েছেন	য়েছ	য়েছিস	য়েছেন	য়েছ	য়েছিস	য়েছেন
Imperative	ও	*	ন	ও	*	ন	ও	*	ন	ও	*	ন
Past Indefinite	লে	লি	লেন	লে	লি	লেন	লে	লি	লেন	লে	লি	লেন
Past Habitua	তে	তি	তেন	তে	তি	তেন	তে	তি	তেন	তে	তি	তেন
Past Continuous	ছিলে	ছিলি	ছিলেন	ছিলে	ছিলি	ছিলেন	ছিলে	ছিলি	ছিলেন	ছিলে	ছিলি	ছিলেন
Past Perfect	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন
Future Indefinite	বে	বি	বেন	বে	বি	বেন	বে	বি	বেন	বে	বি	বেন
Imperative	য়ো	স	*	য়ো	স	*	য়ো	স	*	য়ো	স	*
	VEG5											

Table 8. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG6 and VEG7 for Second Person

	Vowel Ended Roots								
	দু (du)			নু (nu)			রু (ru)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	দু>দো ও	স	দু>দো ন	নু>নো ও	স	নু>নো ন	রু>রো ও	স	রু>রো ন
Present Continuous	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন
Present Perfect	য়েছ	য়েছিস	য়েছেন	য়েছ	য়েছিস	য়েছেন	য়েছ	য়েছিস	য়েছেন
Imperative	দু>দো ও	দু>দো	ন	নু>নো ও	নু>নো	নু>নো ন	রু>রো ও	রু>রো	রু>রো ন
Past Indefinite	দু>দুই লে	দু>দুই লি	দু>দুই লেন	নু>নই লে	নু>লি	নু>নই লেন	রু>রুই লে	রু>রুই লি	রু>রুই লেন
Past Habitual	ইতে	ইতি	ইতেন	ইতে	ইতি	ইতেন	ইতে	ইতি	ইতেন
Past Continuous	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন
Past Perfect	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন
Future Indefinite	ইবে	ইবি	ইবেন	ইবে	ইবি	ইবেন	ইবে	ইবি	ইবেন
Imperative	ইও, ইয়ো	ইস	ইবেন	ইও, ইয়ো	ইস	ইবেন	ইও, ইয়ো	ইস	ইবেন
	VEG6			VEG7					

Table 9. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG8 and VEG9 for Second Person

	Vowel Ended Roots					
	ল (lo)			হ (ho)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	ও	স	ন
Present Continuous	*	*	*	চ্ছ	চ্ছিস	চ্ছেন
Present Perfect	*	*	*	য়েছ	য়েছিস	য়েছেন
Imperative	ও		ন	ও	স	ওন
Past Indefinite	*	*	*	লে	লি	লেন
Past Habitual	*	*	*	তে	তিস	তেন
Past Continuous	*	*	*	চ্ছিলে	চ্ছিলি	চ্ছিলেন
Past Perfect	*	*	*	য়েছিলে	য়েছিলি	য়েছিলেন
Future Indefinite	*	*	*	বে	বি	বেন
Imperative	ইও	ইস	ইবেন	ও	স	*
	VEG8			VEG9		

In Table 9, no changes have been made in roots since they can easily be combined with their inflexions in forming accurate verbs. Roots ধা (dha), না (na) and বা (ba) are changed into ধে (dhe), নে (ne) and বে (be) in present and past perfect tenses and the same roots are changing to ধাই (dhai), নাই (nai) and বাই (bai) for past indefinite and past habitual tenses respectively in Table 10. Changes also occure in imperative

tense in the table. Table 11 demonstrates the verbal inflexions of roots ক (ko), ব (bo), র (ro) and স (so) for all forms of second person.

Table 10. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG10 for Second Person

	Vowel Ended Roots								
	ধা (dha)			না (na)			বা (ba)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	ও	স	ন	ও	স	ন
Present Continuous	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন	চ্ছ	চ্ছিস	চ্ছেন
Present Perfect	ধা>ধে য়েছ	ধা>ধে য়েছিস	ধা>ধে য়েছেন	না>নে য়েছ	না>নে য়েছিস	না>নে য়েছেন	বা>বে য়েছ	বা>বে য়েছিস	বা>বে য়েছেন
Imperative	ও	*	ন	ও	*	ন	ও	*	ন
Past Indefinite	ধা>ধা ইলে	ধা>ধা লি	ধা>ধা ইলেন	না>না ইলে	না>না ইলি	না>নাই লেন	বা>বাই লে	বা>বাই লি	বা>বাই লেন
Past Habitual	ধা>ধাই তে	ধা>ধাই তি	ধা>ধাই তেন	না>নাই তে	না>নাই তি	না>নাই তেন	বা>বাই তে	বা>বাই তি	বা>বাই তেন
Past Continuous	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন
Past Perfect	ধা>ধে য়েছিলে	ধা>ধে য়েছিলি	ধা>ধে য়েছিলেন	না>নে য়েছিলে	না>নে য়েছিলি	না>নে য়েছিলেন	বা>বে য়েছিলে	বা>বে য়েছিলি	বা>বে য়েছিলেন
Future Indefinite	ইবে	ইবি	ইবেন	ইবে	ইবি	ইবেন	ইবে	ইবি	ইবেন
Imperative	ধা>ধে ও	স	*	না>নে ও	স	*	বা>বে ও	স	*
	Group VEG10								

Table 11. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG11 for Second Person

