



# TALKING TO YOUR IDE

Supporting Developers with Software Evolution Queries

A woman with brown hair and blue eyes, wearing a black top and large hoop earrings, is looking upwards and to the right with a questioning expression. She is standing in a forest with green trees and sunlight filtering through the leaves. The background is slightly blurred, focusing attention on her.

**What fields are declared as  
being of this type?**

**Which classes inherit from this class?**

**Does this type have any siblings?**

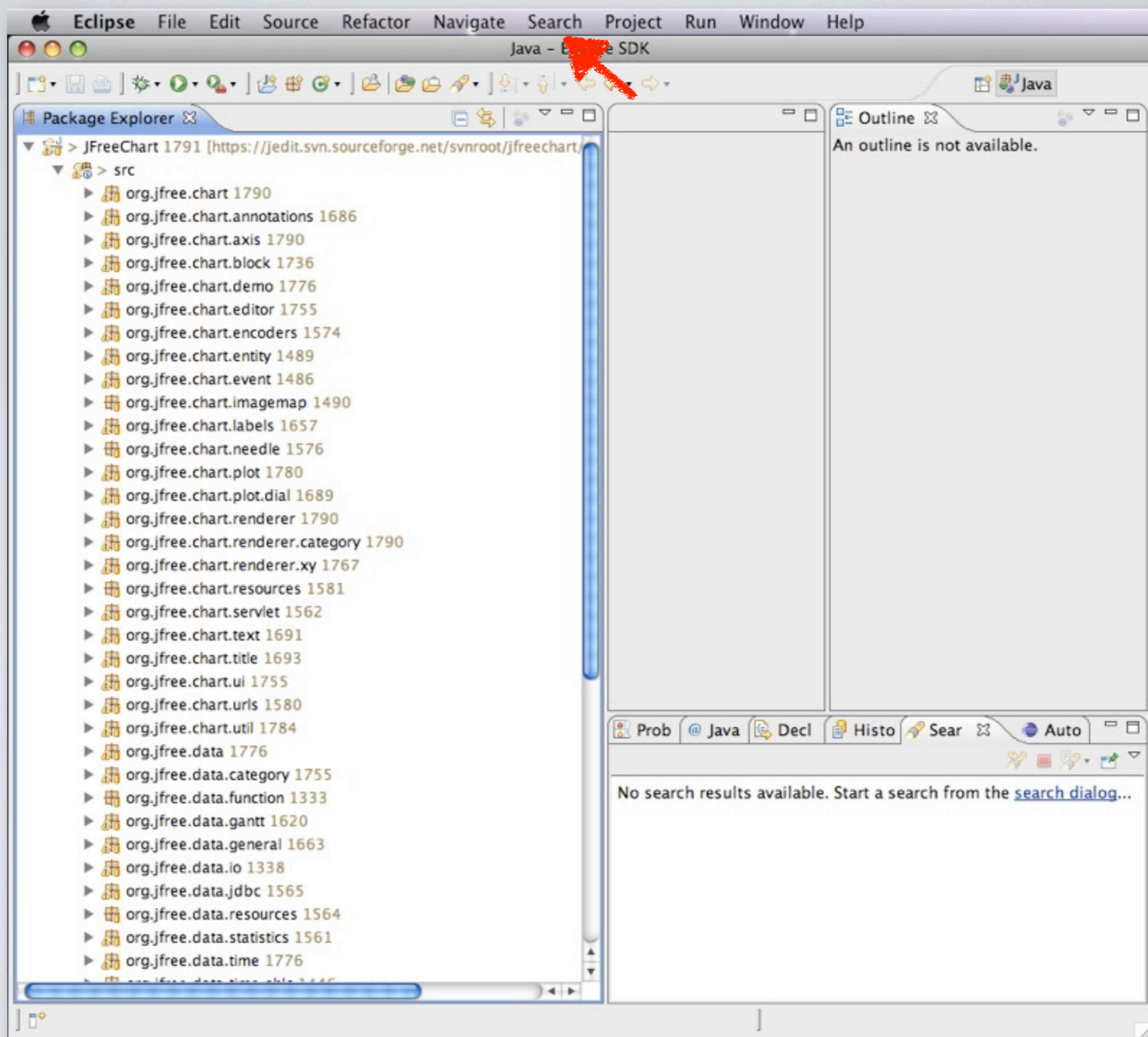
**Where in the  
type hierarchy is  
this field  
declared?**

