WHITE PAPER

Aspect® Natural Language Understanding™ Architecture and Design Philosophy

Aspect NLU is the framework behind the advanced natural language self-service capabilities of Aspect's Customer Experience Platform (CXP). The purpose of Aspect NLU is to analyze written natural language content and generate its structured representation, making it available to different applications. Aspect NLU was previously known as Carabao Linguistic Virtual Machine, which was developed and distributed by LinguaSys.

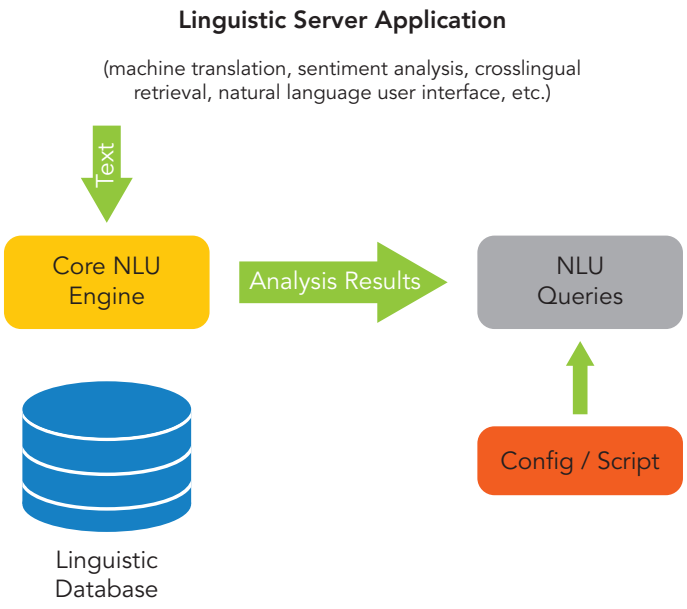
Perhaps the most uncommon trait of Aspect NLU is being a multi-purpose component used in a variety of applications. The users may not always realize that, being familiar with only the application they use. It's as if the same physical engine could be used for a plane, a boat, and a car. Why did the designers of the engine make this decision? Wouldn't it be more simple to focus on one particular application?

The answer lies in the economics of the natural language software. While growing, most natural language applications fill only a small economic niche. At the same time, natural language R&D effort is one of the most resource-consuming ones in the world of software. The reason is that **nearly every application**, barring those with the simplicity of "Hello world", **is forced to handle an infinite set of inputs**, which is in the nature of human languages. In all these cases we have to handle the complex tasks of morphological analysis (dissecting word structure), classification of words, determining the connections between them, and more. This means that, if one software component can handle all of them, the R&D effort costs are paid by all the applications using this component; this means that **allocating more R&D resources for better, bigger, and richer dictionaries becomes economically viable**.

This is the reason that the core engine of Aspect NLU serves all the different applications using the same process of analysis and transformation.

Core NLU Engine vs. Applications

Foundational Architecture



Applications using Aspect NLU typically share a common pattern. These applications can power natural language interaction with a user (e.g. for customer service chatbots), or allow semantic search, or sentiment analysis, and so on.

The applications send the natural language content to the Core NLU engine (in LinguaSys, called Carabao Linguistic Virtual Machine), which returns a graph of natural language entities created from the content. These natural language entities contain a rich set of grammatical, stylistic, and semantic features. The Core NLU Engine relies on a linguistic database to convert the content into the set of features.

The results of the analysis are then inspected and queried in a fashion similar to the document object model (DOM). The results of the queries then determine the application's behavior. The NLU queries are normally language-independent.

Given the customization capabilities of the core, these applications typically contain extensive configuration options used to define the business logic while keeping the applications more generic. The configurations often store the NLU queries described above.