	Vowel Ended Roots											
	ক (ko)			ব (bo)			র (ro)			স (so)		
Tense	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	ও	স	ন	ও	স	ন	ও	স	ন
Present Continuous	চ্ছ, ইচ্ছ	চ্ছিস, ইচ্ছিস	চ্ছেন, ইচ্ছেন	চ্ছ,ইচ্ছ	চ্ছিস,ইচ্ছিস	চ্ছেন, ইচ্ছেন	চ্ছ,ইচ্ছ	চ্ছিস, ইচ্ছিস	চ্ছেন, ইচ্ছেন	চ্ছ,ইচ্ছ	চ্ছিস, ইচ্ছিস	চ্ছেন, ইচ্ছেন
PresentPerfect	য়েচ্ছ	য়েচ্ছিস	য়েচ্ছেন	য়েচ্ছ	য়েচ্ছিস	য়েচ্ছেন	য়েচ্ছ	য়েচ্ছিস	য়েচ্ছেন	য়েচ্ছ	য়েচ্ছিস	য়েচ্ছেন
Imperative	ও	*	উন	ও	*	উন	ও	*	উন	ও	*	উন
PastIndefinite	ইলে	ইলি	ইলেন	ইলে	ইলি	ইলেন	ইলে	ইলি	ইলেন	ইলে	ইলি	ইলেন
Past Habitual	ইতে	ইতিস	ইতেন	ইতে	ইতিস	ইতেন	ইতে	ইতিস	ইতেন	ইতে	ইতিস	ইতেন
Past Continuous	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন	চ্ছিলে	চ্ছিলি	চ্ছিলেন
PastPerfect	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন	য়েছিলে	য়েছিলি	য়েছিলেন
Future Indefinite	বে	বি	বেন	বে	বি	বেন	বে	বি	বেন	বে	বি	বেন
Imperative	ইও	ইস	*	ইও	ইস	*	ইও	ইস	*	ইও	ইস	*
	Group VEG11											

4.3 Vowel Ended Roots and Their Verbal Inflexion for Third Person

Tables 12 to 17 present the subgroups of VEG1-to-VEG11 along with their alternatives and inflexions respectively. The tables show the roots with their corresponding tenses for third person as a subject.

Table 12. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG1 and VEG2 for Third Person

Tense	Vowel Ended Roots									
	পা (pa)		খা (kah)		গা (ga)		চা (cha)		ছা (chha)	
	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)
Present Indefinite	য়	ন	য়	ন	য়	ন	য়	ন	য়	ন
Present Continuous	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন
Present Perfect	পা>পে য়েছে	পা>পে য়েছেন	খা>খে ছে	খা>খে ছেন	গা>গে য়েছে	গা>গে য়েছেন	চা>চে য়েছে	চা>চে য়েছেন	ছা>ছে য়েছে	ছা>ছে য়েছেন
Imperative	ক	ন	ক	ন	ক	ন	ক	ন	ক	ন
Past Indefinite	পা>পে ল	পা>পে লেন	খা>খে ল	খা>খে লেন	ইল	ইলেন	ইল	ইলেন	ইল	ইলেন
Past Habitual	পা>পে ত	পা>পে তেন	খা>খে ত	খা>খে তেন	ইত	ইতেন	ইত	ইতেন	ইত	ইতেন
Past Continuous	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন
Past Perfect	পা>পে য়েছিল	পা>পে য়েছিলেন	খা>খে য়েছিল	খা>খে য়েছিলেন	গা>গে য়েছিল	গা>গে য়েছিলেন	চা>চে য়েছিল	চা>চে য়েছিলেন	ছা>ছে য়েছিল	ছা>ছে য়েছিলেন
Future Indefinite	বে	বেন	বে	বেন	ইবে	ইবেন	ইবে	ইবেন	ইবে	ইবেন
Imperative	*	*	*	*	*	*	*	*	*	*
	Group VEG1				Group VEG2					

Table 13. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG3 and VEG4 for Third Person

Tense	Vowel Ended Roots					
	নি (ni)		দি (di)		যা (ja)	
	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)
Present Indefinite	নি>নে য়	নি>নে ন	দি>দে য়	দি>দে ন	য়	ন
Present Continuous	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন
Present Perfect	য়েছে	য়েছেন	য়েছে	য়েছেন	যা>গি য়েছে	যা>গি য়েছেন
Imperative	ক	ন	ক	ন	ক	ন
Past Indefinite	ল	লেন	ল	লেন	যা>গে ল	যা>গে লেন
Past Habitual	ত	তেন	ত	তেন	যা>যে ত	যা>যে তেন
Past Continuous	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন
Past Perfect	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন	যা>গি য়েছিল	যা>গি য়েছিলেন
Future Indefinite	নি>নে বে	নি>নে বেন	দি>দে বে	দি>দে বেন	বে	বেন
Imperative	*	*	*	*	*	*
	Group VEG3				Group VEG4	

Table 14. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG5 for Third Person

Tense	Vowel Ended Roots							
	ছুঁ (chhu)		থু (thu)		শু (shu)		ধু (dhu)	
	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)
Present Indefinite	ছুঁ>ছোঁ য়	ছুঁ>ছোঁ ন	থু>থো য়	থু>থো ন	শু>শো য়	শু>শো ন	ধু>ধোয়	ধু>ধো ন
Present Continuous	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন
Present Perfect	য়েছে	য়েছেন	য়েছে	য়েছেন	য়েছে	য়েছেন	য়েছে	য়েছেন
Imperative	ক	ন	ক	ন	ক	ন	ক	ন
Past Indefinite	ল	লেন	ল	লেন	ল	লেন	ল	লেন
Past Habitual	ত	তেন	ত	তেন	ত	তেন	ত	তেন
Past Continuous	ছিল	ছিলেন	ছিল	ছিলেন	ছিল	ছিলেন	ছিল	ছিলেন
Past Perfect	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন
Future Indefinite	বে	বেন	বে	বেন	বে	বেন	বে	বেন
Imperative	*	*	*	*	*	*	*	*
	Group VEG5							

Table 15. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG6 and VEG7 for Third Person

Tense	Vowel Ended Roots							
	ন (n)		দু (du)		নু(nu)		রু (ru)	
	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)
Present Indefinite	য়	ন	দু>দো য়	দু>দো ন	নু>নো য়	নু>নো ন	রু>রো য়	রু>রো ন
Present Continuous			চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন
Present Perfect			য়েছে	য়েছেন	য়েছে	য়েছেন	য়েছে	য়েছেন
Imperative			ক	ন	ক	ন	ক	ন
Past Indefinite			দু>দু ইল	দু>দুই লেন	নু>নুই ল	নু>নুই লেন	রু>রুই ল	রু>রুই লেন
Past Habitual			ইত	ইতেন	ইত	ইতেন	ইত	ইতেন
Past Continuous			ছিল	ছিলেন	ছিল	ছিলেন	ছিল	ছিলেন
Past Perfect			য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন
Future Indefinite			ইবে	ইবেন	ইবে	ইবেন	ইবে	ইবেন
Imperative			*	*	*	*	*	*
	Group VEG6		Group VEG7					

5 Formation of Template of Bangla Vowel Ended Roots

As per the detailed analyses of the Bangla VERs in above section, following template has been developed following the format defined in Section 3.