**What are the  
arguments of this  
function?**

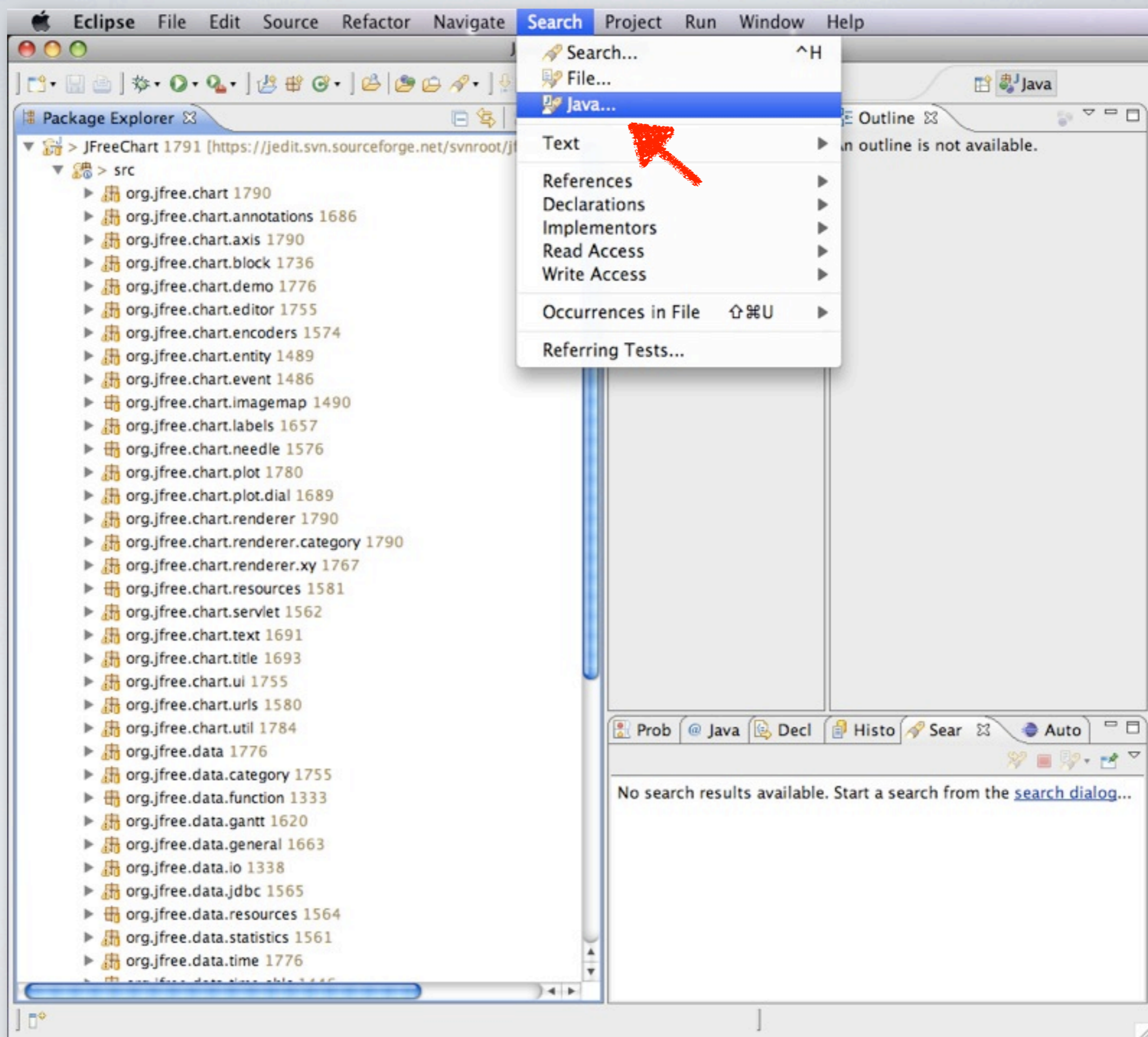
**Who implements this interface?**

**I wonder whether this method is somewhere  
overridden.**

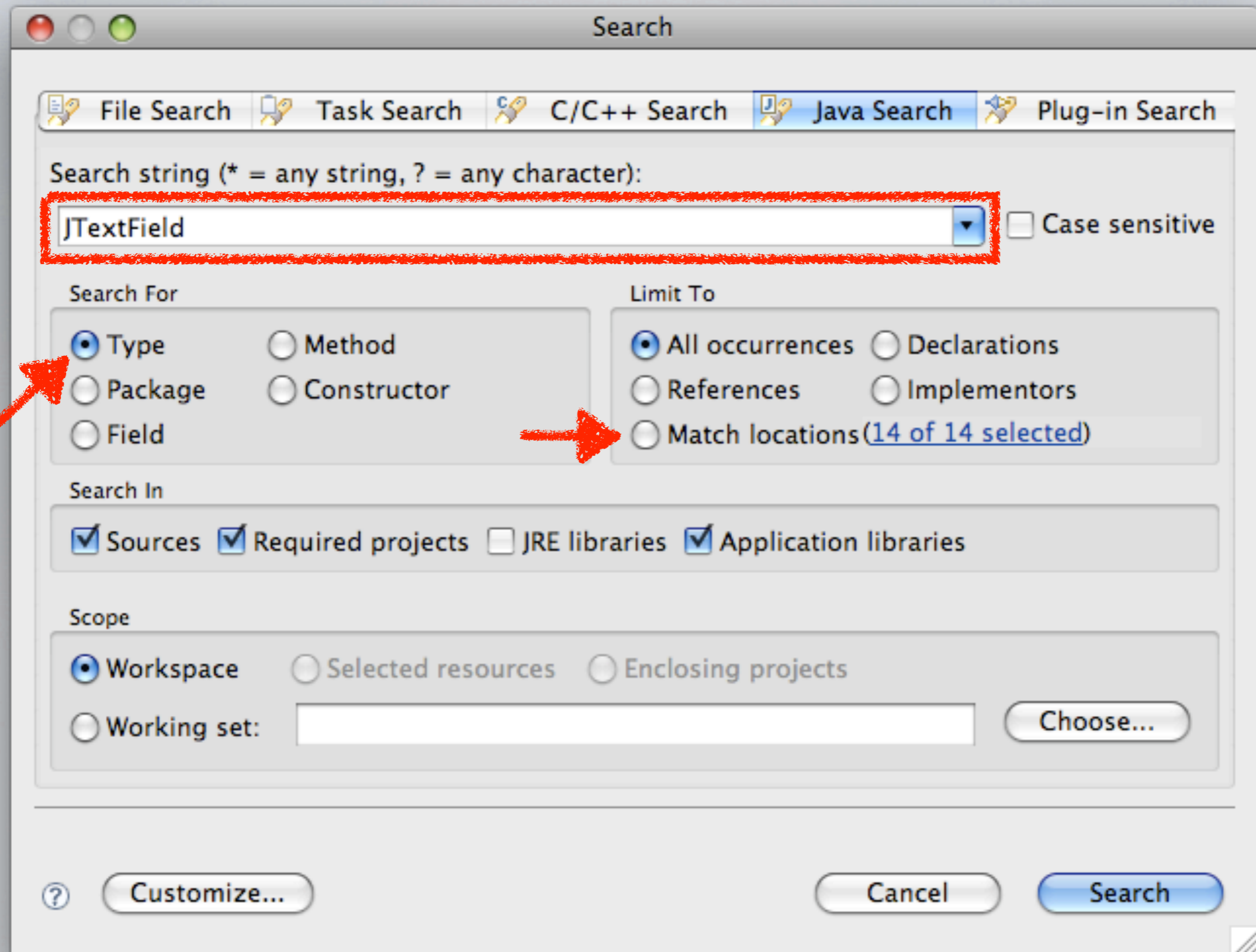
**What are the callers of this  
method?**



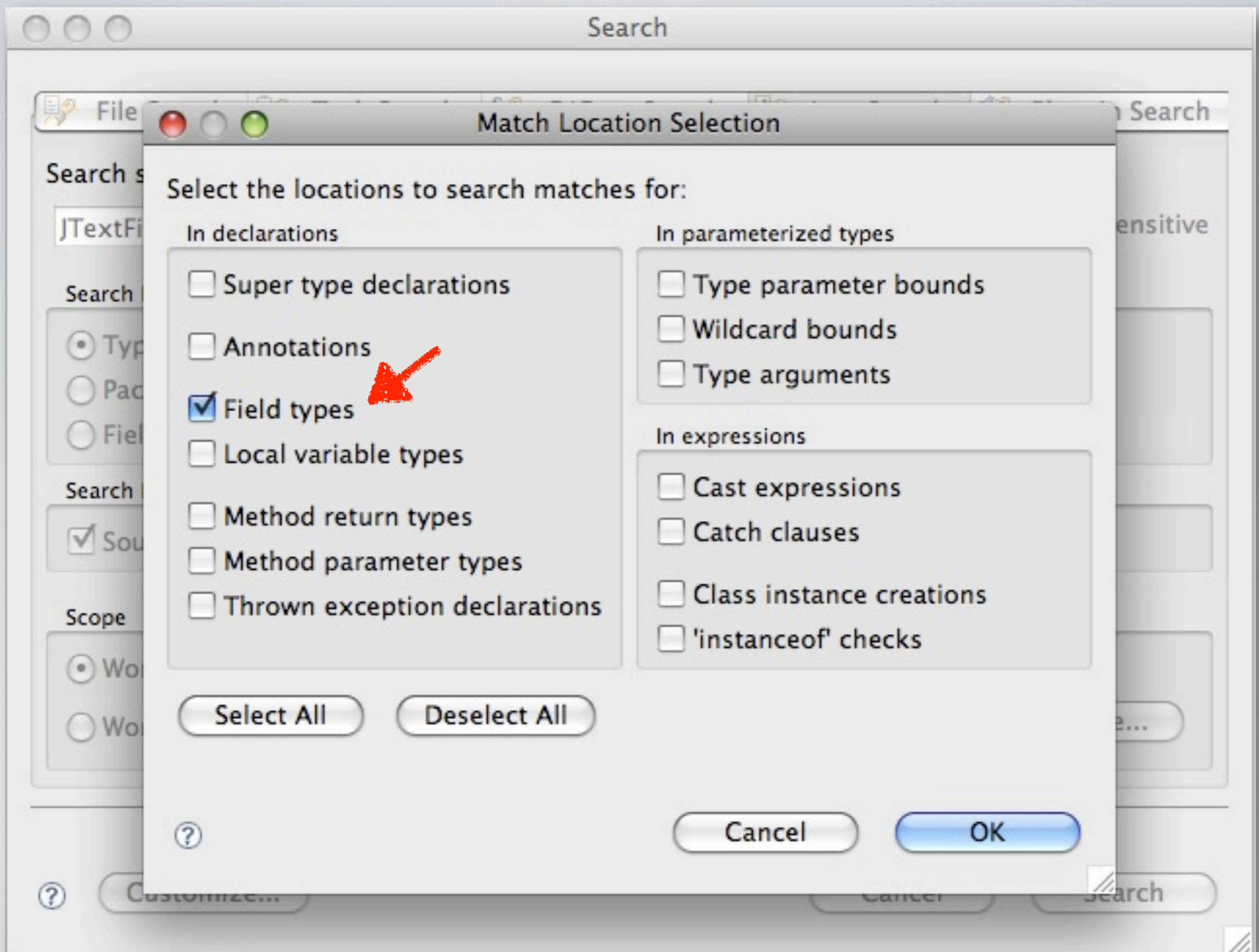
What fields are declared as being of the type JTextField?



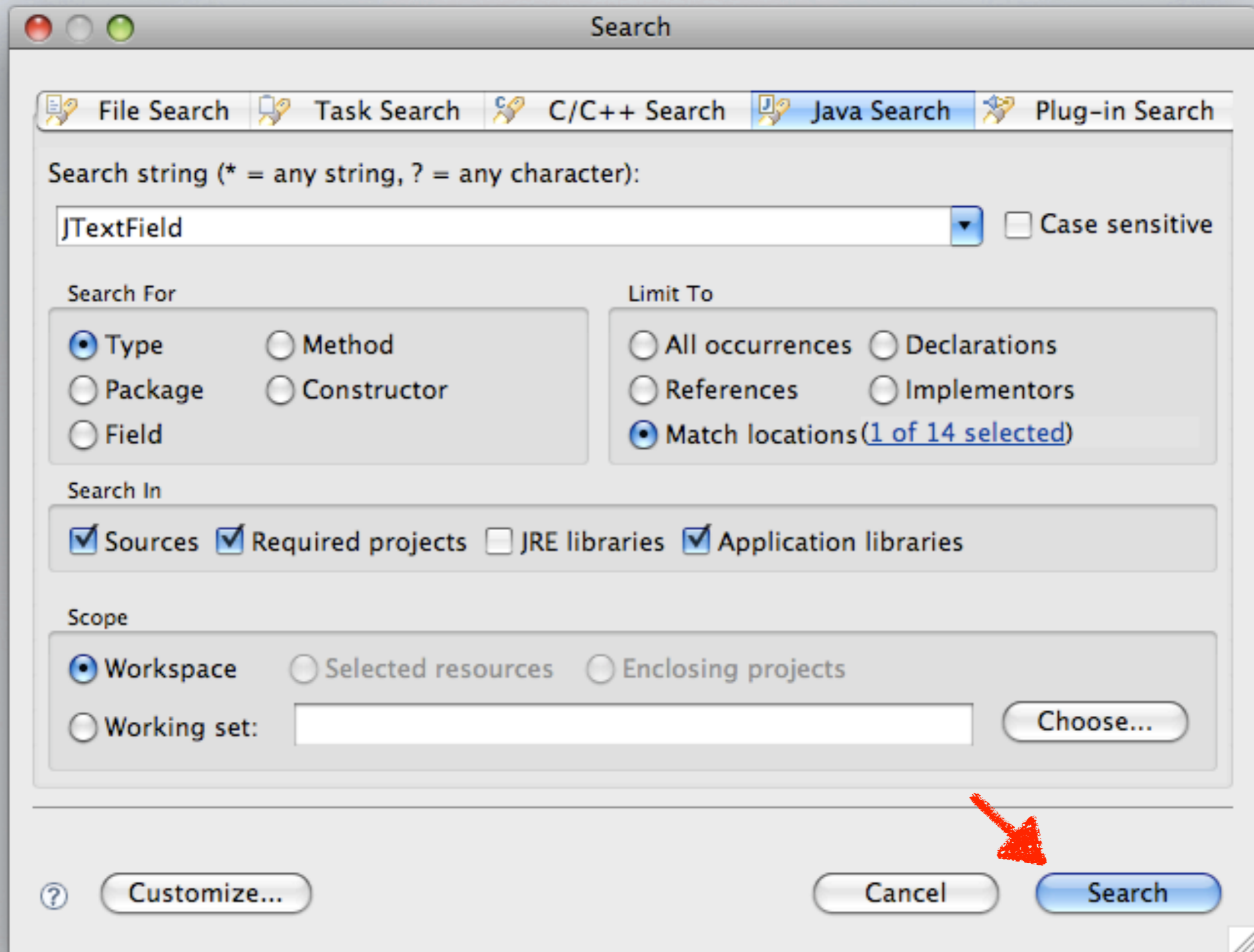
What fields are declared as being of the type JTextField?



