# Sophisticated Lexical Databases - Simplified Usage: Mobile Applications and Browser Plugins For Wordnets

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## Abstract

India is a country with 22 officially recognized languages and 17 of these have WordNets, a crucial resource. Web browser based interfaces are available for these WordNets, but are not suited for mobile devices which deters people from effectively using this resource. We present our initial work on developing mobile applications and browser extensions to access WordNets for Indian Languages.

Our contribution is two fold: (1) We develop mobile applications for the Android, iOS and Windows Phone OS platforms for Hindi, Marathi and Sanskrit WordNets which allow users to search for words and obtain more information along with their translations in English and other Indian languages. (2) We also develop browser extensions for English, Hindi, Marathi, and Sanskrit WordNets, for both Mozilla Firefox, and Google Chrome. We believe that such applications can be quite helpful in a classroom scenario, where students would be able to access the WordNets as dictionaries as well as lexical knowledge bases. This can help in overcoming the language barrier along with furthering language understanding.

## 1 Introduction

India is among the topmost countries in the world with massive language diversity. According to a recent census in 2001, there are 1,365 rationalized mother tongues, 234 identifiable mother-tongues and 122 major languages[1] . Of these, 29 languages have more than a million native speakers, 60 have more than 100,000 and 122 have more than 10,000 native speakers. With this in mind, the construction of the Indian WordNets, the IndoWordNet (Bhattacharyya, 2010) project was initiated which was an effort undertaken by over 12 educational and research institutes headed by IIT Bombay. Indian WordNets were inspired by the pioneering work of Princeton WordNet(Fellbaum, 1998) and currently, there exist WordNets for 17 Indian languages with the smallest one having around 14,900 synsets and the largest one being Hindi with 39,034 synsets and 100,705 unique words. Each WordNet is accessible by web interfaces amongst which Hindi WordNet(Dipak et al., 2002), Marathi WordNet and Sanskrit WordNet(Kulkarni et al., 2010) were developed at IIT Bombay[2]. The WordNets are updated daily which are reflected on the websites the next day. We have developed mobile applications for the Hindi, Marathi and Sanskrit WordNets, which are the first of their kind to the best of our knowledge.

This paper is organized as follows: Section 2 gives the motivations for the work. Section 3 contains the descriptions of the application with screen-shots and the nitty gritties. We describe the browser extensions in Section 4, and we conclude the paper with conclusions, and future work in Section 5. At the very end, some screen-shots of the applications and browser extensions are provided.

[1] http://en.wikipedia.org/wiki/Languages_of_India
[2] http://www.cfilt.iitb.ac.in/

## 2 Motivation

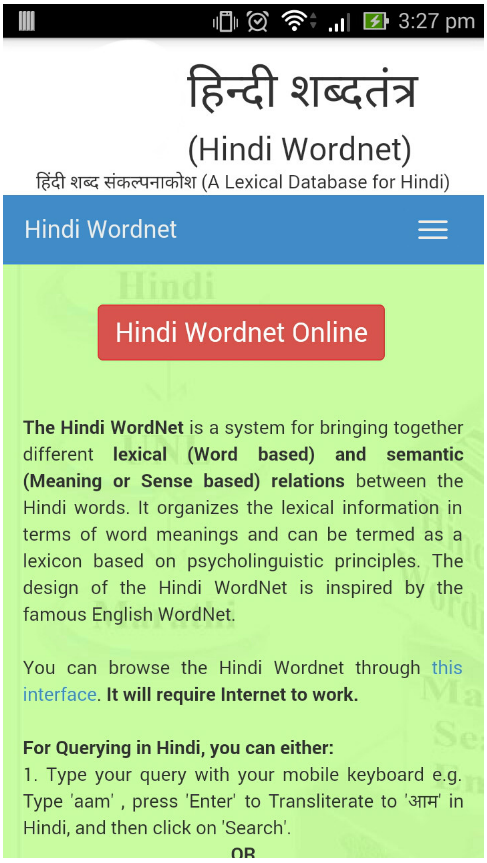
According to recent statistics, about 117 million Indians[3], are connected to the Internet through mobile devices. It is common knowledge that websites like Facebook, Twitter, Linkedin, Gmail and so on can be accessed using their web browser based interfaces but the mobile applications developed for them are much more popular. This is a clear indicator that browser based interfaces are inconvenient which was the main motivation behind our work. We studied the existing interfaces and the WordNet databases and developed applications for Android, iOS and Windows Phone platforms, which we have extensively tested and plan to release them to the public as soon as possible.