[HW]{}"UW(icl/iof…>concept1>concept2…,REL1>…,REL2>…," (ROOT, VEND, DEF/ ALT1/ ALT2/ALT3.., VEGn, #REL1, #REL2, …) <FLG, FRE, PRI>

where,

HW← Head Word (Bangla Word; in this case it is Bangla root);

UW← Universal Word (English word from knowledge base);

icl/iof/… means *inclusion/instance of …*to represent the concept of universal word

REL1/REL2.., indicates the related relations regarding the corresponding word.

ROOT ← it is an attribute for Bangla roots. This attribute is immutable for all Bangla roots.

Table 16. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG8-to-VEG10 for Third Person

	Vowel Ended Roots									
	ল (lo)		হ (ho)		ধা (dha)		না (na)		বা (ba)	
Tense	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)
Present Indefinite	য়	ন	য়	ন	য়	ন	য়	ন	য়	ন
Present Continuous	*	*	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন	চ্ছে	চ্ছেন
Present Perfect	*	*	য়েছে	য়েছেন	ধা>ধে য়েছে	ধা>ধে য়েছেন	না>নে য়েছে	না>নে য়েছেন	বা>বে য়েছে	বা>বে য়েছেন
Imperative	*	*	হ>হো ক	হ>হো ন	ক	ন	ক	ন	ক	ন
Past Indefinite	*	*	ল	লেন	ইল	ইলেন	ইল	ইলেন	ইল	ইলেন
Past Habitual	*	*	ত	তেন	ইত	ইতেন	ইত	ইতেন	ইত	ইতেন
Past Continuous	*	*	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন
Past Perfect	*	*	য়েছিল	য়েছিলেন	ধা>ধে য়েছিল	ধা>ধে য়েছিলেন	না>নে য়েছিল	না>নে য়েছিলেন	বা>বে য়েছিল	বা>বে য়েছিলেন
Future Indefinite	*	*	বে	বেন	ইবে	ইবেন	ইবে	ইবেন	ইবে	ইবেন
Imperative	*	*	*	*	*	*	*	*	*	*
	Group VEG8		Group VEG9		Group VEG10					

Table 17. Variation of Vowel Ended Roots and their Verbal Inflexions of VEG11 for Third Person

	Vowel Ended Roots							
	ক (ko)		ব (bo)		র (ro)		স (so)	
Tense	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)	সে (Gen.)	তিনি (Res.)
Present Indefinite	য়	ন	য়	ন	য়	ন	য়	ন
Present Continuous	চ্ছে, ইছে	চ্ছেন, ইছেন	চ্ছে, ইছে	চ্ছেন, ইছেন	চ্ছে, ইছে	চ্ছেন, ইছেন	চ্ছে, ইছে	চ্ছেন, ইছেন
Present Perfect	য়েছে	য়েছেন	য়েছে	য়েছেন	য়েছে	য়েছেন	য়েছে	য়েছেন
Imperative	উক	উন	উক	উন	উক	উন	উক	উন
Past Indefinite	ইল	ইলেন	ইল	ইলেন	ইল	ইলেন	ইল	ইলেন
Past Habitual	ত	তেন	ত	তেন	ত	তেন	ত	তেন
Past Continuous	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন	চ্ছিল	চ্ছিলেন
Past Perfect	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন	য়েছিল	য়েছিলেন
Future Indefinite	ইবে	ইবেন	ইবে	ইবেন	ইবে	ইবেন	ইবে	ইবেন
Imperative	*		*	*	*	*	*	*
	Group VEG11							

VEND is the attributes for vowel ended roots.

VEGn ← attribute for the group number of vowel ended roots (n=1, 2…10).

DEF/ALT1/ALT2/ALT3 etc. are the attributes for the default, first, second or third alternatives of the vowel ended roots respectively.

#REF1, #REF2 etc. are the possible corresponding relations regarding the root word.

In our dictionary we avoid <FLG, FRE, PRE> part of the entry as it is mostly same for all entries.

Here, attributes, ROOT and VEND are fixed for all Bangla vowel ended roots, whereas ALT1, ALT2 or ALT3 etc. are not necessary for all roots, they are used only for alternative roots.

In the following examples we construct the dictionary entries for some sample verb roots using our designed template:

[যা]{}"go(icl>move>do, plf>place, plt>place, agt>thing)" (ROOT, VEND, VEG3, #PLF, #PLT, #AGT)

[গি]{}"go(icl>move>do, plf>place, plt>place, agt>thing)" (ROOT, VEND, ALT1, VEG3, #PLF, #PLT, #AGT)

[খা]{}"eat(icl>consume>do,agt>living_thing, ins>thing, obj>concrete_thing, plf>thing, tim>abstract_thing)" (ROOT, VEND, VEG1, #PLF, #PLT, #AGT)

For first two entries the relation *plf* (place from) indicates from where agent go/goes, plt (place to) means to where go/goes, agt (agent) for who go/goes and attribute ALT1 indicates that root 'গি' (*gi*) is the first alternative of root 'যা' (*ja*) shown in Table 1. Attributes #PLF, #PLT and #AGT indicate that relations *plf, plt* and *agt* can be made with roots 'গি' (*gi*) and 'যা' (*ja*). Similarly, other entries have been developed according to the format discussed above. Our proposed dictionary entries of VERs along with their alternatives are given below.