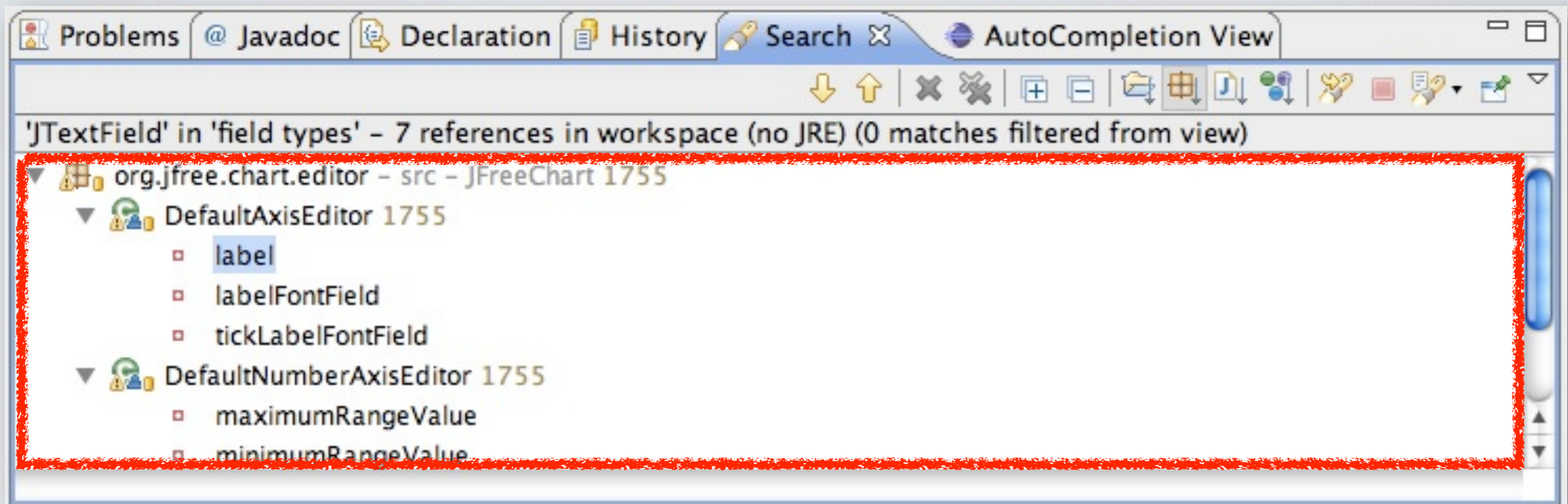
What fields are declared as being of the type JTextField?



What fields are declared as being of the type JTextField?



What fields are declared as being of the type JTextField?



What fields are declared as being of the type JTextField?



**What fields are declared as  
being of this type?**

**Simple question!**

**Not so simple  
answer!**



Package Explorer | History

NetBeans IDE 5.0

File Edit View Navigate Source Refactor Build Run

build-impl.xml | genfiles

[#IVY-1347] StackOverflowError

https://issues.apache.org/jira/browse/

The Apache Software Foundation  
http://www.apache.org

Dashboards | Projects | Issues | Agile

Ivy / IVY-1347  
**StackOverflowError when**

Log In

Details

Type: Bug  
Priority: Critical  
Affects Version/s: 2.3.0-RC1  
Component/s: Core  
Labels: None

Description

When using <extends> without specifying a location, the following is an example:

```
...  
<info organisation="foo" module="bar">  
  <extends organisation="foo" module="baz" />  
</info>  
...
```

jdt-dev Archive (Thread View)

dev.eclipse.org/mhonarc/lists/jdt-dev/threads.html#00693

jdt-dev Archive (Thread View - Most Recent First)

• [Main Index](#)

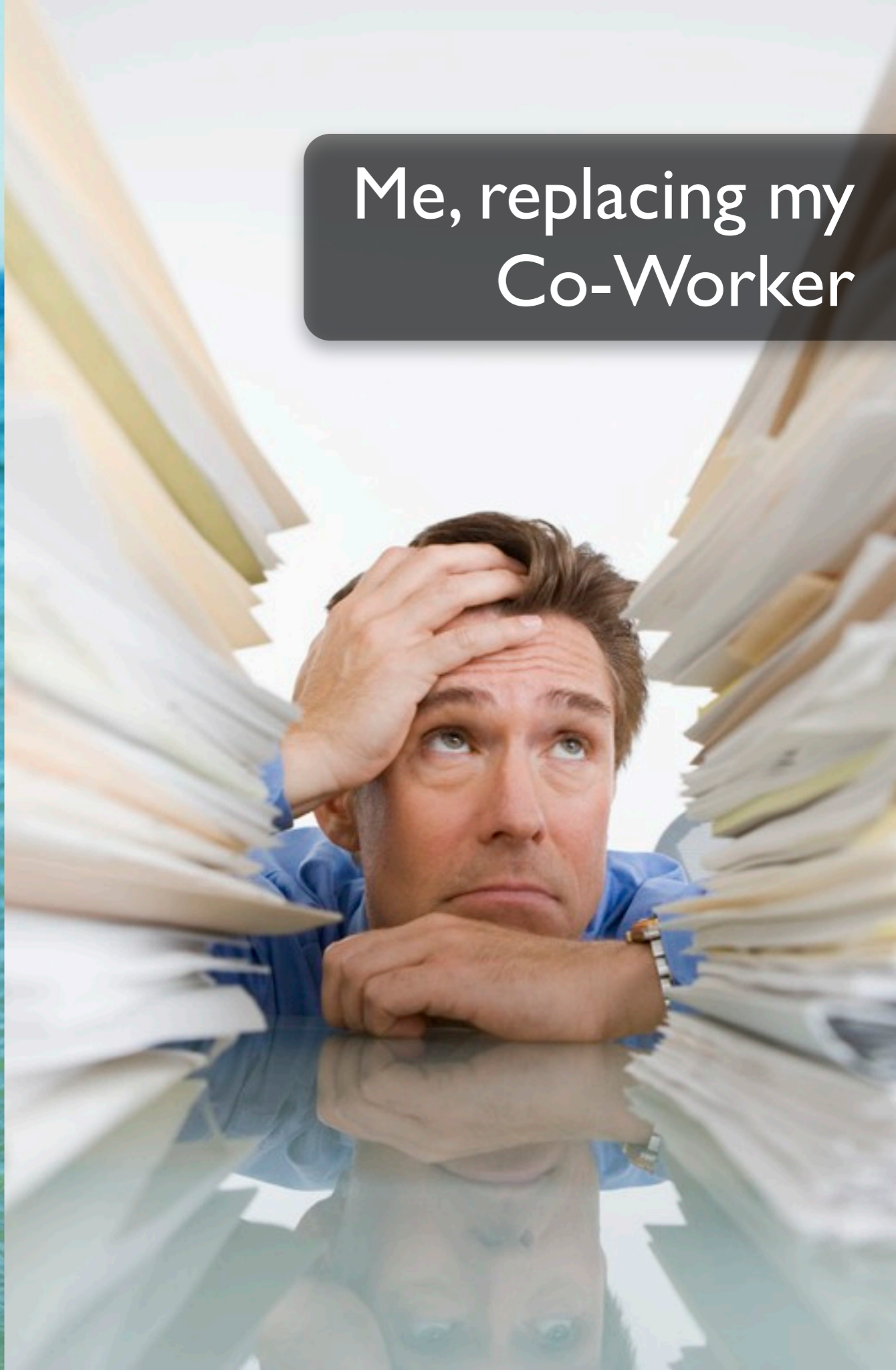
[First Page] [Prev Page] [Next Page] [Last Page]