Our applications and plugins are applicable in the following use cases:

1. Consider an educational classroom scenario, where students, often belonging to different cultural and linguistic background wish to learn languages. They would be able to access the WordNets as dictionaries for multiple Indian languages. This would help overcome the language barrier which often hinders communication, and thus, understandability. The cost effective and readily available "Aakash" tablet device[4] will be one of the means by which our application will be accessed by educational institutes over India.

2. Tourists traveling to India can use the WordNet mobile apps for basic survival communication, because Indian language WordNets contain a lot of culture and language specific concepts, meanings for which may not even be available on internet search.

3. People who read articles on the internet may come across words they do not understand and can benefit from our plugins which can help translate words and give detailed information about them at the click of a button.



**The Hindi WordNet** is a system for bringing together different **lexical (Word based) and semantic (Meaning or Sense based) relations** between the Hindi words. It organizes the lexical information in terms of word meanings and can be termed as a lexicon based on psycholinguistic principles. The design of the Hindi WordNet is inspired by the famous English WordNet.

You can browse the Hindi Wordnet through this interface. **It will require Internet to work.**

**For Querying in Hindi, you can either:**
1. Type your query with your mobile keyboard e.g. Type 'aam' , press 'Enter' to Transliterate to 'आम' in Hindi, and then click on 'Search'.
**OR**

Figure 1: Home Screen

4. Linguists who happen to be experts at lexical knowledge can use the WordNet apps as well as plugins to acquire said knowledge irrespective of whether they have mobile phones or PCs.

Apart from the cases mentioned above, there are many other cases where our apps and plugins can be used effectively.

## 3 Mobile WordNet Applications

In the subsections below we describe the features of the applications accompanied by screen-shots.

### 3.1 Home Screen

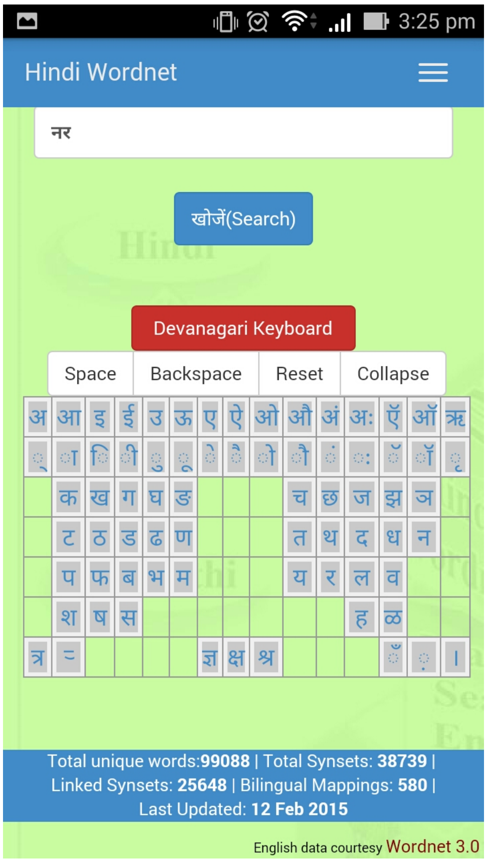
When the user starts the application, the home screen (Figure: 1) is shown with a brief description of how to use it, the link which takes the user to search interface.

### 3.2 Search Interface

We have provided the user with two types of input mechanisms, Phonetic Translitera-

[3] "Internet trends 2014 report" by Mary Meeker, Kleiner Perkins Caufield & Byers (KPCB)

[4] http://www.akashtablet.com/



नर

Total unique words:**99088** | Total Synsets: **38739** | Linked Synsets: **25648** | Bilingual Mappings: **580** | Last Updated: **12 Feb 2015**

English data courtesy Wordnet 3.0

Figure 2: Devanagari Keyboard

tion using Google Transliteration API[5], and a JavaScript based online keyboard (Figure: 2) for input of Hindi Unicode characters. Transliteration for a native user is very convenient. In case, the user does not know the right combination of keys then the keyboard for Devanagari is provided. These two methods ensure that all words can be easily entered for searching. Thereafter, by touching / clicking on "Search", the synsets with all relevant information are retrieved.