- **Dictionary Entries of VEG1:**

[পা]{}"get((icl>do,equ>obtain,src>uw,agt>thing,obj>thing)" (ROOT, VEND, DEF, VEG1, #OBJ,#AGT)

[পে]{}"get((icl>do,equ>obtain,src>uw,agt>thing,obj>thing)" (ROOT, VEND, ALT1, VEG1, #OBJ,#AGT)

[খা]{}"eat(icl>consume>do,agt>living_thing,obj>concrete_thing,ins>thing)"(ROOT,VEND, DEF,VEG1,#AGT, #OBJ,#INS)

[খে]{}"eat(icl>consume>do,agt>living_thing,obj>concrete_thing,ins>thing)"(ROOT,VEND, ALT1,VEG1,#AGT, #OBJ,#INS)

- **Dictionary Entries of VEG2:**

[গা]{}"sing(icl>do,com>music,cob>thing,agt>living_thing,obj>song,rec>living_thing)" (ROOT, VEND, DEF, VEG2,#AGT,#OBJ,#COM,#COB,#REC)

[গে]{}"sing(icl>do,com>music,cob>thing,agt>living_thing,obj>song,rec>living_thing)" (ROOT, VEND, ALT1, VEG2, #AGT,#OBJ,#COM,#COB,#REC)

[গাই]{}"sing(icl>do,com>music,cob>thing,agt>living_thing,obj>song,rec>living_thing)" (ROOT, VEND, ALT2, VEG2, #AGT,#OBJ,#COM,#COB,#REC)

[চা]{}"want(icl>desire>be,obj>uw,aoj>volitional_thing,pur>thing)"(ROOT,VEND,DEF,VEG2,#OBJ,#AOJ, #PUR)

[চে]{}"want(icl>desire>be,obj>uw,aoj>volitional_thing,pur>thing)"(ROOT,VEND,ALT1,VEG2,#OBJ,#AOJ, #PUR)

[চাই]{}"want(icl>desire>be,obj>uw,aoj>volitional_thing,pur>thing)"(ROOT,VEND,ALT2,VEG2,#OBJ,#AOJ, #PUR)

[ছা]{}"roof(icl>cover>do,agt>volitional_thing,obj>thing,ins>thing)"(ROOT,VEND,DEF,VEG2,#AGT,#OBJ,#INS)

[ছে]{}"roof(icl>cover>do,agt>volitional_thing,obj>thing,ins>thing)"(ROOT,VEND,ALT1,VEG2,#AGT,#OBJ, #INS)

[ছাই]{}"roof(icl>cover>do,agt>volitional_thing,obj>thing,ins>thing)"(ROOT,VEND,ALT2,VEG2,AGT,#OBJ, #INS)

- **Dictionary Entries of VEG3:**

[নি]{}"take(icl>capture>do,agt>thing,obj>thing)"(ROOT, VEND, DEF,VEG3, #AGT, #OBJ)<B,0,0>

[দি]{}"give(icl>do,equ>hand_over,agt>living_thing,obj>concrete_thing,rec>person)" (ROOT, VEND, DEF, VEG3, #AGT,#OBJ,#REC)

- **Dictionary Entries of VEG4:**

[যা]{}"go(icl>move>do, plf>place, plt>place, agt>thing)" (ROOT, VEND, DEF, VEG4, #PLF, #PLT, #AGT)

[গি]{}"go(icl>move>do, plf>place, plt>place, agt>thing)" (ROOT, VEND, ALT1, VEG4, #PLF, #PLT, #AGT)

[গে]{}"go(icl>move>do, plf>place, plt>place, agt>thing)" (ROOT, VEND, ALT2, VEG4, #PLF, #PLT, #AGT)

[যে]{}"go(icl>move>do, plf>place, plt>place, agt>thing)" (ROOT, VEND, ALT3, VEG4, #PLF, #PLT, #AGT)

- **Dictionary Entries of VEG5:**

[ছুঁ]{}"touch(icl>come_in_contact>do,agt>person,obj>concrete_thing,ins>thing"(ROOT,VEND,DEF,VEG5, #AGT, #OBJ,#INS)

[থু]{}"put(icl>displace>do,plc>thing,agt>thing,obj>thing)"(ROOT,VEND,DEF, VEG5, #AGT, #OBJ,#PLC)

[শু]{}"sleep(icl>rest>be,aoj>living_thing)"(ROOT,VEND,VEG5,#AOJ,#PLC)<B,0,0>

[ধু]{}"wash(icl>serve>do,agt>living_thing,obj>concrete_thing,ins>functional_thing)"(ROOT,VEND,DEF, VEG5, #AGT,#OBJ,#INS)

- Dictionary Entries of VEG6:

[ন]{}"be(icl>be>not, aoj>thing)" (ROOT, VEND, DEF, VEG6, #AOJ)

- **Dictionary Entries of VEG7:**

[দু]{}“milk(icl>draw>do,agt>thing,obj>thing)” (ROOT, VEND, DEF, VEG7, #AGT, #OBJ)

[নু]{}“bath(icl>vessel>thing)” (ROOT, VEND, VEG7, #PLF, #PLT, #AGT)

[রু]{}“sow(icl>put>do,plt>thing,agt>thing,obj>concrete_thing)”(ROOT,VEND,DEF,VEG7,#PLT, #AGT,#OBJ)

- **Dictionary Entries of VEG8:**

[ল]{}“take(icl>require>be,obj>thing,aoj>thing,ben>person)” (ROOT, VEND, DEF, VEG8, #OBJ, #AOJ, #BEN)

- **Dictionary Entries of VEG9:**

[হ]{}“be(icl>be,equ>be_located,aoj>thing,plc>uw)”(ROOT,VEND,DEF,VEG9,#AOJ, #PLC)

- **Dictionary Entries of VEG10:**

[ধা]{}“urge(icl>rede>do,agt>volitional_thing,obj>volitional_thing,gol>thing)”(ROOT,VEND,DEF,VEG10,#AGT, #OBJ,#GOL)

[না]{}“bath(icl>vessel>thing)” (ROOT, VEND, VEG10,#AGT,#PLC)

[বা]{}“row(icl>move(icl>cause)>do,plt>thing,agt>person,obj>boat,ins>thing)”(ROOT,VEND,DEF,VEG10,#PLF, #PLT, #AGT,#OBJ,#INS)