- [\[jdt-dev\] how to replace the Javadoc in MethodDeclaration?](#), dan.zheng
- [\[jdt-dev\] Build Eclipse using Eclipse](#), Jongwook Kim
- [\[jdt-dev\] Architecture and Documentation site for JDT](#), Vineet Sinha
  - [Re: \[jdt-dev\] Architecture and Documentation site for JDT](#), Daniel Megert
    - [Re: \[jdt-dev\] Architecture and Documentation site for JDT](#), Vineet Sinha
- [\[jdt-dev\] Execute JUnitLaunchShortcut with several Class Tests](#), JosÃ Carlos de Campos
- [\[jdt-dev\] Listen for JRE/classpath changes](#), Andrey Razumovsky
  - [Re: \[jdt-dev\] Listen for JRE/classpath changes](#), Markus Keller
    - [Re: \[jdt-dev\] Listen for JRE/classpath changes](#), Andrey Razumovsky
- [\[jdt-dev\] PLEASE READ: Git Migration](#), Daniel Megert
- [\[jdt-dev\] ASTView 1.1.8 for JDT 3.7.1 and 3.8](#), Markus Keller
- [\[jdt-dev\] Update of the Java 7 p2 repos](#), Olivier Thomann
- [\[jdt-dev\] Eclipse JDT Architecture Site \(Prototype\)](#), Abhishek Rakshit
- [\[jdt-dev\] Helping Developers understand and document Eclipse JDT](#), Abhishek Rakshit
  - [Re: \[jdt-dev\] Helping Developers understand and document Eclipse JDT](#), Daniel Megert
    - [Re: \[jdt-dev\] Helping Developers understand and document Eclipse JDT](#), Deepak Az
    - [Re: \[jdt-dev\] Helping Developers understand and document Eclipse JDT](#), Abhishek Rakshit
    - [Re: \[jdt-dev\] Helping Developers understand and document Eclipse JDT](#), Abhishek Rakshit
- [\[jdt-dev\] AUTO: Gili Mendel is out of the office. \(returning 06/11/2011\)](#), Dr Gili Mendel
- [\[jdt-dev\] Disabling JDT's RunAs launch shortcut](#), Sven KÄhler
  - [Re: \[jdt-dev\] Disabling JDT's RunAs launch shortcut](#), Sven KÄhler
- [\[jdt-dev\] Interested in helping a research study on Eclipse?](#), Mohsen Vakilian
  - [Re: \[jdt-dev\] Interested in helping a research study on Eclipse?](#), Mohsen Vakilian
- [\[jdt-dev\] RenameSupport](#), Dimov, Stefan
  - [Re: \[jdt-dev\] RenameSupport](#), Markus Keller
    - [Re: \[jdt-dev\] RenameSupport](#), Dimov, Stefan
- [\[jdt-dev\] Updated JavaElement View and ASTView](#), Markus Keller
- [\[jdt-dev\] Cindy Guenther is out of the office.](#), Cindy . Guenther
- [\[jdt-dev\] Running formatter from the command line](#), Panayotis Katsaloulis
  - [Re: \[jdt-dev\] Running formatter from the command line](#), Daniel Megert
  - [Re: \[jdt-dev\] Running formatter from the command line](#), Panayotis Katsaloulis



My Co-Worker

Me, replacing my  
Co-Worker



jQuery

ASTLog

CodeQuest

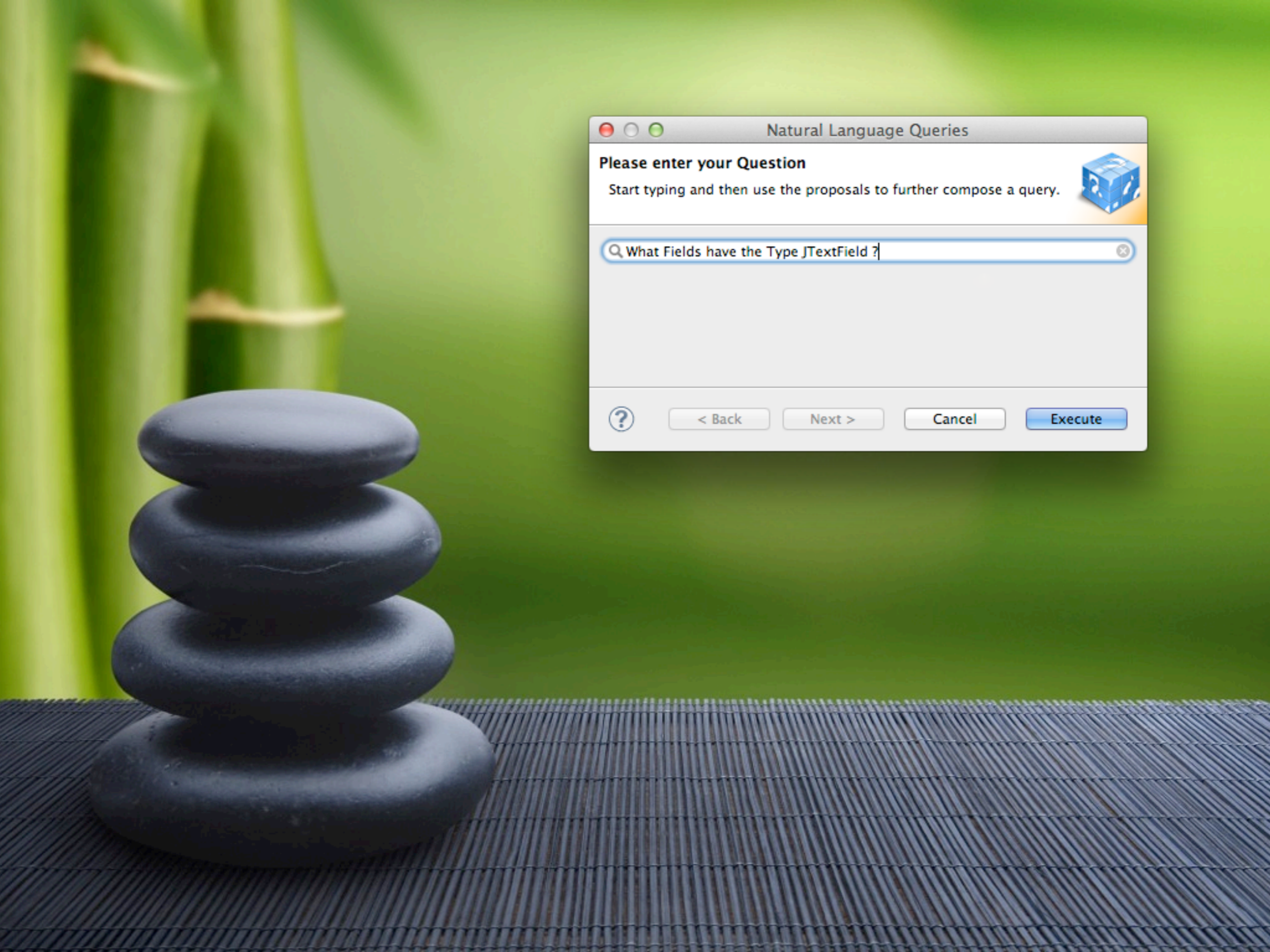
Semmlle

```
from Method caller, Method callee
where caller.calls(callee)
and caller.fromSource()
and callee.fromSource()
and caller != callee
and callee.getName().matches("addChart%")
select caller.getName()
```




*“The most comfortable way for a user to express an information need is as a **natural language** statement”*

—G. G. Chowdhury  
Modern Information Retrieval, 2004




Natural Language Queries

**Please enter your Question**

Start typing and then use the proposals to further compose a query. 

What Fields have the Type JTextField ?



W3C<sup>®</sup>



**Semantic  
Web**





**wweb**

**1.0**



## CVS - Concurrent Versions System

[Introduction](#) | [News](#) | [Documentation](#) | [Get the Software](#) | [Help and Bug Reports](#) | [Development](#)

### [Introduction to CVS](#)

CVS is a version control system, an important component of Source Configuration Management (SCM). Using it, you can record the history of sources files, and documents. It fills a similar role to the free software [RCS](#), [PRCS](#), and [Aegis](#) packages.

CVS is a production quality system in wide use around the world, including many free software projects.

While CVS stores individual file history in the same format as RCS, it offers the following significant advantages over RCS:

- It can run scripts which you can supply to log CVS operations or enforce site-specific policies.
- **Client/server** CVS enables developers scattered by geography or slow modems to function as a single team. The version history is stored on a single central server and the client machines have a copy of all the files that the developers are working on. Therefore, the network between the client and the server must be up to perform CVS operations (such as checkins or updates) but need not be up to edit or manipulate the current versions of the files. Clients can perform all the same operations which are available locally.
- In cases where several developers or teams want to each maintain their own version of the files, because of geography and/or policy, CVS's **vendor branches** can import a version from another team (even if they don't use CVS), and then CVS can merge the changes from the vendor branch with the latest files if that is what is desired.
- **Unreserved checkouts**, allowing more than one developer to work on the same files at the same time.
- CVS provides a flexible **modules database** that provides a symbolic mapping of names to components of a larger software distribution. It applies names to collections of directories and files. A single command can manipulate the entire collection.
- CVS servers run on most unix variants, and clients for Windows NT/95, OS/2 and VMS are also available. CVS will also operate in what is sometimes called server mode against local repositories on Windows 95/NT.

### [CVS News](#)

Recent CVS news, including release announcements, are posted on the [Current events page](#). To receive the same news via email, subscribe to the [cvs-announce mailing list](#) (these announcements are duplicated on the bug-cvs@nongnu.org and info-cvs@nongnu.org [mailing lists](#)).

### [CVS Documentation](#)

The [cvs Information Page](#) contains detailed, and current information on CVS.



**Web**

**2.0**

WordPress.com is also available in [Deutsch](#), [Français](#) and [Italiano](#).



Language: English

A better way to blog.

Get started here

[Learn more](#) or [sign up now](#).

### Freshly Pressed:

The best of **482,909** bloggers, **923,106** new posts, **1,542,188** comments, & **195,678,564** words posted today on WordPress.com.



#### A Year in the Life of an Apple Tree

The Teacup Chronicles  
Posts about Nature →



#### Hong Kong – Hipstamatic Tour

The Blissful Adventurer  
Posts about Food →



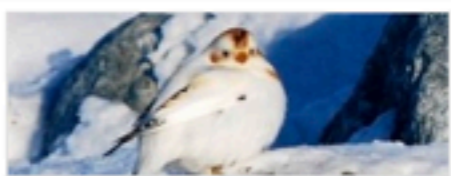
#### In Downtown L.A.