## 3.3 Search Process

Indian languages are fairly new to the web, and despite standard UTF encoding of characters, there remain a few steps to be taken to sanitize the input for WordNet search. The steps taken by us are given below:

### 3.3.1 *Nukta* Normalization for Hindi

Hindi Characters such as क (ka), ख (kha), ग (ga), ज (ja), ड (ḍa), ढ (ḍha), फ (pha), झ (jha), take up *nukta* symbol to form क़ (qa), ख़ (kẖa),ग़ (ġa),ज़ (za),ड़ (da),ढ़ (ṛha),फ़ (fa),झ़ (zha), respectively. These characters occur twice in the Unicode chart, both with *nukta* as a separate unicode character, and adjoining the parent character. We normalize the input for standard unicode encoding with nukta as a separate character before search.

### 3.3.2 Morphological Analysis

Before searching in the databases the word is first passed to a morphological analyzer to obtain its root form. We use Hindi Morph Analyzer (Bahuguna et al., 2014) to return the root form of the input word for Hindi language, since by principle, WordNet only contains root forms of the words.

Due to non availability of other language Morphological Analyzers, we may not be able to include them in the search process. Though, in the future, we can use a fully automated version of the "Human mediated TRIE base generic stemmer"(Bhattacharyya et al., 2014) for obtaining root forms for other languages later.

### 3.3.3 Handling Multiple Root forms

Our interface also requests the user to select the preferred root, if more than one root forms are returned post morphological analysis. The user can then just select one and then the synset retrieval process is initiated on the server. It gives the user more control, and choice over results. We assume that while searching the WordNet, a user may not be familiar with all the senses of the words, or all the morphology of the word. It may be possible that the user came across the word over the internet, and is using our plugin to search the WordNet. This feature enables the user to select the appropriate root, or check all the possibilities for the correct answer.

## 3.4 Application Design

We have used the WebView class, and URL loading from the Android SDK[6], and Windows Phone SDK[7] to display a responsive layout of the WordNets. WebView renders the application pages seamlessly onto the mobile / handheld devices, thus making the application usable for mobile, tablet, and other handheld

[5] https://developers.google.com/transliterate/

[6] https://developer.android.com/

[7] https://dev.windows.com/en-us/develop/download-phone-sdk

device of any size.

Similarly, for iOS, we have used the UIWebView class with some scaling measures to render the pages with a responsive layout onto the device screen. Our application is compatible with all iOS devices. It will be deployed to Apple App Store soon.

A preliminary check on internet connection is done before connecting to the web interface, and retry button is provided on the front, in case an internet connection is not detected.

### 3.5 Search Results

The results returned by the server are interpreted by the application pages and displayed in a very simplistic manner. We display all synsets for each part of speech and all senses of that word and initially showing the synset words, gloss and example.These senses are categorized by their part of speech categories. We have conformed to the principles of good User Interface design and provided for an incremental information display.

#### 3.5.1 Additional Information

If the user wishes to see the synset relations and the translations of that word in other synsets the link "Relations and Languages" should be clicked to give a list of all additional information that can be displayed. Relations like Hypernymy and Hyponomy and the relevant synset in the other 16 languages can be displayed. Please refer to figure 3 for an example.

#### 3.5.2 Current Drawbacks

Current version of Android OS (Lollipop 5.0) deployed on most of the smartphones, does not support rendering of Gujarati, Punjabi, and Nepali languages, on all devices. The language support also depends on the device manufacturer. Hence, they are currently disabled from the interface.

Also, Our applications are currently online, and can only be used if the user is connected to the internet. We plan to implement an offline version of our applications.

## 4 Browser Extensions

Major WordNets of the world are available via web interfaces, enabling a user to search for the senses using a web browser on a computer or mobile. The process commonly involves a user navigating to a web page, and searching the required 'word' for its senses. In a world where getting things done in one click is important, we feel that the process of searching needs to be simplified. We develop browser extensions to ease this process. Google Chrome and Mozilla Firefox are the most popular web browsers among the web users[8]. Our approach makes the search quite simple and is summarized in the following 3 steps:

- User highlights the word of interest and right-clicks the page or clicks on the plugin shortcut.
- They click the context menu option for 'Search <relevant> WordNet for . . .'
- A new tab opens up showing the information from the relevant WordNet.

