

# KAT: An Annotation Tool for STEM Documents

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## Abstract

Current natural language understanding systems do not work particularly well on mathematical and technical documents as they cannot deal with formulae, diagrams, and the special, technical vocabularies and discourse conventions of such documents. To retrain existing tools and evaluate new ones specifically developed for STEM documents, we need to establish manually annotated document corpora. Unfortunately, even the annotation tools used in computational linguistics do not work well with mathematical documents, as they assume plain texts.

This report presents the KAT system, browser-based annotation tool for linguistic/semantic annotations in structured (XHTML5) documents. As it is parametric in the annotation ontology and represents annotations as RDF, it can easily be integrated into RDF-based corpus management systems; we present an integration into the CorTeX system.

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# 1 Introduction

Text annotation is the practice of adding a note to a text, which may include highlights or underlining, comments, footnotes or links. In most of the cases, annotations can be thought of as text-metadata because they are usually added post hoc and provide information about the text without fundamentally altering it.

A web annotation is an online annotation associated with a web resource. The annotation of web-based documents by user communities is a widely used method of augmenting and adding value to these resources and there are numerous use cases where the process can disambiguate contexts or improve the overall readability.

In this report we present the KAT annotation tool for (X)HTML documents, built with the following objectives:

1. *Usability* – The tool should be convenient and easy to use by regular internet users allowing them varying degrees of complexity in the user interface.
2. *Ease of integration* – The tool should be easy to integrate into existing projects, and should have minimal to none dependencies on the server side.
3. *Semantic Richness* – The annotations provided by our users should contain the necessary level of information for NLP tools to use.

KAT is open source, it is licensed under the Gnu Public License [Fre91] and hosted on GitHub [KG].

Development was started in Spring 2011 by Alex Mircea Dumitru and Vlad Merticariu as a Computational Semantics Project at Jacobs University under the supervision of Deyan Ginev and Michael Kohlhase. Stefan Mirea contributed the firefox plugin and the reviewing functionality, and Tom Wiesing added JOBAD integration and general interface polish.

In the next section we review the state of the art in linguistic/semantic annotation systems,<sup>1</sup> Section 6 concludes this report.

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**Acknowledgements** The development of the KAT was partially supported by the Leibniz association under grant SAW-2012-FIZ KA-2.

## 2 State of the Art & Related Systems

We will present a few of the current annotation tools available on the web, extracting the most relevant features that were taken into account when building KAT.

Different types of web-based projects will require different approaches to annotations, allowing us to distinguish between 2 main categories:<sup>2</sup>

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<sup>1</sup>EdNOTE: MK: continue

<sup>2</sup>EdNOTE: MK: I think that what we really mean here is the difference between stand-off markup and inline markup.

1. **Dynamic annotations:** implemented by systems which allow the annotation of the text itself. In such a system, the anchor of an annotation is a piece of digitized text.
2. **Static annotations:** implemented by systems which allow the annotation of a specific region of content. In this case, the anchor of an annotation is the fixed, in-page, position of the annotated region.

Digitized, mathematical text lies in the center of our research direction during this project and, for this reason, we are going to focus mainly on the first category. However, in order to have a complete overview of the available features, the last subsection of this part presents one example from the second category.

An important aspect of our desired system is that, even though it is very close to a dynamic annotation system, we are looking for a more stable and semantically rich format, such as OMDoc, to anchor the annotations.<sup>3</sup>

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## 2.1 the brat Annotation Tool

brat [BR] Is a web based tool for text annotation. It is designed in particular for structured annotation, where the notes are not freeform text but have a fixed form that can be automatically processed and interpreted by a computer and implicitly belongs to the category of dynamic annotation tools.