Hyo Shin Pak Photography



#### 5 Reasons Why Life Should Be More Like Baseball

Tri Fatherhood  
Posts about Family →



#### The Birds are Back in Town!

Frozen Moments  
Posts about Photography →



#### By the River

Vintage Reflection  
Posts about Fashion →



#### Chunky Salad with Basil Vinaigrette

(Mrs. Buena Vida)



#### Bruce Davidson – Subway

surface & surface  
Posts about Art →



#### Zumba: The Great Equalizer



#### And it Was All Yellow



#### Crystal Mountain and The



Browse | Upload

Michael Würsch 0 +

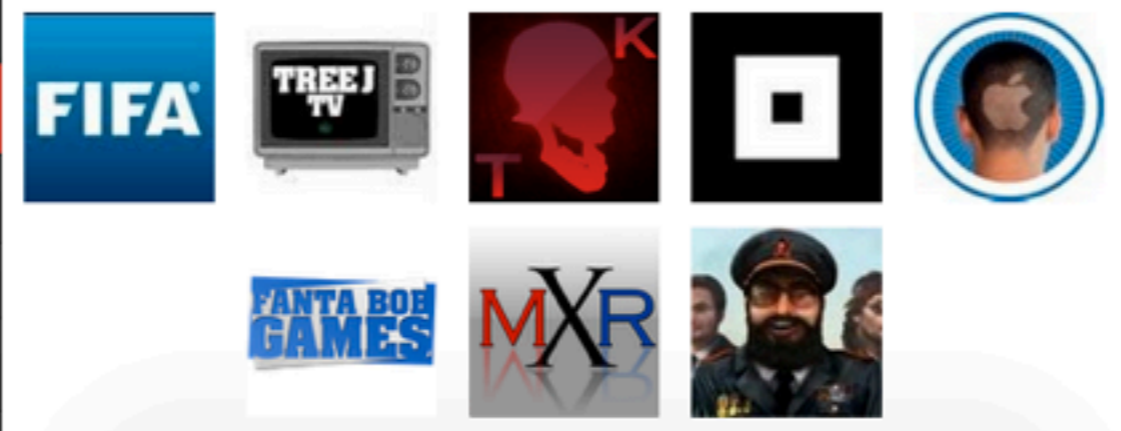
- Browse channels
- My channel >
  - Videos
  - Likes
  - History
  - Watch Later
- Subscriptions
- Social
- see all >
- From YouTube
- Trending
- Popular
- Music
- Entertainment
- more see all >

### Subscriptions

0 subscriptions >

Show uploads only | View >

It looks like you don't have any subscriptions yet.  
[Get started by adding channels >](#)



Advertisement



**Tommy Emmanuel - Close To You** 3 weeks ago

Tommy plays a cover of Burt Bacharach's "Close To You"  
TommyEmmanuelTV · 109,537 views

Yi Guo +1'd



**A look inside Google's "Driverless Car"** 3 months ago

The Google Driverless Car is a project by Google that involves developing technology for

Recommended >

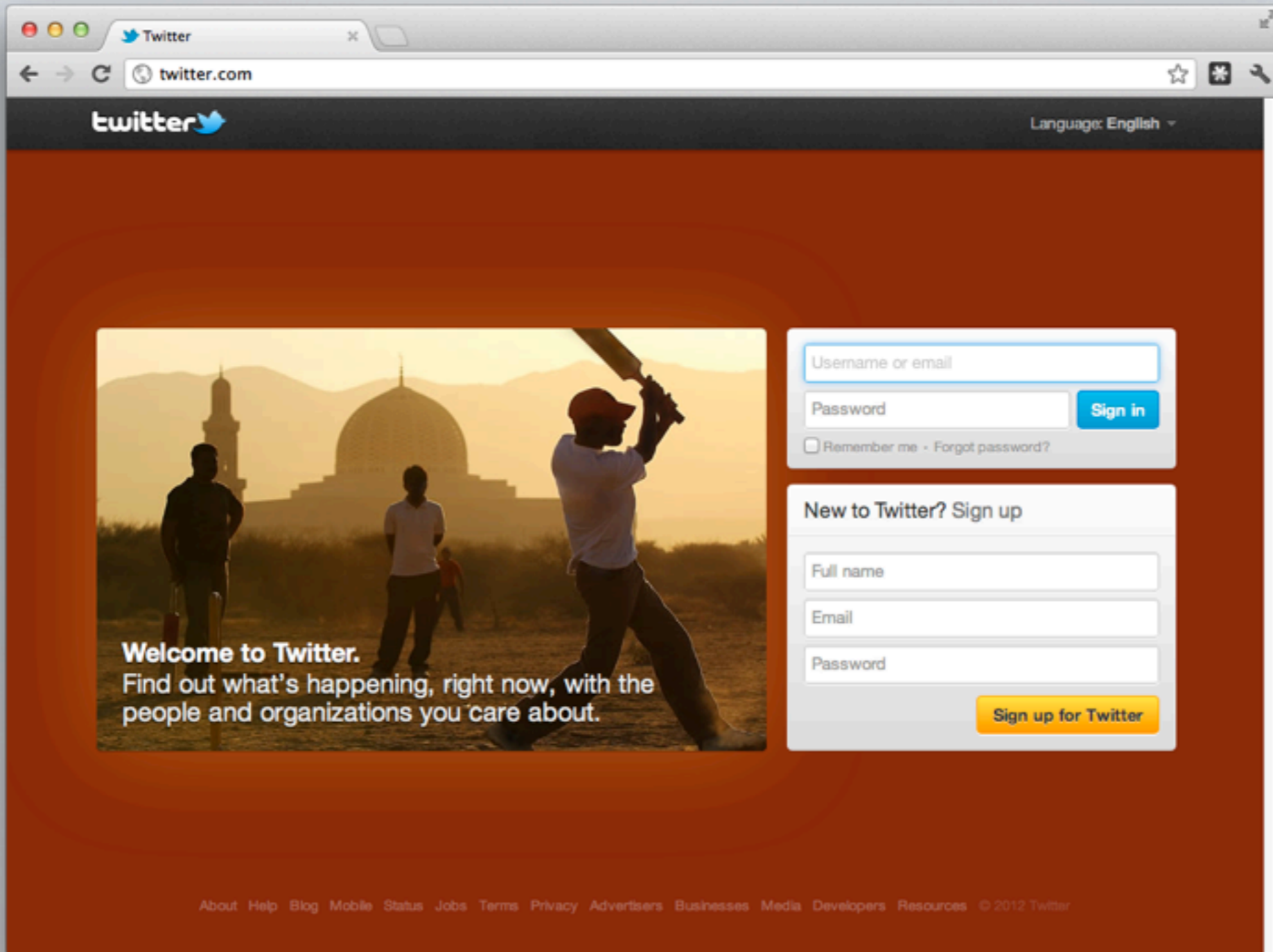
Spotlight

### Fenway Park's 100th Anniversary

For the then-princely sum of \$650,000 (about \$16 million in today's dollars), the citizens of Boston received in 1912 one of the most renowned sports venues in the world: Fenway Park. A century later, the stadium that nurtured a young Babe Ruth and witnessed the miraculous hitting of Ted Williams is still in use ... and the score is still updated by hand.



**History of Fenway Park: Greatest Sports Buildings**  
by WatchMojo  
1,106 views



**Welcome to Twitter.**  
Find out what's happening, right now, with the people and organizations you care about.

Username or email

Password

Remember me - [Forgot password?](#)

**New to Twitter? Sign up**

Full name

Email

Password

# facebook

Email

Password

Log In

Keep me logged in

[Forgot your password?](#)

## Facebook helps you connect and share with the people in your life.



### Sign Up

It's free and always will be.

First Name:

Last Name:

Your Email:

Re-enter Email:

New Password:

I am:

Select Sex:

Birthday:

Month:

Day:

Year:

[Why do I need to provide my birthday?](#)

By clicking Sign Up, you agree to our [Terms](#) and that you have read and understand our [Data Use Policy](#).

Sign Up

[Create a Page](#) for a celebrity, band or business.



# WIKIPEDIA

## English

*The Free Encyclopedia*  
3 907 000+ articles

## 日本語

フリー百科事典  
799 000+ 記事

## Español

*La enciclopedia libre*  
879 000+ artículos

## Deutsch

*Die freie Enzyklopädie*  
1 383 000+ Artikel

## Русский

*Свободная энциклопедия*  
838 000+ статей

## Français

*L'encyclopédie libre*  
1 230 000+ articles

## Italiano

*L'enciclopedia libera*  
905 000+ voci

## Polski

*Wolna encyklopedia*  
887 000+ haseł



## Português

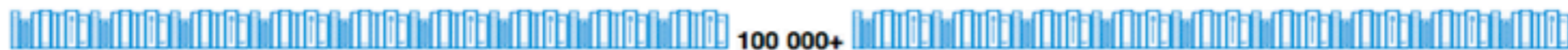
*A enciclopédia livre*  
718 000+ artigos

## 中文

自由的百科全書  
429 000+ 條目

search • suchen • rechercher • zoeken • ricerca • szukaj • buscar • поиск • 検索 • busca • sök • 搜尋 •  
tim kiém • пошук • cerca • søk • haku • hledání • keresés • 찾기 • cari • ara • جستجو • căutare • بحث •  
hľadať • søg • serçu • претрага • paieška • poišči • cari • חיפוש • търсене • іздеу • bilatu • suk •  
bilnga • traži • खोजे