We present the sample context menu screenshots, post installation in Figures 6 and 7, respectively.

## 5 Conclusions and Future Work

In this era of handheld mobile devices, there is a great need to make available traditional web services as mobile applications which are extremely popular. Our success in developing mobile applications for Hindi, Marathi and Sanskrit WordNets along with browser plugins for English, Hindi, Marathi and Sanskrit to simplify word look-up is the first step in providing people with easy access to such important knowledge bases. We have described a variety of use cases for our apps and plugins which are quite realistic, especially in India where language and cultural diversity is quite varied. These can have a huge impact on language education, especially in the rural areas, along with enabling people to understand a multitude of languages.

We plan to make available offline search in our apps. Also, we plan to make efforts towards improving this application to enable searching for words belonging to all languages which have a common interface via language detection. We also plan to inculcate Word Suggestions as they are being typed so that the

[8] http://gs.statcounter.com/#all-browser-ww-monthly-201506-201506-bar

user is presented with better lexical choices. Plugins like PeraPera[9] for Japanese and Chinese are quite popular since they simply provide lexical information when the user hovers the mouse over words. Implementing such a feature is something we plan to do in the immediate future. Also, We would publish our application, and browser plugin source codes publicly for research purposes.

## 6 Acknowledgment

We gratefully acknowledge the support of the Department of Electronics and Information Technology, Ministry of Communications and IT, Government of India. We also thank Ravi Nambudripad, for replicating the application in other languages and the entire computational linguistics group at Centre For Indian Language Technology, IIT Bombay, which has provided its valuable input and critique, helping us refine our work.

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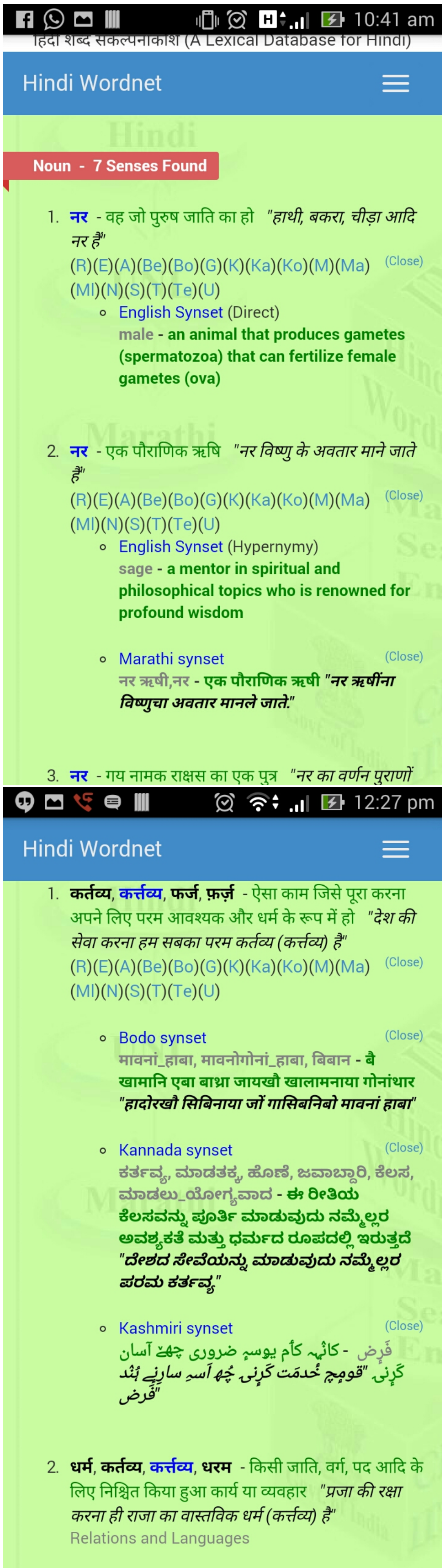