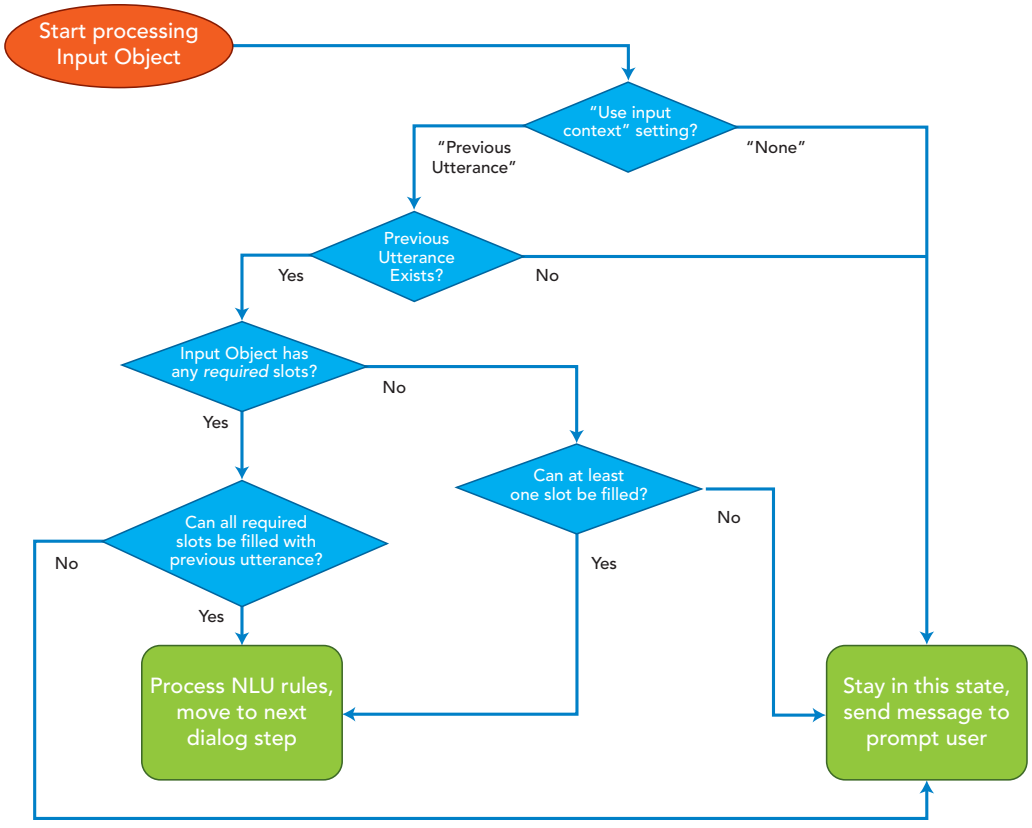
Conceptually, the relationship between the core engine and the applications based on it can be explained using the analogy of a movie theater ticket vendor. Just like most human beings, the ticket vendors are fluent in their native tongue. Anyone will understand when told, "I'd like two adult tickets for 2pm". However, before they learn the business processes and how their point of sale system works, they may not know exactly what to do with this utterance. The understanding of language is common to the speakers of a language; their work-related skills are not.

In the Aspect NLU architecture, the core engine encapsulates the generic language skills. The application configurations and scripts are analogous to the work-related skills.

Integration of Aspect NLU and Aspect CXP

Aspect CXP uses Aspect NLU to enhance its Interactive Text Response (ITR) functionality with natural language understanding capabilities. The integration follows the pattern described above.

The results of the NLU queries on the analysis results drive the flow of the conversation with the user as described in the flowchart below.



The business logic of the CXP scripts can determine whether the conversation is handled autonomously by the script, or transferred to a contact center agent.

Deterministic vs Nondeterministic Parsing

Words in natural languages may have more than one meaning. Finding out the correct meaning of every word, or disambiguation, is an essential step, and the most complex task in natural language understanding. Today, no framework, including Aspect NLU, can reliably disambiguate every text to the level of a word sense. In some applications, a good-enough disambiguation is acceptable. However, errors made by conversational UIs are too obvious and unacceptable to an average user.

Aspect NLU adopted an approach similar to speech recognition grammars. In the speech recognition world, grammars provide context making it easier to analyze speech. NLU conditions used by Aspect NLU applications with Aspect CXP are also focused on a specific domain or task to be accomplished. When reserving a table in a restaurant, "book" is likely not a printed publication; a "ticket" is likely not a warrant in a ticket-selling application.

Leaving the word senses exposed to the application using Aspect NLU is called **nondeterministic parsing** while leaving the application only the word senses as determined by Aspect NLU is called **deterministic parsing**. In the nondeterministic parsing mode, the application typically scans all the word-senses until it finds the one matching its conditions. It is recommended that once matched, other senses should be disabled by the application for the sake of consistency.