English



**www**

**web**

**3.0**



Syntax is the study of **grammar**

142

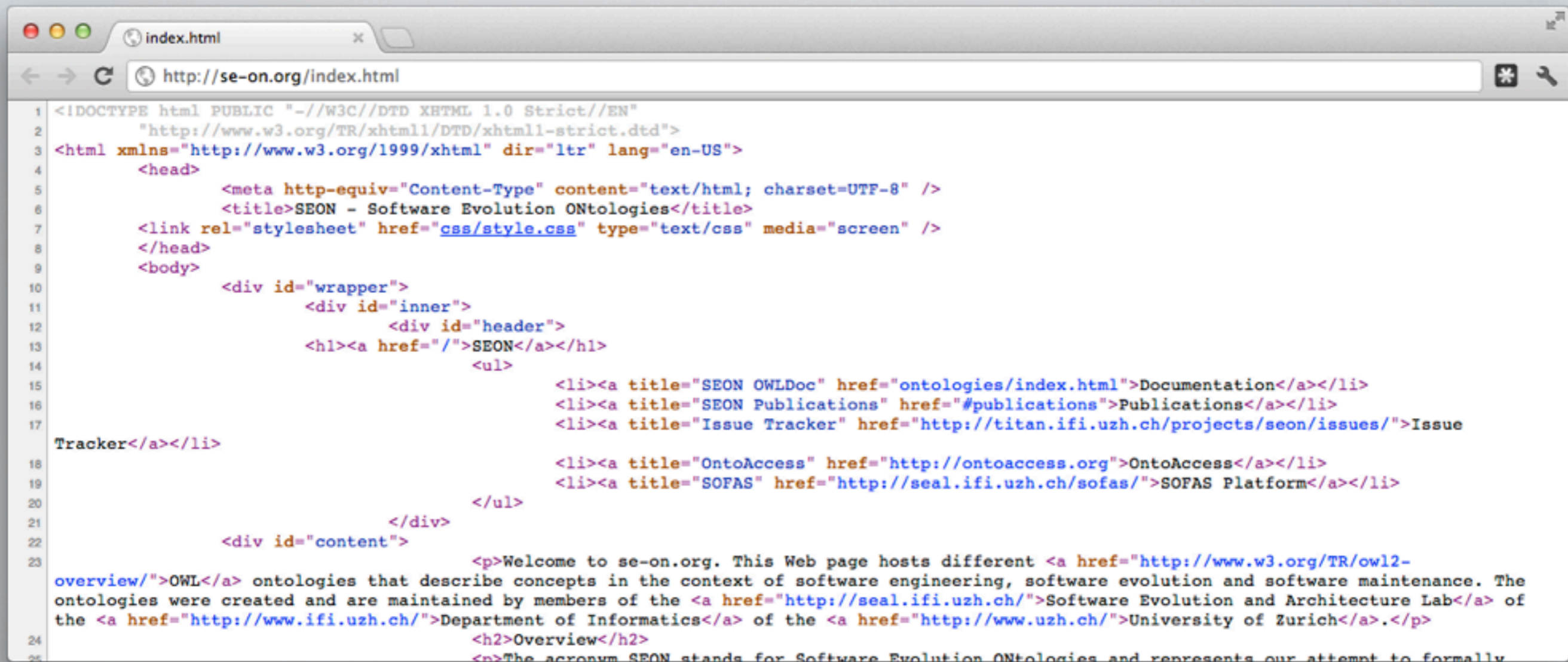


Semantics is the study of **meaning**

A group of four people (three men and one woman) are sitting in a circle on white chairs in a bright, minimalist room. They appear to be in a discussion or meeting. The man in the center is speaking and gesturing with his hands. The woman to his right is listening intently with her hand on her chin. The man on the far right is also listening. The woman on the far left is partially visible, looking towards the speaker. The background is a large window with a view of a city skyline.

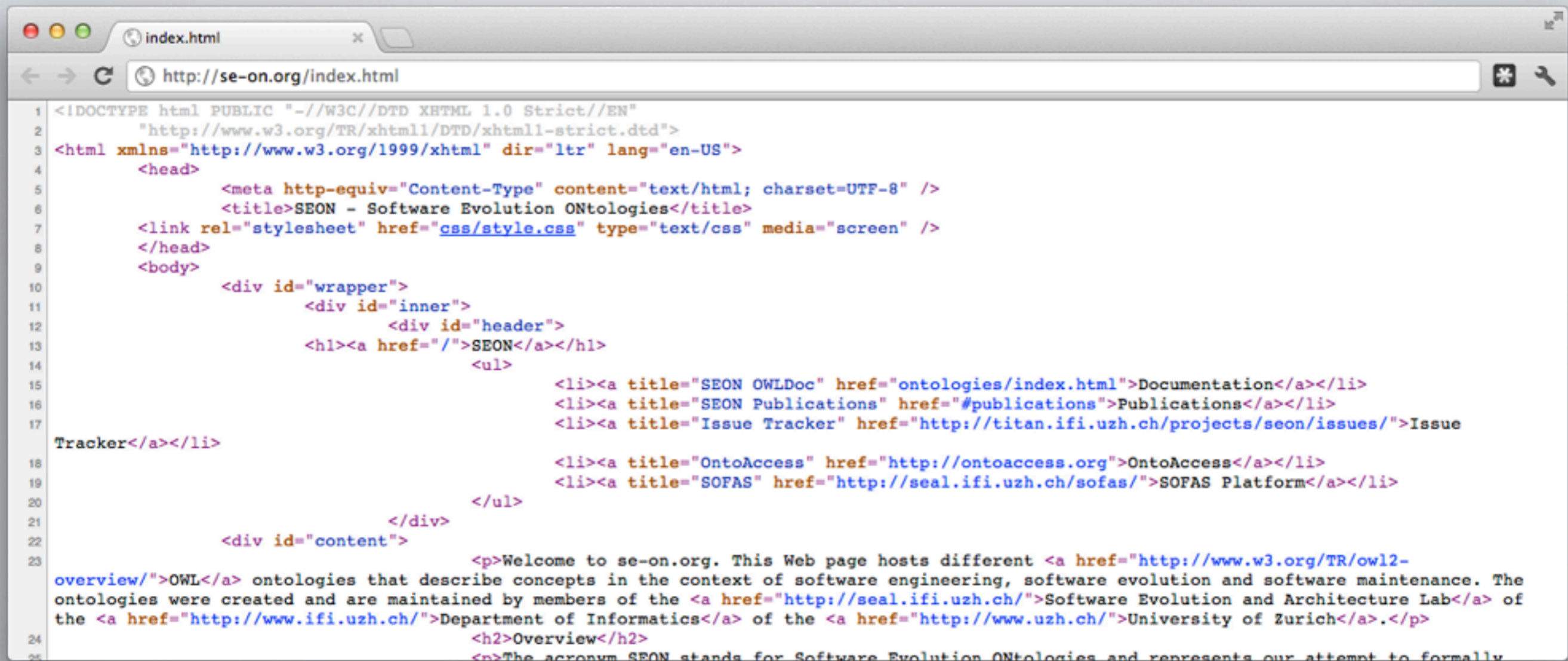
Syntax and semantics are  
all about **communication**

HTML describes the **structure** of information



```
1 <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
2   "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
3 <html xmlns="http://www.w3.org/1999/xhtml" dir="ltr" lang="en-US">
4   <head>
5     <meta http-equiv="Content-Type" content="text/html; charset=UTF-8" />
6     <title>SEON - Software Evolution ONtologies</title>
7     <link rel="stylesheet" href="css/style.css" type="text/css" media="screen" />
8   </head>
9   <body>
10    <div id="wrapper">
11      <div id="inner">
12        <div id="header">
13          <h1><a href="/">SEON</a></h1>
14          <ul>
15            <li><a title="SEON OWLDoc" href="ontologies/index.html">Documentation</a></li>
16            <li><a title="SEON Publications" href="#publications">Publications</a></li>
17            <li><a title="Issue Tracker" href="http://titan.ifi.uzh.ch/projects/seon/issues/">Issue
18Tracker</a></li>
19            <li><a title="OntoAccess" href="http://ontoaccess.org">OntoAccess</a></li>
20            <li><a title="SOFAS" href="http://seal.ifi.uzh.ch/sofas/">SOFAS Platform</a></li>
21          </ul>
22        </div>
23        <div id="content">
24          <p>Welcome to se-on.org. This Web page hosts different <a href="http://www.w3.org/TR/owl2-
25overview/">OWL</a> ontologies that describe concepts in the context of software engineering, software evolution and software maintenance. The
ontologies were created and are maintained by members of the <a href="http://seal.ifi.uzh.ch/">Software Evolution and Architecture Lab</a> of
the <a href="http://www.ifi.uzh.ch/">Department of Informatics</a> of the <a href="http://www.uzh.ch/">University of Zurich</a>.</p>
26          <h2>Overview</h2>
27          <p>The acronym SEON stands for Software Evolution ONtologies and represents our attempt to formally
```

HTML describes the **syntax** not the **semantics**



```
1 <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
2   "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
3 <html xmlns="http://www.w3.org/1999/xhtml" dir="ltr" lang="en-US">
4   <head>
5     <meta http-equiv="Content-Type" content="text/html; charset=UTF-8" />
6     <title>SEON - Software Evolution ONtologies</title>
7     <link rel="stylesheet" href="css/style.css" type="text/css" media="screen" />
8   </head>
9   <body>
10    <div id="wrapper">
11      <div id="inner">
12        <div id="header">
13          <h1><a href="/">SEON</a></h1>
14          <ul>
15            <li><a title="SEON OWLDoc" href="ontologies/index.html">Documentation</a></li>
16            <li><a title="SEON Publications" href="#publications">Publications</a></li>
17            <li><a title="Issue Tracker" href="http://titan.ifi.uzh.ch/projects/seon/issues/">Issue
Tracker</a></li>
18            <li><a title="OntoAccess" href="http://ontoaccess.org">OntoAccess</a></li>
19            <li><a title="SOFAS" href="http://seal.ifi.uzh.ch/sofas/">SOFAS Platform</a></li>
20          </ul>
21        </div>
22        <div id="content">
23          <p>Welcome to se-on.org. This Web page hosts different <a href="http://www.w3.org/TR/owl2-
overview/">OWL</a> ontologies that describe concepts in the context of software engineering, software evolution and software maintenance. The
ontologies were created and are maintained by members of the <a href="http://seal.ifi.uzh.ch/">Software Evolution and Architecture Lab</a> of
the <a href="http://www.ifi.uzh.ch/">Department of Informatics</a> of the <a href="http://www.uzh.ch/">University of Zurich</a>.</p>
24          <h2>Overview</h2>
25          <p>The acronym SEON stands for Software Evolution ONtologies and represents our attempt to formally
```

W3C<sup>®</sup>



**RDF**

Resource Description Framework

W3C<sup>®</sup>



**OWL**

Web Ontology Language

A close-up photograph of a computer keyboard, tilted at an angle. The keys are dark, and the background is a bright, slightly blurred blue. A semi-transparent blue horizontal band is overlaid across the middle of the image, containing the text. The text 'RDF identifies things with URIs' is centered within this band. 'RDF' and 'URIs' are in a bold, orange font, while the rest of the text is in white. The word 'http' is visible on a key in the lower-left foreground, partially obscured by the overlay.