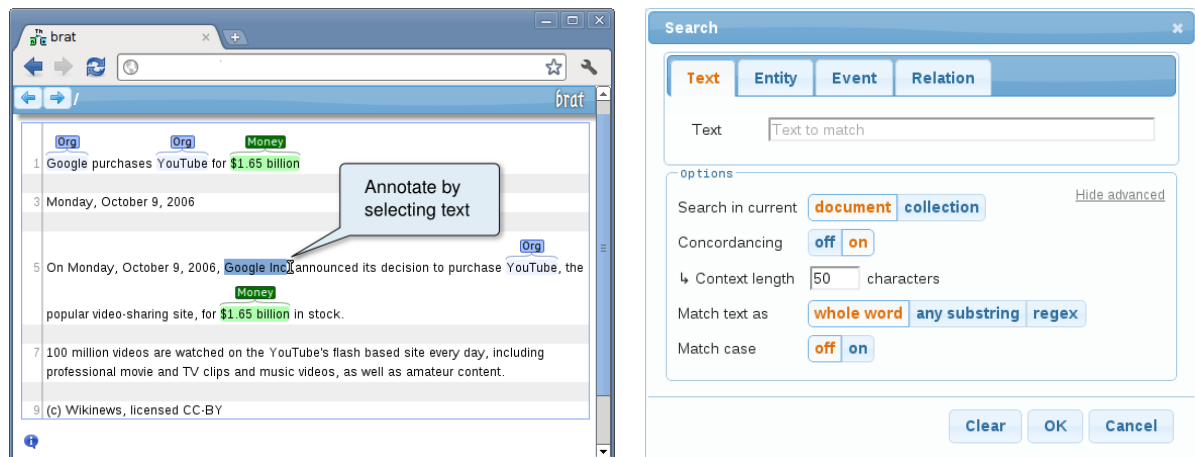


Figure 1: Annotation & Search in brat

The most important features that we identified were:

1. The text must be preprocessed into a particular, fixed format before being annotated.
2. Two types of annotation are supported (see Figure 2):
  - phrase classifications: simple annotation of a piece of text and
  - relational annotations: two separated pieces of text are annotated and a connection between them is created:
3. Extensive search functionality for annotations, see the panel on the right in Figure ??

<sup>3</sup>EdNOTE: MK: completely rework this introduction, talk about annotation ontologies, give examples

4. Export interface: annotations can be exported in an internal format, which can then be converted in other formats such as PDF or HTML. Furthermore, visualizations can be exported as well, into SVG and bitmap formats (PNG).
5. Each annotation is accessible by URL: every brat annotation can be uniquely addressed within the brat server. Together with the URL of the server, this form of addressing provides a globally unique address for every brat annotation.
6. Brat provides a validation system for its annotations: the admin can define validation grammar rules, forcing the user to adhere to a specific annotation format.
7. Annotations are anchored based on a word-counter: this makes the annotated text unchangeable and constitutes one of our main concerns regarding the system.<sup>4</sup> EdN:4



Figure 2: Types of Annotation in brat

## 2.2 Yawas Annotation Tool

Yawas [YW] is an annotation system designed as an extension for Firefox and Google Chrome; see Figure 3. It is different than the other systems that we analyzed in that the annotation doesn't belong to the text but to the user. After installing the extension, the user can navigate to any page and can highlight any piece of text. The annotation is saved in the user's google account and is displayed every time the user accesses the page.

Feature-wise the system is much weaker than the previously analyzed brat (and much older), however it contains a potentially useful idea: user-specific annotations which can later be made accessible only to specific users or groups of users.

## 2.3 Annotatie Systeem Annotation Tool

Annotatie [AN] is an annotation tool for printed documents and belongs to the static annotation category.

The anchoring of the annotations is done by page positioning: this seems inflexible at a first glance, however, it constitutes a good alternative when the text in the page is not digitized. The feature that caught our attention is the extensive comment section derived from the annotations:

- Each annotation represents a new comment thread.
- In each comment thread other users can further discuss on both the contents of the annotated text and the annotation itself.

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<sup>4</sup>EdNOTE: MK: this should be discussed



Figure 3: Annotation in Yawas

- All the annotations in a page are displayed in the right side of the page, as collapsed threads.

We believe that allowing discussion based on one user's annotation is an important feature in such a system, as the context introduced by annotations is one which emphasizes user collaboration.