Noun - 7 Senses Found

1. नर - वह जो पुरुष जाति का हो "हाथी, बकरा, चीड़ा आदि नर हैं"
(R)(E)(A)(Be)(Bo)(G)(K)(Ka)(Ko)(M)(Ma)(Ml)(N)(S)(T)(Te)(U) (Close)
   - English Synset (Direct)
     male - an animal that produces gametes (spermatozoa) that can fertilize female gametes (ova)

2. नर - एक पौराणिक ऋषि "नर विष्णु के अवतार माने जाते हैं"
(R)(E)(A)(Be)(Bo)(G)(K)(Ka)(Ko)(M)(Ma)(Ml)(N)(S)(T)(Te)(U) (Close)
   - English Synset (Hypernymy)
     sage - a mentor in spiritual and philosophical topics who is renowned for profound wisdom
   - Marathi synset (Close)
     नर ऋषी,नर - एक पौराणिक ऋषी "नर ऋषींना विष्णुचा अवतार मानले जाते."

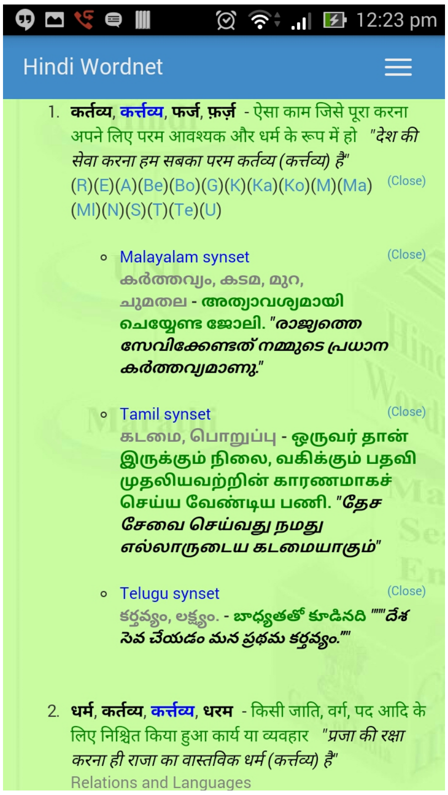
3. नर - गय नामक राक्षस का एक पुत्र "नर का वर्णन पुराणों

1. कर्तव्य, कर्त्तव्य, फर्ज, फ़र्ज़ - ऐसा काम जिसे पूरा करना अपने लिए परम आवश्यक और धर्म के रूप में हो "देश की सेवा करना हम सबका परम कर्तव्य (कर्त्तव्य) है"
(R)(E)(A)(Be)(Bo)(G)(K)(Ka)(Ko)(M)(Ma)(Ml)(N)(S)(T)(Te)(U) (Close)
   - Bodo synset (Close)
     मावनां_हाबा, मावनोगोनां_हाबा, बिबान - बै खामानि एबा बाथ्रा जायखौ खालामनाया गोनांथार "हादोरखौ सिबिनाया जों गासिबनिबो मावनां हाबा"
   - Kannada synset (Close)
     ಕರ್ತವ್ಯ, ಮಾಡತಕ್ಕ, ಹೊಣೆ, ಜವಾಬ್ದಾರಿ, ಕೆಲಸ, ಮಾಡಲು_ಯೋಗ್ಯವಾದ - ಈ ರೀತಿಯ ಕೆಲಸವನ್ನು ಪೂರ್ತಿ ಮಾಡುವುದು ನಮ್ಮೆಲ್ಲರ ಅವಶ್ಯಕತೆ ಮತ್ತು ಧರ್ಮದ ರೂಪದಲ್ಲಿ ಇರುತ್ತದೆ "ದೇಶದ ಸೇವೆಯನ್ನು ಮಾಡುವುದು ನಮ್ಮೆಲ್ಲರ ಪರಮ ಕರ್ತವ್ಯ"
   - Kashmiri synset (Close)
     فَرِض - کانٛہہ کأم یوسہٕ ضروری چھےٚ آسان
     گَرٕنی "قومٕچ خدمَت گَرٕنی چُھ آسہِ سارِنٕی ہُنٛد
     فَرض"

2. धर्म, कर्तव्य, कर्त्तव्य, धरम - किसी जाति, वर्ग, पद आदि के लिए निश्चित किया हुआ कार्य या व्यवहार "प्रजा की रक्षा करना ही राजा का वास्तविक धर्म (कर्त्तव्य) है"
Relations and Languages