- **Dictionary Entries of VEG11:**

[ক]{}“talk(icl>communicate>do,cob>uw,agt>person,obj>thing,ptn>person)”(ROOT,VEND,DEF,VEG11,#AGT, #OBJ,#PTN,#COB)

[ব]{}“bear(icl>have>be,obj>property,aoj>thing)”(ROOT,VEND,DEF, VEG11, #OBJ, #AOJ)

[র]{}“stay(icl>dwell>be,aoj>person,plc>uw)” (ROOT, VEND, DEF, VEG11, #AOJ, #PLC)

6 Formation of Template for Verbal Inflexion

In the previous section, we outlined a template for Bangla verb roots. However, the template for verbal inflexion (VI) is very similar to that of Bangla verb roots with only a difference is that the later one does not have any universal word and that differs from the former with attributes they use. Template of Verbal Inflexions is as follows:

[HW]{} “” (VI, V, Pn [,ALT1/ALT2,ALT3...], GEN/RES/NEG, Atense, LL/CL, VEG_n/ ^VEG_n) <FLG, FRE, PRI>

HW← Head Word (Verbal Inflexion of Bangla Verb Root); UW← Universal Word (In case of Verbal Inflexion, UW is null); VI← is an attribute of Verbal Inflexion, V← for Verb, since Verbal Inflexions form verb when added with Bangla verb root as Suffixes, so the ‘V’ is considered as an attribute.

Pn (n=1 to 3) ← Attribute for person; P1, P2 and P3 refer first, second and third persons respectively. These are important attributes because verb varies according to persons.

ALT1/ALT2/ALT3 ← Attributes for alternative roots. These attributes are used as attributes of verbal inflexions when they are combined with the respective verb roots.

GEN/RES/NEG← Attributes for verbal inflexions when they are combined with verb roots to form general (GEN), respective (RES) and neglect (NEG) verbs in respect to person. They are used as attributes with the VIs that are combined with verb roots to form verb only for second and third persons.

Atense ← Attribute Tense; - this is also an important attribute because verb varies according to Bangla Tenses.

LL/CL← Attribute for types of languages where LL refers to literature language and CL to conversation language. They are used as attributes with the VIs as they form LL or CL types of verbs.

VEG_n//^VEG_n← Attributes indicate for vowel ended group number or not for vowel ended group. They are used as attributes of VIs as they are combined with respective groups or not. Similar to *verb roots* attribute, VI is fixed for all *Verbal Inflexions.* Attribute Pn can be either attributes 'P1' (for first person), 'P2' (for second person) or 'P3' (for third person). Again Atense can be any tense such as attributes 'PRS' (for present indefinite), 'PRG' (progress for present continuous) 'CMPL' (complete for perfect tense), 'IMP' for imperative and 'HAB' for habitual etc. If the tense is past continuous, two attributes are used consecutively such as attribute 'PST' (for past) and 'PRG' (for continuous) and 'FUT' for future tense.

Some examples of dictionary entries of *Verbal Inflexions* according to the proposed template are given below:

[য়েছিলাম] " "{}(VI,P1,PST, PER,ALT1,CH,VEG1,VEG2, VEG9)

[ছিলাম] " "{}(VI,P1,PST,PRG,CH)

[বি] " "{}(VI,P2,NEG,FUT,CH)

[ছেন] " "{}(VI,P2,RES,PRT, PRG,CH)

Here, VI, 'য়েছিলাম' can be combined with first alternative roots (as attribute ALT1 is used to define first alternative root) with verb roots of *vowel ended group 1* or *vowel ended group 2* for past perfect tense (attributes PST for past and CMPL for perfect) to create the verbs of conversation language (CL attribute for conversation language) for first person (attribute is P1). Similarly, attributes for other dictionary entries are defined. Our proposed dictionary entries of verbal inflexions are as follows.

- **Dictionary entries of verbal inflexions of all tenses for first person as a subject:**
  [ই] " "{}(VI, 1P, PRS, DEF, CL)

  [ছি] " "{}(VI, 1P, PRS, PRG, DEF, CL)

  [য়েছি] " "{}(VI, 1P, PRS, CMPL, DEF, ALT1, CL, VEG1, VEG2, VEG4,VEG10)

  [লাম] " "{}(VI,1P,PST,ALT1, ALT2,CL, VEG1, VEG2, VEG4,VEG10)

  [তাম] " "{}(VI,P1,PST,DEF,ALT1,ALT2,ALT3, SHD,VEG3)

[ছিলাম] “ ”{}(VI,1P,PST, PRG, DEF,CL)

[য়েছিলাম] “ ”{}(VI,1P,PST, CMPL,ALT1,CL,VEG1,VEG2, VEG4,VEG10)

[ব] “ ”{}(VI, 1P, FUT, DEF, CL)

[বো] “ ”{}(VI, 1P, FUT, DEF, CL)

- **Dictionary entries of verbal inflexions of all tenses for second person as a subject:**

[ও] “ ”{}(VI, 2P, PRS, DEF, CL,DEF,ALT1,VEG3,VEG5,VEG7,GEN)

[স্] “ ”{}(VI, 2P, PRS, PRG, CL,DEF,ALT1,VEG3,VEG5,VEG7,NEG)

[ন] “ ”{}(VI, 2P, PRS, CMPL, DEF, ALT1, CL, VEG3,VEG5,VEG7,RES)

[চ্ছ] “ ”{}(VI, 2P, PRS, PRG, DEF, CL,GEN)

[চ্ছিস] “ ”{} (VI, 2P, PRS, PRG, DEF, CL,NEG)

[চ্ছেন] “ ”{} (VI, 2P, PRS, PRG, DEF, CL,RES)

[য়েচ্ছ] “ ”{}(VI, 2P, PRS, CMPL, DEF, ALT1,VEG1, VEG2, VEG4, VEG10, CL,GEN)

[য়েছিস] “ ”{} (VI, 2P, PRS, CMPL, DEF, ALT1,VEG1, VEG2, VEG4, VEG10, CL,NEG)

[য়েচ্ছেন] “ ”{} (VI, 2P, PRS, CMPL, DEF, ALT1,VEG1, VEG2, VEG4, VEG10, CL,RES)