### 3 KAT System & Information Architecture

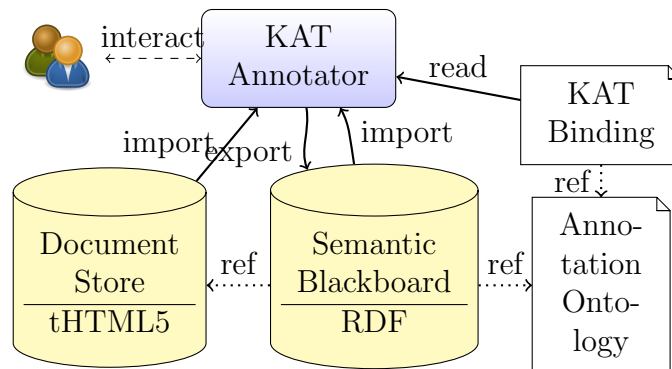


Figure 4: The KAT System Architecture

### 3.1 KAT Annotation Data Model

The annotations that the users will provide must be well structured in order for our third requirement to be accomplished. This assures us that the work of annotators can best be put to use by automatic processors or computer interpreters.

A good example of a use case is a self-learning software that translates text fragments from one language to another. For it to function properly it needs to know the grammatical structure of the languages and here is where annotation tools can help. Users can annotate predefined sentences or paragraphs and identify specific parts of speech (e.g. a noun) that the translation tool software developers can then use as a training material for their machine-learning product.

Our system is flexible enough for administrators to define how annotations should be structured and what connections can be made between different annotations. Furthermore this flexibility is also be applicable in the visual interfaces with which users interact. In a typical system you will have users coming from different backgrounds with various skills and interests. We believe that this variety should not be suppressed but rather encouraged by allowing for multiple annotation interfaces to be presented to the user so that he can choose the best suited one for his contributions. This feature helps projects where crowdsourcing is detrimental by making the users comfortable with the UI and allowing them to become proficient without a steep learning curve.

### 3.2 Concept Architecture

At the center of our system is the **annotation concept**, several of which being described by a user-supplied ontology. The format in which the ontology should be provided is the standard OWL model. Each annotation concept should correspond to an OWL instance that is a member of the annotation class to which the following elements should be added:

- fields - this section describes how a user can input the necessary information for the annotation to be valid according to its concept. The section should contain for each field describing the annotation concept an entry that describes how a user can populate this information in a form.

Each child of the entry should be of the following form:

- filed - the field wrapper, all further options are children of this element. It has *name* and *type* as attributes. The *type* can be one of: text, select, reference, radios or text area.
- documentation - further information about the field, to be displayed to the user.
- value - a default value for the field.
- validation - a regular expression that the user input must match.
- number - a field having 2 attributes: *atleast* and *atmost*, indicating how many inputs of this type can the user make in the same annotation.

- options [only available for field type = "select"] - the options from which the user should choose from. Each new option is an individual element having children of type *documentation* and *value*.
- referencedType [only available for field type = "reference"] - indicates the concept name that should be referenced by this input.
- display - this section describes how an annotation is displayed. It consists of the following fields:
  - template - an HTML string containing the desired display format of the annotation fields. Each annotation field that is mentioned between curly braces will be replaced by the actual value of the field.
  - style - a list of CSS valid rules to be applied to the annotation display.

In Appendix A2 you can find an example of an annotation ontology. It defines 2 concepts which allow the user to annotate text as Symbols or definitions of Symbols. As you can see in the example, the model gives us the necessary flexibility at the administrator level while at the same time providing for a clear customizable method of displaying the annotation form and representation for the user.

## 4 Annotation Workflows

### 4.1 Adding an annotation

The following steps must be followed for adding a KAT annotation:

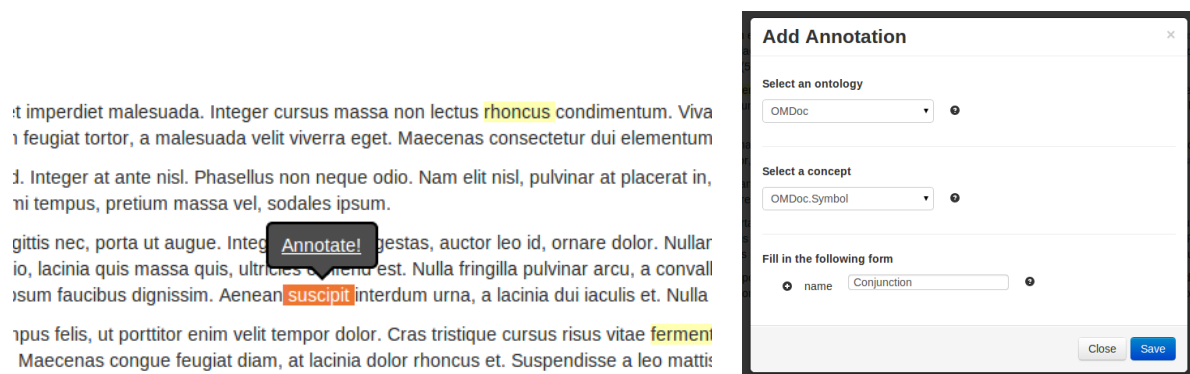


Figure 5: Annotating in KAT: Selection and Form-Filling

1. The target text of the annotation is highlighted (by simple selection), see Figure 5 on the left.
2. The first step triggers an annotation-menu.
3. The annotation-menu is populated with the available annotation types, given by the available ontology.



4. The user clicks on the desired annotation concept.
5. A modal box containing the annotation form opens.
6. The annotation form is populated with the fields indicated in the ontology as shown on the right of Figure 5
7. After completing the form fields, the user saves the annotation.

This approach ensures 2 things:

- The navigation flow is never interrupted: adding an annotation is done via pop-up and modal boxes and windows, so after completing the steps, the user finds himself in the same place in the document.
- Annotation type checking is implicit: the annotation form is populated with the fields indicated in the ontology so the user doesn't have to check the required types himself, see Figure 6. In the KAT binding, the OMDoc.Definition concept is defined to be for annotations of type Symbol. The “for” field is automatically populated with all the annotations of this type.

Figure 6: Annotating a definition for “suscipit”.

## 4.2 Displaying an annotation

Annotated text is marked with special CSS style so it becomes easily identifiable. The type of the annotation is also displayed above the annotation itself so one can have a clear overview of the whole document.

At click, a pop-up window containing the annotation display opens.

The annotation display consists of the following elements:

1. The type of the annotation.
2. The formatted annotation input according to the rules described in the ontology.
3. For the annotations of type reference, an arrow indicated the referenced element.

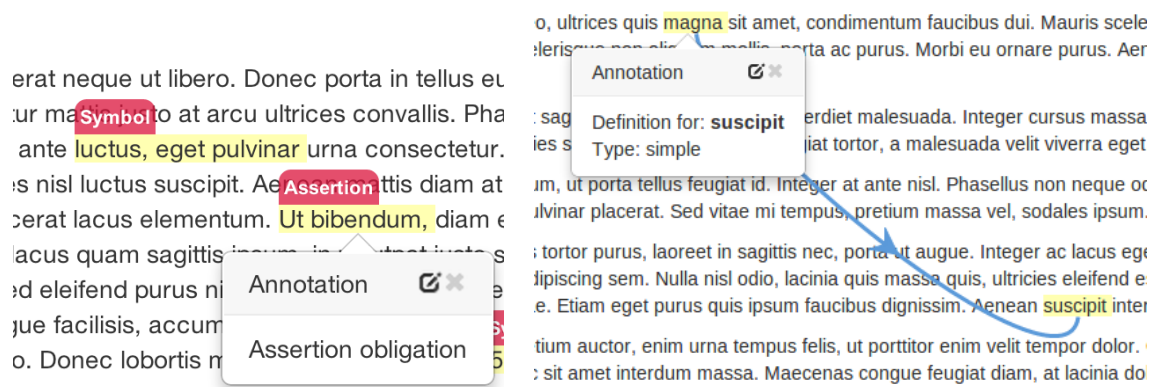


Figure 7: Display for simple text and reference annotations

### 4.3 Reviewing annotation versions

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Reviewing is done in a side-by-side view which allows the user to see two versions of the same document in order to see discrepancies and correct them; see Figure 8. The viewer allows to toggle view one ontology at a time which can be toggled individually on each panel by clicking on the.

While reviewing, the left panel (also called the main panel) is the current document with the local annotations while the right panel (referred to as the mirror panel) is the the different version of the document being reviewed against.

KAT is only enabled in the main panel so changes/edits/annotations can still be done while reviewing, while the mirror panel is read-only. Scrolling the main panel will cause the mirror panel to automatically follow suite.