Figure 3: Screen-shots of Search Results

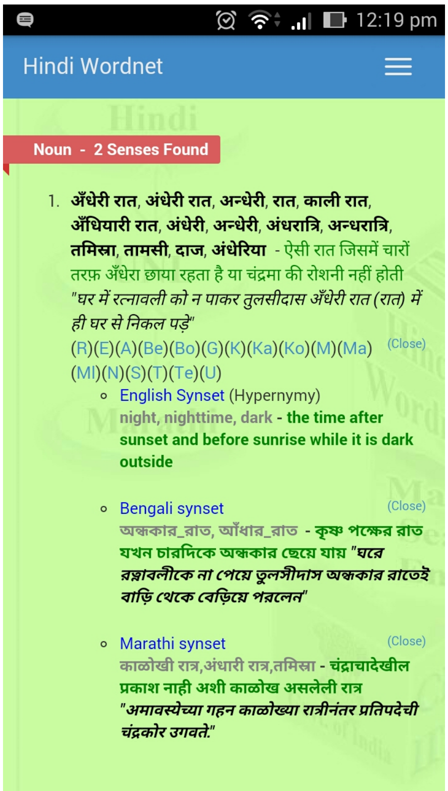
[9] http://www.perapera.org/



1. **कर्तव्य**, **कर्त्तव्य**, **फर्ज**, **फ़र्ज़** - ऐसा काम जिसे पूरा करना अपने लिए परम आवश्यक और धर्म के रूप में हो *"देश की सेवा करना हम सबका परम कर्तव्य (कर्त्तव्य) है"*
(R)(E)(A)(Be)(Bo)(G)(K)(Ka)(Ko)(M)(Ma) (Close)
(Ml)(N)(S)(T)(Te)(U)
    - Malayalam synset (Close)
      കർത്തവ്യം, കടമ, മുറ, ചുമതല - അത്യാവശ്യമായി ചെയ്യേണ്ട ജോലി. *"രാജ്യത്തെ സേവിക്കേണ്ടത് നമ്മുടെ പ്രധാന കർത്തവ്യമാണു."*
    - Tamil synset (Close)
      கடமை, பொறுப்பு - ஒருவர் தான் இருக்கும் நிலை, வகிக்கும் பதவி முதலியவற்றின் காரணமாகச் செய்ய வேண்டிய பணி. *"தேச சேவை செய்வது நமது எல்லாருடைய கடமையாகும்"*
    - Telugu synset (Close)
      కర్తవ్యం, లక్ష్యం. - బాధ్యతతో కూడినది *""''దేశ సెవ చేయడం మన ప్రథమ కర్తవ్యం.''"*
2. **धर्म**, **कर्तव्य**, **कर्त्तव्य**, **धरम** - किसी जाति, वर्ग, पद आदि के लिए निश्चित किया हुआ कार्य या व्यवहार *"प्रजा की रक्षा करना ही राजा का वास्तविक धर्म (कर्त्तव्य) है"*

Relations and Languages

Figure 4: Search Results with Malayalam, Tamil, and Telugu Synsets



**Noun - 2 Senses Found**

1. **अँधेरी रात**, **अंधेरी रात**, **अन्धेरी**, **रात**, **काली रात**, **अँधियारी रात**, **अंधेरी**, **अन्धेरी**, **अंधरात्रि**, **अन्धरात्रि**, **तमिस्रा**, **तामसी**, **दाज**, **अंधेरिया** - ऐसी रात जिसमें चारों तरफ़ अँधेरा छाया रहता है या चंद्रमा की रोशनी नहीं होती *"घर में रत्नावली को न पाकर तुलसीदास अँधेरी रात (रात) में ही घर से निकल पड़े"*
(R)(E)(A)(Be)(Bo)(G)(K)(Ka)(Ko)(M)(Ma) (Close)
(Ml)(N)(S)(T)(Te)(U)
    - English Synset (Hypernymy)
      night, nighttime, dark - **the time after sunset and before sunrise while it is dark outside**
    - Bengali synset (Close)
      অন্ধকার_রাত, আঁধার_রাত - কৃষ্ণ পক্ষের রাত যখন চারদিকে অন্ধকার ছেয়ে যায় *"ঘরে রত্নাবলীকে না পেয়ে তুলসীদাস অন্ধকার রাতেই বাড়ি থেকে বেড়িয়ে পরলেন"*
    - Marathi synset (Close)
      काळोखी रात्र,अंधारी रात्र,तमिस्रा - चंद्राचादेखील प्रकाश नाही अशी काळोख असलेली रात्र *"अमावस्येच्या गहन काळोख्या रात्रीनंतर प्रतिपदेची चंद्रकोर उगवते."*