The deterministic parsing is not left to chance either. Aspect NLU disambiguates by mapping syntactic structures, analysis of the active domains of discourse, and available common-sense cues. Additionally, there are ways to parametrically introduce a bias for specific domains of discourse and groups of word-senses.

As a general rule, an application in a relatively constrained domain should use the nondeterministic parsing mode, while a more generic application is more suitable for the deterministic parsing mode.

Main Elements of Architecture

Semantic Framework

The dictionaries of Aspect NLU are built around a semantic network. Words are grouped into so-called **families**, which are the most basic structures in Aspect NLU. A family contains words related to the same concept and all their inflected forms. It is worth noting that the family ID is the same across all languages; this makes it possible to build language-agnostic applications for languages foreign to the developer. This application will also work for languages not yet supported by Aspect NLU, when they are added.

Families have two types of links: **hypernyms** and **domains**. A hypernym is a parent, more generic concept. For instance, a vehicle is a *hypernym* of a truck (and truck a *hyponym* of vehicle), a mammal is a hypernym of a dog, and so on. A domain is an area of knowledge which the family belongs to. For instance, a truck belongs to the domain of "car". A family used as a domain for other families, may belong to the same domain. Both hypernyms and domains are many to many links. While it may seem odd for the hypernym, it is akin to the concept of multiple inheritance. E.g. Isaac Newton was both a physicist and a mathematician.

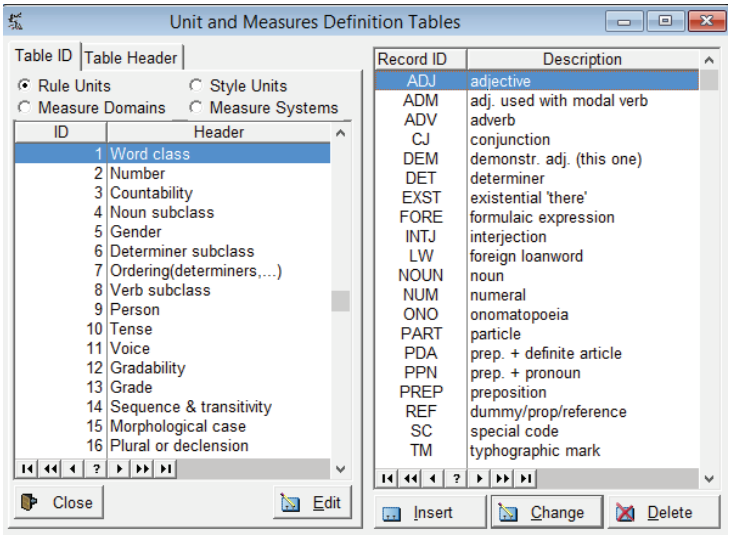
The semantic network is cross-lingual, as these links do not depend on the language used.

There are three main sets of features:

- Semantics (family ID)
- Grammar (part of speech, countability, plurality, inflection patterns, gender, person, etc.)
- Style (region where the word-sense is used, professional use, whether it is a colloquialism, etc.)

The grammar and style are stored in cross-lingual alphanumeric codes.

Linguistic Abstraction



To allow for maximum flexibility and cover the vast variety of language grammar and style features, Aspect NLU utilizes an abstract approach. While relying on the linguistic concepts like part of speech, plurality, etc. none of them is hard-coded in the system. Their definitions are kept in the same linguistic database as the dictionaries, the morphology, the syntactic structures, etc. and can be redefined or modified by the database designers, which are usually computational linguists by education.

This same method is used with the dimension of style tags, which hold references to associated regions, media, whether the term is colloquial, etc.

With the bulk of the linguistic logic stored in a database format, the deployment team can modify nearly everything, from words and inflectional morphology paradigms to punctuation, and add their own custom linguistic categories.

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About Aspect

Aspect helps enterprises break down the walls between people, processes, systems and data sources, empowering organizations to unite around the customer journey. Our customer engagement center offers native interaction management, workforce optimization and self-service capabilities that drive dynamic, conversational interactions and create a truly frictionless omni-channel customer experience. Leveraging all the benefits of the cloud and over 40 years of industry ingenuity, Aspect conveniently and easily connects questions to answers while helping enterprises keep service levels high and operational costs contained. For more information, visit **www.aspect.com**.