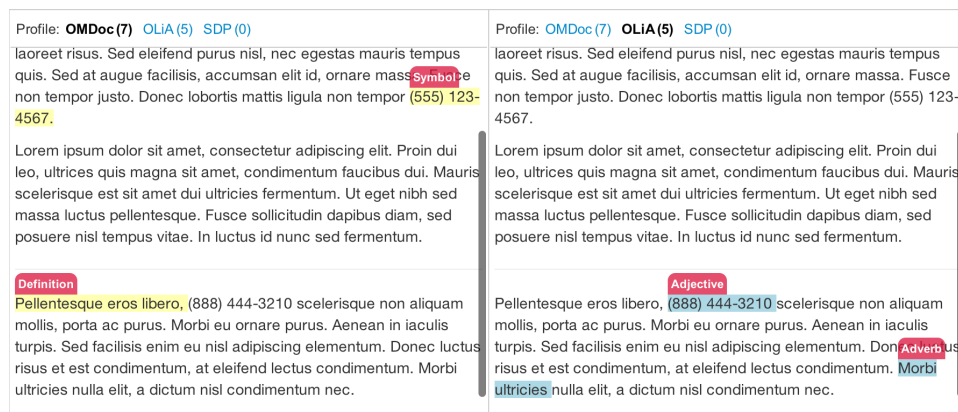
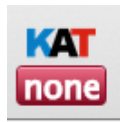


Figure 8: Reviewing two ontologies of the same document side-by-side

<sup>5</sup>EdNOTE: MK: need intro here, inter-annotator agreement, riew, ... Probably move into a section of its own.

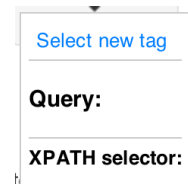
## 4.4 Annotating external documents using the browser extension

A different way of annotating a document which is not part of the corpus is by using the KAT browser extension. It provides a point-and-click interface which allows users to easily select the tags they wish to annotate.



The following steps must be followed to add an annotation with the KAT browser extension. Make sure you have the extension installed. You should see the KAT icon near your URL bar. Under the icon the extension always displays if the page currently viewed has any annotations or not. The figure on the right shows the KAT browser icon when viewing a page with no annotations on it.

After loading the page you want to annotate, click the extension icon which will insert a menu in the page. From the menu, choose "Select new tag" as shown on the left. When moving your mouse around the page, the current tag is always highlighted and its respective DOM and XPATH selectors are displayed in the menu. After right clicking on the desired element, the "Annotate" pop-up will appear and the current element will remain selected (see Figure 9)



Afterwards the work-flow follows the one of adding a normal annotation. Upon adding an annotation the icon of the extension also changes to reflect the existence of annotations on the current page.

### cept Demo

elit. Nullam euismod, sapien id rhoncu  
rabitur mattis justo at arcu ultrices cor  
suscipit. Aenean mattis diam at tortor  
tpat justo sapien laoreet risus. Sed ele  
ce non tempor justo. Donec lobortis m

eli Annotate! p, ultrices quis magna  
assa luctus pellentesque. Fusce sollicitudin dapibus diam, sed posuere nisl tempus vitae. In luctus  
38) 444-3210 scelerisque non aliquam mollis, porta ac purus. Morbi eu ornare purus. Aenean in  
mentum. Donec luctus risus et est condimentum, at eleifend lectus condimentum. Morbi ultricies

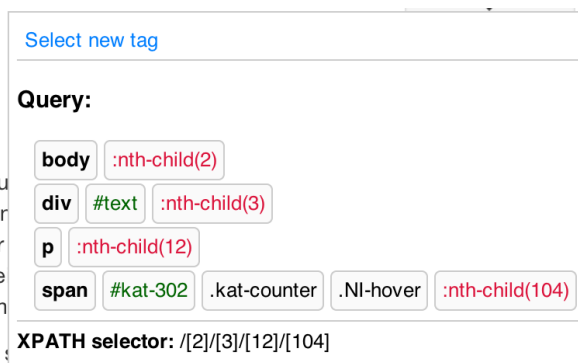


Figure 9: Right-clicking on an element causes the "Annotation" pop-up to show

## 5 Storage & Integration

KAT is storage-agnostic per-se. As no back-end platform is provided alongside the application, administrators are free to develop their own custom workflows of storing an annotation. By default annotations are stored in the user's browser database (or localStorage if the browser is older) and can be automatically transferred to a given URI

through a POST request. Annotations can also be loaded through GET requests from a configurable URI or from the user's local storage.