Figure 5: Search Results with English, Bengali, and Marathi Synsets

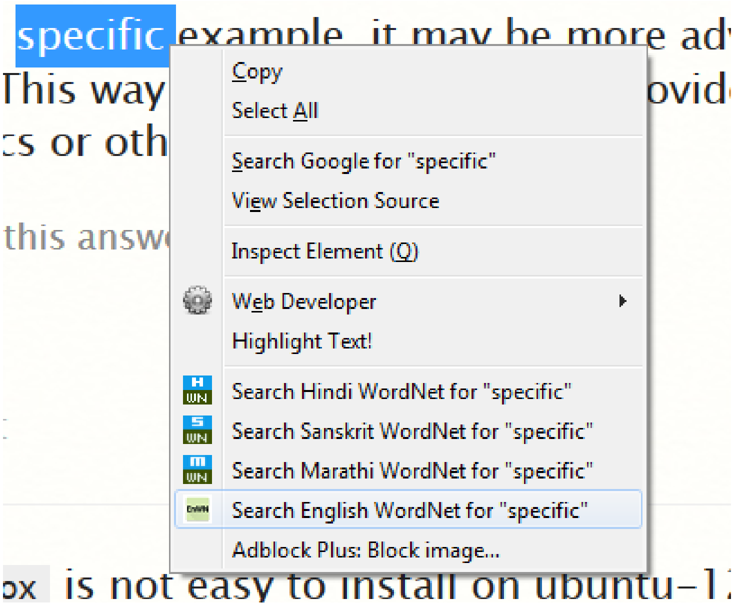

specific example, it may be more ad
This way
ovid
cs or oth
this answ
ox is not easy to install on ubuntu-1
Copy
Select All
Search Google for "specific"
View Selection Source
Inspect Element (Q)
Web Developer
Highlight Text!
Search Hindi WordNet for "specific"
Search Sanskrit WordNet for "specific"
Search Marathi WordNet for "specific"
Search English WordNet for "specific"
Adblock Plus: Block image...

Figure 6: Browser Extensions Context Menu for word ‘specific’

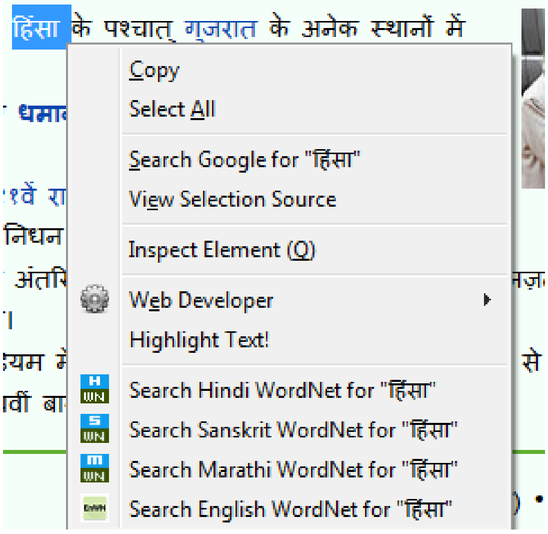

हिंसा के पश्चात् गुजरात के अनेक स्थानों में
धमा
१वें रा
निधन
अंतरि
यम मे
र्वी बा
नज़
से
Copy
Select All
Search Google for "हिंसा"
View Selection Source
Inspect Element (Q)
Web Developer
Highlight Text!
Search Hindi WordNet for "हिंसा"
Search Sanskrit WordNet for "हिंसा"
Search Marathi WordNet for "हिंसा"
Search English WordNet for "हिंसा"

Figure 7: Browser Extensions Context Menu for word 'हिंसा' (hiMsaa) translated to ‘violence’