**RDF** identifies things with **URIs**

**RDF** describes things with simple  
statements (**Triples**)

subject → Predicate → Object



<http://www.w3.org/2010/swap/pim/contact#Person>

<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>

<http://www.w3.org/People/EM/contact#me>

# Syntax!

<http://www.w3.org/2000/10/swap/pim/contact#fullName>

<http://www.w3.org/2000/10/swap/pim/contact#mailBox>

<mailto:em@w3.org>

<http://www.w3.org/2000/10/swap/pim/contact#personalTitle>

Dr.



...



- + class system
- + domain/range
- + transitivity
- + symmetry
- + cardinality
- + existence
- + reasoning

# SEON

Software  
Evolution  
Ontologies

General Concepts

Domain-Spanning Concepts

Domain-Specific Concepts

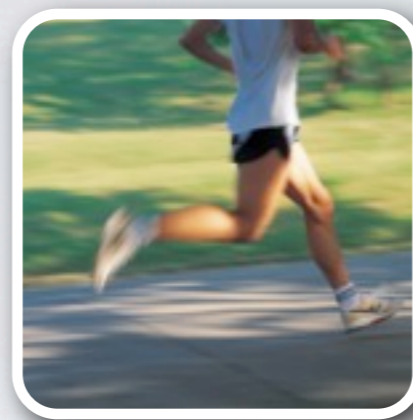
System-Specific Concepts



Resources



Stakeholders



Activities



Metrics



Changes



Clones



Coupling



Flaws



Code



History

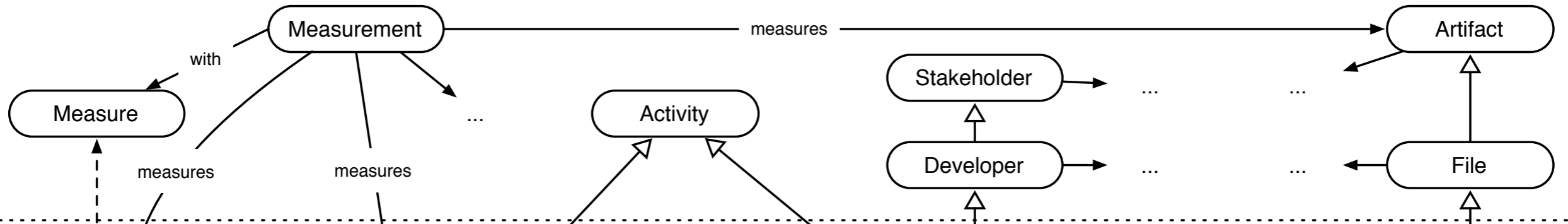


Bugs

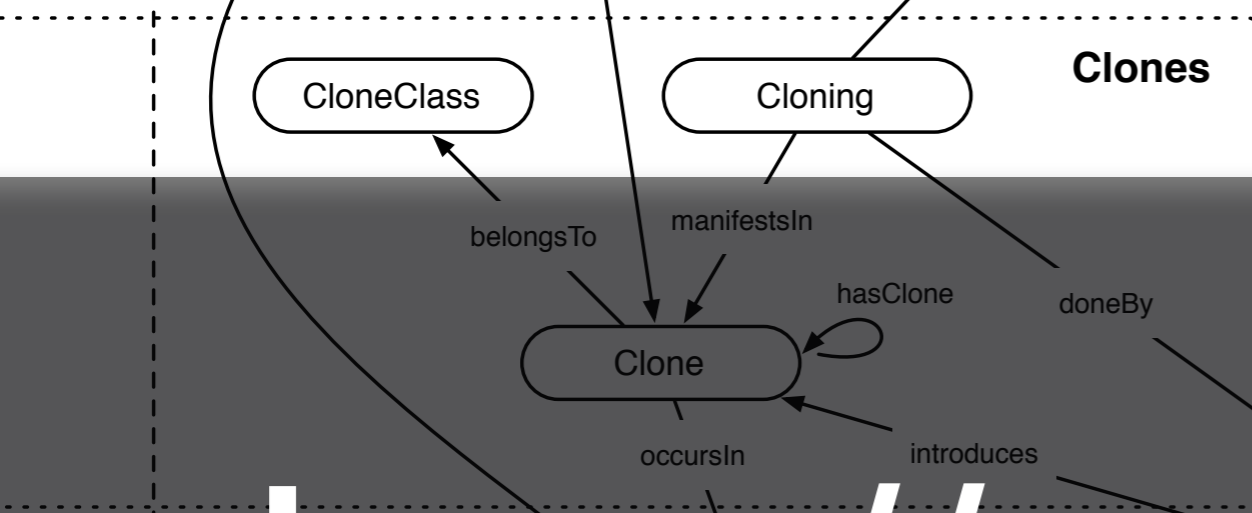


NL Annotations

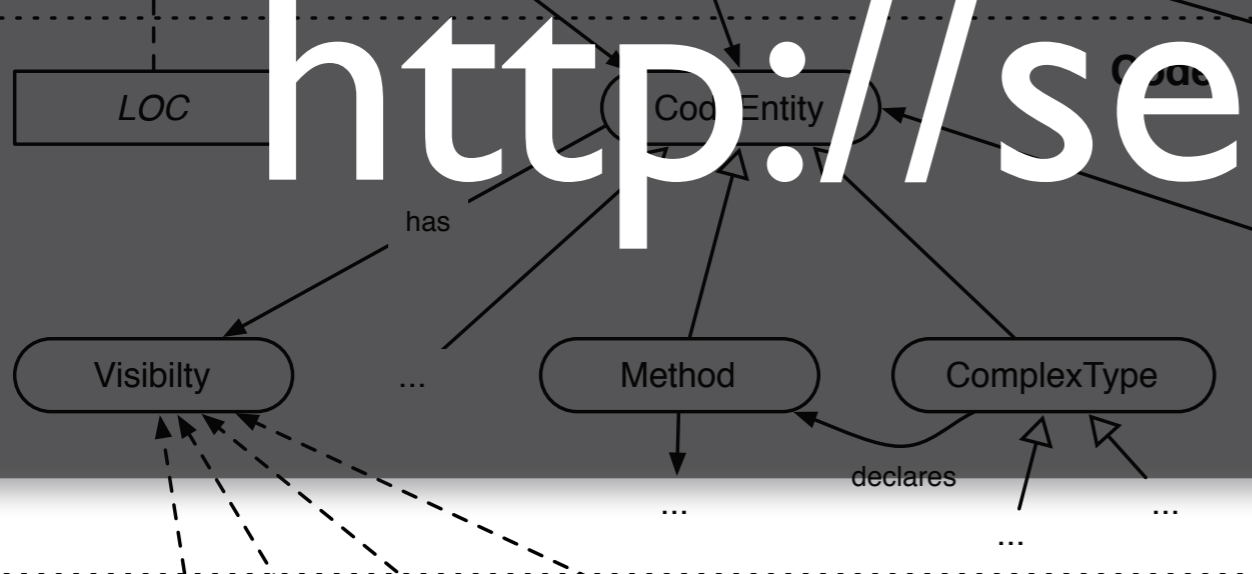
General



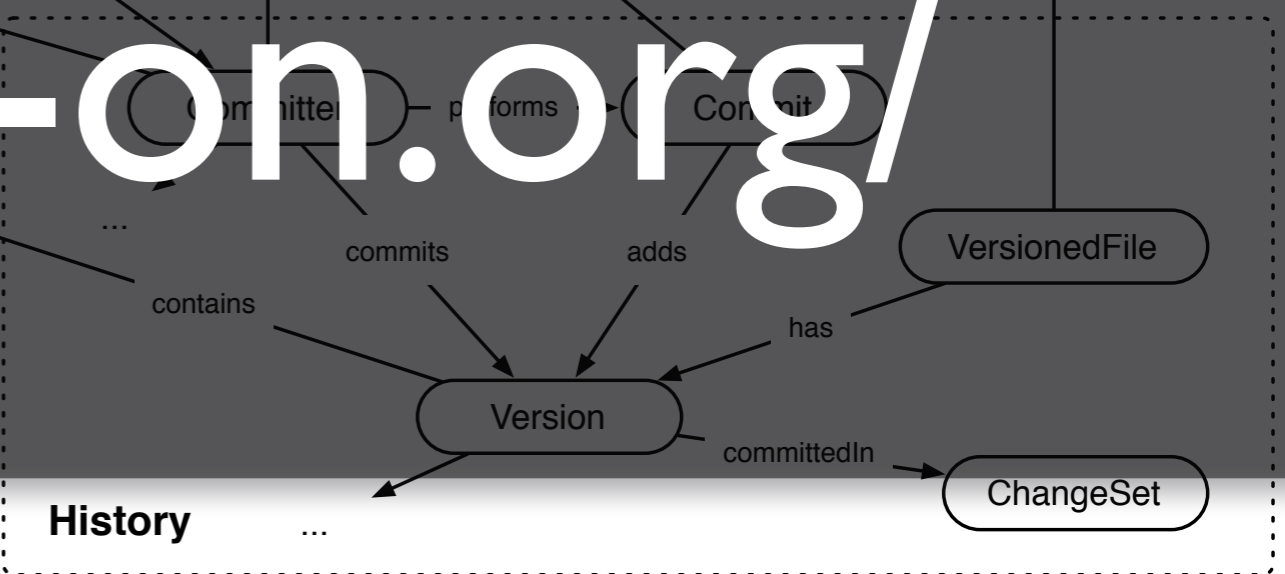
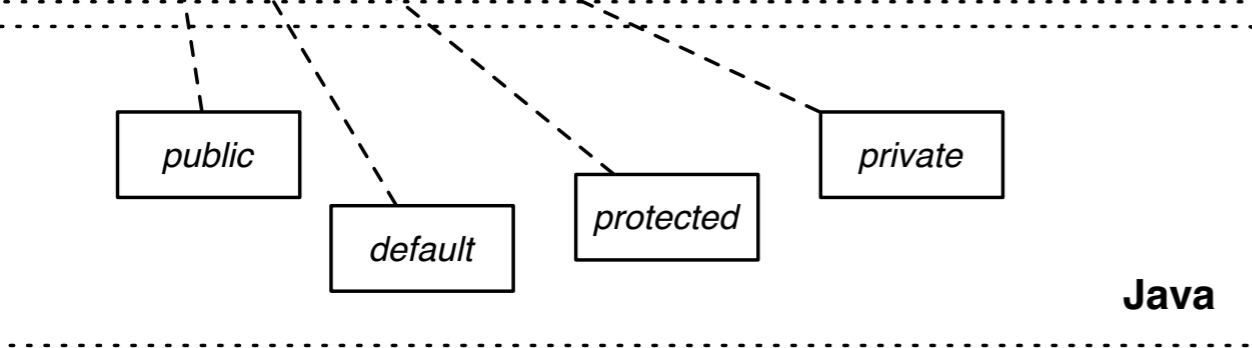
Domain-spanning



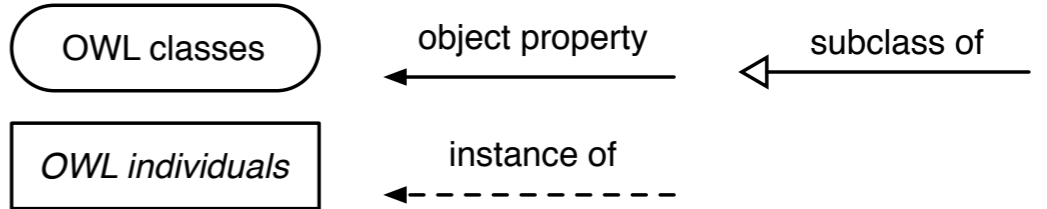
Domain-specific



System-specific



<http://se-on.org/>



Class hierarchy | Class hierarchy (inferred)

### Class hierarchy: Method

- Datatype
  - ComplexType
    - AnnotationType
    - ClassType
      - ExceptionType
      - SubClass
      - SuperClass
    - EnumerationType
    - InterfaceType
  - PrimitiveType
- Method