Although the system is flexible in this regard, we ultimately recommend the storage of annotations in a triple store as it provides a nicely continuity with the existing ontology based model. The annotations can be easily represented as RDF structures and the application itself stores it as so internally. A graph database seems best suited for storing and querying annotation metadata.

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## 6 Conclusion

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<sup>6</sup>EdNOTE: MK: Describe link to CorT<sub>E</sub>X [CT; CG]

<sup>7</sup>EdNOTE: MK: write something

## References

- [AN] *Annotation tool*. URL: [Http://www.annotatiesysteem.nl](http://www.annotatiesysteem.nl) (visited on 02/15/2014).
- [BR] *brat rapid annotation tool*. URL: <http://brat.nlplab.org> (visited on 02/15/2014).
- [CG] GitHub repository. URL: <https://github.com/dginev/CorTeX/>.
- [CT] *CorT<sub>E</sub>XFramework*. URL: <http://cortex.mathweb.org> (visited on 02/15/2014).
- [Fre91] Free Software Foundation. *GNU General Public License*. 1991. URL: <http://www.gnu.org/copyleft/gpl.html> (visited on 05/22/2013).
- [KG] GitHub repository. URL: <https://github.com/KWARC/KAT/>.
- [YW] *Yawas - The Original Web Highlighter*. URL: <http://www.keeness.net/yawas/> (visited on 02/15/2014).

## A Installation Guide

In order to deploy KAT, please follow the next steps:

1. In Makefile.in, change INSTALLDIR to the desired installation directory (e.g. /srv/http/kat or /var/www/kat).
2. Rename Makefile.in into Makefile. Run make all && make install.
3. You will find a proof of concept demo at <http://localhost/katInstallDir/test>.
4. In order to add annotations, you need to add an annotation ontology first. You can do that in the KAT Control Panel (link in the bottom-right of the page). For starting you can copy the example you find in test/annotations.xml.
5. The default storage environment is the browser's local storage. An API to connect to different storage environment can be found in the classes from the remote/ directory.

## B An Annotation Specification

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```
<?xml version="1.0" encoding="UTF-8"?>
<!-- A KAT annotations specification for OMDoc annotations
      copyright 2013 Michael Kohlhase released under the GPL -->
<annotation xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
            xmlns:o="http://omdoc.org/ontology#" name="OMDoc">
  <documentation>
    The OMDoc ontology is a flexiformal data model for matheamtical (and
    general STEM) documents
  </documentation>
  <concepts>
    <concept name="Symbol">
      <documentation>An OpenMath/OMDoc Symbol</documentation>
      <fields>
        <field name="name" type="text">
          <documentation>
            The name of the symbol defines it in a theory
          </documentation>
          <value>Name</value>
          <default>Symbol</default>
          <validation>[A-Z][a-z]*</validation>
          <number atleast="1" atmost="2"></number>
        </field>
      </fields>
      <display>
        <template>
```

---

<sup>8</sup>EdNOTE: MK: explain this and the features it corresponds to

```

        <b>Symbol:</b>
        <br/>
        {name}
    </template>
</display>
<rdf:RDF>
    <rdf:Description>
        <rdf:type rdf:resource="http://omdoc.org/ontology#Symbol"></rdf:type>
        <o:symbolname>{name}</o:symbolname>
    </rdf:Description>
</rdf:RDF>
</concept>

<concept name="Definition">
    <fields>
        <field name="for" type="reference">
            <value>For</value>
            <referencedType>OMDoc.Symbol</referencedType>
            <number atleast="1"></number>
        </field>
        <field name="type" type="select">
            <options>
                <option default="true">
                    <value>simple</value>
                    <documentation>
                        Definiens is does not contain the definiendum
                    </documentation>
                </option>
                <option>
                    <documentation>
                        definiendum applied to formal variables
                    </documentation>
                    <value>pattern</value>
                </option>
            </options>
        </field>
    </fields>
<display>
    <template>
        <b>Definition</b>
        <br/>
        {for}
        <br/>
        {type}
    </template>
</display>
<rdf:RDF>
    <rdf:Description>
        <rdf:type rdf:resource="http://omdoc.org/ontology#GeneralDefinition">
        </rdf:type>
        <o:defines rdf:resource="{for}"></o:defines>
    </rdf:Description>
</rdf:RDF>

```