[লে] “ ”{}(VI, 2P, PST, DEF, ALT1,ALT2,VEG1, VEG2, VEG4, VEG7, CL,GEN)

[লি] “ ”{} (VI, 2P, PST, DEF, ALT1,ALT2,VEG1, VEG2, VEG4, VEG7, CL,NEG)

[লেন] “ ”{} (VI, 2P, PST, DEF, ALT1,ALT2,VEG1, VEG2, VEG4, VEG7, CL,RES)

[তে] “ ”{}(VI, 2P, PST, HAB, DEF, ALT1,ALT2,VEG1, VEG1, VEG2, VEG4, VEG10, CL,GEN)

[তি] “ ”{} (VI, 2P, PST, HAB, DEF, ALT1,ALT2,VEG1, VEG1, VEG2, VEG4, VEG10, CL,NEG)

[তেন] “ ”{} (VI, 2P, PST, HAB, DEF, ALT1,ALT2,VEG1, VEG1, VEG2, VEG4, VEG10, CL,RES)

[ছিলে] “ ”{}(VI, 2P, PST, PRG, DEF,CL,GEN)

[ছিলি] “ ”{} (VI, 2P, PST, PRG, DEF,CL,GEN)

[ছিলেন] “ ”{} (VI, 2P, PST, PRG, DEF,CL,GEN)

[য়েছিলে] “ ”{}(VI, 2P, PST, CMPL, DEF, ALT1, VEG1, VEG2, VEG4, CL,GEN)

[য়েছিলি] “ ”{} (VI, 2P, PST, CMPL, DEF, ALT1, VEG1, VEG2, VEG4, CL,NEG)

[য়েছিলেন] “ ”{} (VI, 2P, PST, CMPL, DEF, ALT1, VEG1, VEG2, VEG4, CL,RES)

[বে] “ ”{}(VI, 2P, FUT, DEF, ALT1, ALT2, VEG3, VEG4, CL,GEN)

[বি] " "{} (VI, 2P, FUT, DEF, ALT1, ALT2, VEG3, VEG4, CL,NEG)

[বেন] " "{} (VI, 2P, FUT, DEF, ALT1, ALT2, VEG3, VEG4, CL,RES)

[ইবে] " "{} (VI, 2P, FUT,DEF, CL, VEG7, VEG10,GEN)

[ইবি] " "{} (VI, 2P, FUT,DEF, CL, VEG7, VEG10,NEG)

[ইবেন] " "{}(VI, 2P, FUT,DEF, CL, VEG7, VEG10,RES)

[ও] " "{}(VI, 2P, IMPR, ALT1,VEG3,VEG5,VEG7,GEN)

[য়ো] " "{}(VI, 2P, IMPR, CL,DEF,VEG5)

[ইও] " "{}(VI, 2P, IMPR, DEF, CL,VEG5,GEN)

[ইস] " "{} (VI, 2P, IMPR, CMPL, DEF, CL,VEG5,NEG)

[ইবেন] " "{} (VI, 2P, IMPR, DEF, CL,VEG5,RES)

- **Dictionary entries of verbal inflexions of all tenses for third person as a subject:**

[য়] " "{} (VI, 3P, PRS, DEF, ALT1, CL,VEG3, VEG5, VEG7, GEN)

[ন] " "{} (VI, 3P, PRS, DEF, ALT1, CL,VEG3, VEG5, VEG7, RES)

[চ্ছে] " "{} (VI, 3P, PRS, PRG, DEF, CL, GEN)

[চ্ছেন] " "{} (VI, 3P, PRS, PRG, DEF, CL, RES)

[য়েছে] " "{} (VI, 3P, PRS, CMPL, DEF, ALT1,CL,VEG1, VEG2, VEG4, VEG10,GEN)

[য়েছেন] " "{} (VI, 3P, PRS, CMPL, DEF, ALT1,CL,VEG1, VEG2, VEG4, VEG10,RES)

[ক] " "{} (VI, 3P, IMP, DEF, ALT1,CL, VEG9,GEN)

[উক] " "{} (VI, 3P, IMP, DEF,CL,VEG11,GEN)

[উন] " "{} (VI, 3P, IMP, DEF, CL,VEG11, RES)

[ল] " "{} (VI, 3P, PST, DEF, ALT1, ALT2, CL,VEG1, VEG2, VEG4,GEN)

[লেন] " "{} (VI, 3P, PST, DEF, ALT1, ALT2, CL,VEG1, VEG2, VEG4, RES)

[ইল] " "{} (VI, 3P, PST, DEF, CL, VEG2, VEG10, VEG11, GEN)

[ইলেন] " "{} (VI, 3P, PST, DEF, CL, VEG2, VEG10, VEG11, RES)

[ত] " "{} (VI, 3P, PST, HAB, DEF, ALT1, ALT2, CL,VEG1, VEG4,GEN)

[তেন] " "{} (VI, 3P, PST, HAB, DEF, ALT1, ALT2, CL,VEG1, VEG4, RES)

[ইত] " "{} (VI, 3P, PST, HAB, DEF, CL,VEG2, VEG7,VEG10, GEN)

[ইতেন] " "{} (VI, 3P, PST, HAB, DEF, CL,VEG2, VEG7,VEG10, RES)

[ছিল] " "{} (VI, 3P, PST, PRG, DEF, CL, GEN)

[ছিলেন] " "{} (VI, 3P, PST, PRG, DEF, CL, RES)

[য়েছিল] " "{} (VI, 3P, PST, CMPL, DEF, ALT1, CL, VEG1, VEG2, VEG4,VEG10, GEN)

[য়েছিলেন] " "{} (VI, 3P, PST, CMPL, DEF, ALT1, CL, VEG1, VEG2, VEG4,VEG10, RES)

[বে] " "{} (VI, 3P,FUT, DEF, ALT1, CL, VEG3, GEN)

[বেন] " "{} (VI, 3P,FUT, DEF, ALT1, CL, VEG3, RES)

[ইবে] " "{} (VI, 3P, FUT, DEF, CL, VEG2, VEG7,VEG10, VEG11, GEN)

[ইবেন] " "{} (VI, 3P, FUT, DEF, CL, VEG2, VEG7,VEG10, VEG11, RES)

7 Conversion of a Bangla Sentence into UNL Expression

The encoding process is performed by shift/reduce parsing [22-23]. To explain the encoding steps, we give an example of a simple Bangla assertive sentence. Assertive simple sentences have only one main clause. We assume that analysis rules and the dictionary of Bangla to UNL are given to the analyser system *EnCo*. The following Bangla sentence is considered as an example

Bangla sentence: আমরা আম খাইতেছি ।

Transliterated sentence: Amra aam khaitechi.