```

    </rdf:Description>
  </rdf:RDF>
</concept>
</concepts>
</annotation>

```

## C Developer Guide

KAT is written using FlancheJS: a simple library that provides javascript classical inheritance. The classes are structured java-like, having:

- constructors: provided by the method *init*.
- properties: the library automatically generates getters and setters.
- methods: publicly available functions.
- internals: properties and methods available only by underscore (*\_*) prefixing.

The table below describes the KAT classes (available under **src/js/**) and their behavior:

Class Name	Class Description
<b>main</b> namespace:	
<i>kat.main.KATService</i>	The main entry point of the service. The KAT Service requires a CSS3/XPATH selector to identify the container on which annotations can be made, and optionally a CorTeX service URL [CG; CT] and a document identifier for the annotated document.
<b>annotation</b> namespace:	
<i>kat.annotation.Annotation</i>	Describes an annotation that was collected from a user and can be saved and transported over network.
<i>kat.annotation.AnnotationRegistry</i>	Describes an annotation registry that keeps track of all the annotations for the current document
<i>kat.annotation.Concept</i>	Class to describe an annotation concept. Annotation concepts describe the annotation model (i.e. the fields contained by the annotation) and the behavior of the annotation (i.e. user interaction and display).
<i>kat.annotation.ConceptRegistry</i>	A registry to keep track of all available concepts for this document.



<i>kat.annotation.Ontology</i>	Class to describe an annotation ontology. Annotation ontologies describe the annotation concepts.
<i>kat.annotation.OntologyRegistry</i>	A registry to keep track of all available ontologies for this document.
<i>kat.annotation.AnnotationForm</i>	Class for handling the form displayed when an annotation is added.
<b>display</b> namespace:	
<i>kat.display.AnnotationEditForm</i>	Class for handling the form displayed when an annotation is edited.
<i>kat.display.ControlPanel</i>	This class provides a tool for displaying and handling the KAT Control Panel.
<i>kat.display.AnnotationRenderer</i>	Class for handling the display of a single annotation.
<i>kat.display.ArrowConnector</i>	Creates an svg arrow that can be used to connect two DOM elements, for example a reference field annotation to the referenced item.
<i>kat.display.Display</i>	Creates and controls the annotation displays.
<b>Class Name</b>	<b>Class Description</b>
<b>input</b> namespace:	
<i>kat.input.Form</i>	The Form class decides which fields to be displayed in the current form.
<i>kat.input.FormParser</i>	A form parser can be used to parse the fields and documentation from a given concept object.
<i>kat.input.FieldParserRegistry</i>	The Field Parser Registry contains all the field parsers that are available to parse for a concept.
<b>input.fieldparser</b> namespace:	
<i>kat.input.fieldparser.FieldParser</i>	A field parser parses an annotation:field into an html string. This trait serves only as an interface that the extending classes follow.
<i>kat.input.fieldparser.Checkboxes</i>	Parses a field of type checkboxes outputting html.
<i>kat.input.fieldparser.Reference</i>	Parses a field of type reference outputting html.
<i>kat.input.fieldparser.Select</i>	Parses a field of type select outputting html.
<i>kat.input.fieldparser.TextArea</i>	Parses a field of type text area outputting html.
<i>kat.input.fieldparser.TextField</i>	Parses a field of type text outputting html.

<b>input.fieldparser</b> namespace:	
<i>kat.input.view.Form</i>	Class that renders an annotation form containing the fields described in the concept.
<i>kat.input.view.ConceptSelector</i>	Class to describe an input element in the form container that is used to select a concept to be used in the annotation form.
<i>kat.input.view.FormContainer</i>	Describes a class that acts as a container for an annotation form and a concept selector.
<b>preprocessor</b> namespace:	
<i>kat.preprocessor.TextPreprocessor</i>	Used to add counters around text but this functionality has been deprecated. Now it only adds selection listeners in the text, for adding annotations.
<b>remote</b> namespace:	
<i>kat.remote.CoreTexAnnotationInsertion</i>	Sends the annotations being created on this document to the CoreTeX system.
<i>kat.remote.CoreTeXAnnotationReceiver</i>	Retrieves the document and the annotations from the CoreTeX service and populates the internal registry.