Equivalent English sentence: We are eating mango.

The input Bangla sentence is processed according to the algorithm that we have developed in [24]. The chunks obtained from the input sentence are given below.

(আমরা) (আম) (খা) (ইতেছি)

(Amra) (aam) (kha) (itechi)

We have used an EnConverter [25] tool for our experiment. The tool takes a dictionary file for the sentence shown in Table 18 and a set of analysis rules shown in Table 19 as its input.

Table 18. Dictionary entries of respective Bangla sentence

[আমরা]{} "we(icl>group)"(PRON, HPRON, P1, PL, SUBJ)
[আম]{}"mango(icl>edible_fruit>thing)"(N, NCOM, FRUIT)
[খা]{}"eat(icl>consume>do,agt>living_thing,obj>concrete_thing)"(ROOT,VEND,VEG1, #AGT, OBJ)
[ইতেছি]{}"INF" (VI,VEND,P1,PRS,PRG)

In Table 18, attributes PRON indicates pronoun, HPRON indicates human pronoun, P1 for first person, PL for plural, SUBJ for subject, N indicates noun, NCOM for common noun, FRUIT for fruit item, ROOT for

verb root, VEND for vowel ended root, PRS for present tense, PRG for progress means present continuous rense respectively.

EnCo can input either a string or a list of words for a sentence of a native language. A list of morphemes or words of a sentence must be enclosed by [<<] and [>>] [1]. When the sentence is taken into EnCo, it places the sentence head (<<) in the LAW (Left Analysis Window), sentence texts or morphemes or words in the RAW (Right Analysis Window) and the sentence tail (>>) in the RCW (Right Condition Window) shown in Figure 2. After insertion of the input file with our given sentence the rules shown in Table 19 will be applied step by step to complete the conversion processes of the sentence to UNL expressions. Rule 1 describes when sentence head is in the LAW and subject 'আমরা' *aamra* (we) is in the RAW then AWs will be shifted to right after rule application. The EnCo will then retrieve the word, 'আমরা' from the Word Dictionary file and remains in the LAW and 'আম খাইতেছি', *aam khaitechi* (mango eating) will be in the RAW. Rule 2 is applied to delete the right node which is a blank space between 'আমরা' and noun 'আম', *aam* (mango) and only the noun 'আম' will be placed in the RAW, while the verb 'খাইতেছি', *khaitechi* (eating) will be placed in the RCW. Rule 3 is then applied to shift the windows to right and Rule 4 is applied to delete the space between 'আম' (aam) and 'খাইতেছি' (khaitechi) so that the word 'আম' (aam) is retrieved from the Word Dictionary and remains in the LAW and the verb 'খাইতেছি' (khatechi) is divided into root 'খা' (kha) which remains in the RAW and verbal inflexion 'ইতেছি' (itechi) remains in the RCW. To perform morphological analysis Rule 5 is now applied to place root 'খা' (kha) in the LAW and verbal inflexion 'ইতেছি' (itechi) in the RAW. At this time, Enco retrieves the dictionary entries 'খা' (kha) and 'ইতেছি' (itechi) from the word dictionary (input file) and will apply Rule 6 to combine the nodes of left and right analysis windows into a composite node to complete the morphological analysis of the verb 'খাইতেছি' (khaitechi). Then Rule 7 rewrites the attributes by deleting VI, VEND, and CEND for verb 'খাইতেছি' (khaitechi) that remains in the RAW.

After completion of the morphological analysis, Rule 8 is applied to perform semantic analysis between noun 'আম' (aam) and verb 'খাইতেছি' (khaitechi) by object relation, *obj* and noun 'আম' (aam) is deleted from the node-list, where 'খাইতেছি'(khaitechi) remains in the RAW. Similarly, another semantic analysis is held by agent relation, *agt* between the subject 'আমরা' (aamra) and verb 'খাইতেছি' (khaitechi) after applying Rule 9. The word 'আমরা' (aamra) is deleted from the node-list and the verb 'খাইতেছি' (khaitechi) remains in the RAW, which is the main predicate of the sentence. Later Rule 10 is applied to shift the windows to right and *&@entry* attribute is added to the verb as verb 'খাইতেছি' (khaitechi) is the main word of the sentence.

Finally, Rule 11 is applied to place the sentence tail (STAIL) on the LAW to complete the conversion process. After completion of the conversion process, the following UNL expresson will be created by the EnConverter shown in Table 20.

Table 19. Dictionary entries of respective Bangla sentence

Rule	Description
Rule 1: R{SHEAD:::}{PRON,SUBJ:::}P10;	Right Shift Rule
Rule 2: DR{SUBJ,^blk:blk::}{BLK:::}P10;	Right Deletion Rule
Rule 3: R{PRON,SUBJ:::}{N:::}P10;	Right Shift Rule
Rule 4: DR{N,^blk:blk::}{BLK:::}P10;	Right Deletion Rule
Rule 5: R{N:::}{ROOT,^VERB:::}P10;	Right Shift Rule
Rule 6: +{ROOT,VEND,^ALT,^VERB:+ VERB,- ROOT, +@::} {VI,VEND:::}P10;	Left Composition Rule
Rule 7: :{:::}{VERB,VI:-KBIV,-VEND,-CEND::}P10;	Insertion Rule
Rule 8: >{N::obj:}{VERB,#OBJ:::}P10;	Right Modification Rule
Rule 9: >{HPRON,SUBJ::agt:}{VERB,#AGT:::}P10;	Right Modification Rule
Rule 10: R{SHEAD:::}{VERB,^&@entry:+&@entry::}P10;	Right Shift Rule
Rule 11: R{VERB:::}{STAIL:::}P10;	Right Shift Rule

Table 20. UNL expression of the converted sentence

{org:en}
We are eating mango.
{/org}
{unl}
agt(eat(icl>consume>do,agt>living_thing,obj>concrete_thing,ins>thing)
.@entry.@pl.@present.@progress,we(icl>group).@pl)
obj(eat(icl>consume>do,agt>living_thing,obj>concrete_thing,ins>thing)
.@entry.@pl.@present.@progress,mango(icl>edible_fruit>thing))
{/unl}

Figure 2. Initial state of the Analysis Windows and the node list

8 Conclusions and Future Works

This paper has explored the Bangla vowel ended roots and grouped them into different categories based on how verbal inflexions are added with them to from verbs for all persons and tenses. This paper has also outlined the formats of word dictionary for the vowel ended roots and verbal inflexions, and developed required dictionary entries related to them. These entries can be used to generate verbs combining with their respective verbal inflexions. Our experimental result shows that Bangla native language sentences with verb can now be easily converted into UNL expression by analysis rules. The proposed format can be equally applicable to other languages with vowel ended roots. Our future research is to develop formats for Bangla consonant ended roots for first, second and third persons in all tenses.

REFERENCES

[1] Uchida, H., Zhu, M., and Senta, T. C. D., *Universal Networking Language*, UNDL Foundation, International environment house, 2005/6, Geneva, Switzerland.

[2] Choudhury, M. E. H., Ali, M. N.Y., Sarkar, M.Z.H., and Ahsan, R., *Bridging Bangla to Universal Networking Language- a Human Language Neutral Meta- Language*, International Conference on Computer and Information Technology (ICCIT), Dhaka, 2005, pp. 104-109.

[3] Ali, M.N.Y., Das, J.K., Mamun, S.M. A. A., and Nurannabi, A.M., *Morphological Analysis of Bangla Words for Universal Networking Language*, Third International Conference on Digital Information Management (ICDIM 2008), London, England. pp. 532-537.

[4] Ali, M. N. Y., Das, J. K., Al Mamun, S. M. A., and Choudhury, M. E.H., *Specific Features of a Converter of Web Documents from Bengali to Universal Networking Language*, International Conference on Computer and Communication Engineering 2008 (ICCCE'08), Kuala Lumpur, Malaysia, pp. 726-731.

[5] Serraset, G. and Boitet, C., *UNL French Deconversion as Transfer and Generation from an Interlinguia with Quality Enhancement through Off-line Human Interaction*, Machine translation Summit, Singapore, 1999.

[6] *EnConverter Specification*, version 3.3, UNL Center/UNDL Foundation, Tokyo 150-8304, Japan 2002.

[7] *UNDL Foundation: The Universal Networking Language (UNL) specifications*, version 3.2., Japan 2003.

[8] *DeConverter Specification*, version 2.7, UNL Center, UNDL Foundation, Tokyo 150-8304, Japan 2002.

[9] Ali, M., and Ali, M. M., *Development of machine translation dictionaries for Bangla Language*, Proceedings of 7th International Conference on Computer and Information Technology (ICCIT), pp. 272-276.

[10] Saha, G. K., *The E2B machine translation: A new approach to HLT. Ubiquity archive*, Association of Computing Machineries (ACM) 6(32), New York, 2005.

[11] Uddin, M. G., Ashraf, H., Kamal. A. H. M, and Ali, M. M., New parameters for Bangla to English statistical machine translation. Proceedings of 3rd International Conference on Electrical & Computer Engineering, 2004, pp. 545-548.

[12] Shahidullah, D. M., *Bangala Vyakaran*, Maola Brothers Prokashoni, Dhaka, August 2003, pp.110-130.

[13] Shniti Kumar, D. C., *Vasha-Prokash Bangla Vyakaran*, Rupa and Company Prokashoni, Calcutta, July 1999, pp.170-175.

[14] Rameswar, D. S., *Shadharan Vasha Biggan and Bangla Vasha*, Pustok Biponi Prokashoni, November 1996, pp.358-377.

[15] Azad, H., *Bakkotottoy*, Second edition, Dhaka-1994.

[16] Karim, M. A., Kaykobad, M., and M. Murshed, *Technical Challenges and Design Issues in Bangla Language Processing*, IGI Global, Disseminator of Knowledge, 2013, pp. 35-78.

[17] Bondopoddaye, H., *Bongio Shobdokosh*, Shahitto Okademy, Calcutta-2001.

[18] Asaduzzaman, M. M., and Ali, M. M., *Morphological analysis of Bangla Words for Automatic Machine Translation*, International Conference on Computer and Information Technology, Dhaka, Bangladesh, 2013, pp. 271-276.

[19] Khairunnahar, K., *Morphological Analysis of Bangla Prefix*, The Dhaka University Journal of Linguistic, 1(2), 2008, pp. 157-168.

[20] Ali, M. N. Y., Sorwar, G., and Shamsujjoha, M., *Formation of Word Dictionary of Bangla Vowel Ended Roots for First Person for Universal Networking Language*, the 2015 International Conference on Information and Knowledge Engineering, Las Vegas, USA.

[21] Ali, M. N. Y., Sorwar, G., Toru, A. and Islam, M. A., and Shamsujjoha, M., *Morphological Rules of Bangla Repetitive Words for UNL Based Machine Translation*, 6th International Conference on Swarm Intelligence, ICSI, Beijing, China, June 25-28, 2015, pp-401-408.

[22] Parikh, J., Khot, J., Dave, S., and Bhattacharyya, P., *Predicate Preserving Parsing*, Department of Computer Science and Engineering, Indian Institute of Technology, Bombay, India.

[23] Earley, J., *An Efficient Context Free Parsing Algorithm*, Communications of the ACM, 1970.

[24] Ali, M. N. Y., Ali, M. A., Nurannabi, M. A., and Das, J. K., *Algorithm for Conversion of Bangla Sentence to Universal Networking Language*, International Conference on Asian Language Processing, IALP, , IEEE Computer Society, Harbin, China, 2010, pp. 118-121.

[25] UNDL, available at http://www.undl.org/, Last access: 02-11-2016.