Object property hierarchy | Data property hierarchy

### Object property hierarchy: invokesMethod

- containsVersion
- ▼ ■ dependsOn
  - accessesField
  - catchesException
  - ▶ ■ dependsOnIssue
  - expectsDatatype
  - hasReturnType
  - ▶ ■ hasSuperType
  - instantiatesClass
  - invokesConstructor
  - invokesMethod
  - throwsException

Annotations | Object Property Usage

### Annotations: invokesMethod

Annotations +

**comment** @ X ○

A constructor or method can invoke another method.

### Characteristics: i

- Functional
- Inverse functional
- Transitive
- Symmetric
- Asymmetric
- Reflexive
- Irreflexive

### Description: invokesMethod

Ranges (intersection) +

- Method @ X ○

Equivalent object properties +

Super properties +

- dependsOn @ X ○

Inverse properties +

- methodIsInvokedBy @ X ○

Disjoint properties +

Property chains +

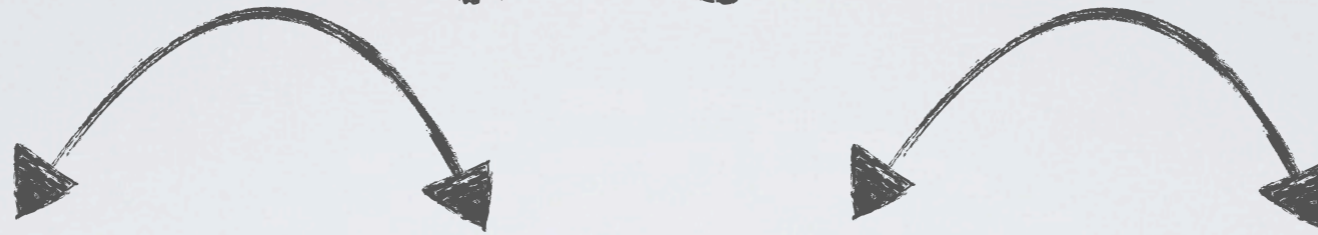
W3C<sup>®</sup>



**Semantic  
Web**



integrate



Code



Bugs



History



Eclipse JDT API

Eclipse Team API

Atlassian JRJC



Change  
Distiller



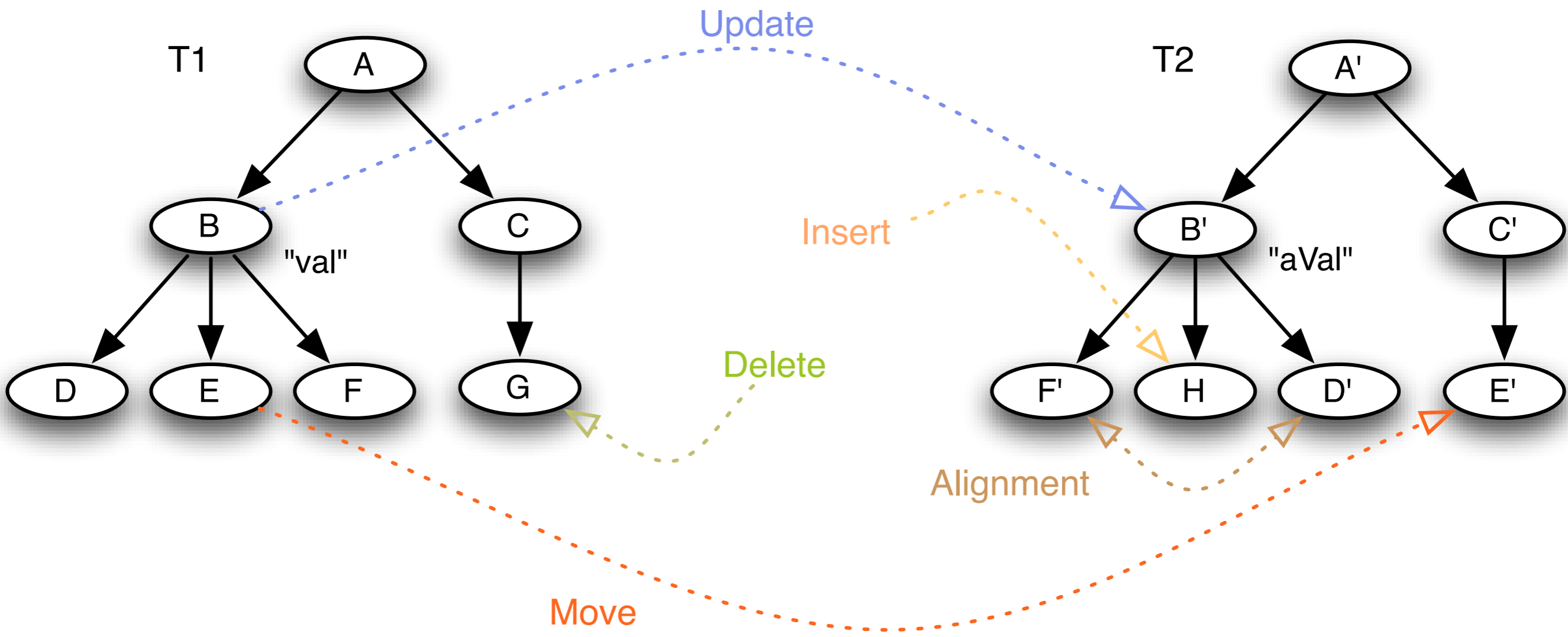
```
Revision: 1068578
Author: maartenc
Message:
ivy:retrieve can now create a
path or fileset containing
the artifacts (IVY-1235)
```

R-I-Linker



Apache Jena TDB

Pellet Reasoner



## E.g., "what methods call (method) m?"  
## "what classes are in (package) p?"

<Q> ::= What <S> <P> <O> ? | SELECT ...

<S> ::= ... Ont Classes (e.g., "Methods")

<P> ::= ... Ont Properties (e.g., "call")

<O> ::= ... Ont Individuals (e.g., "substring()")

```
PREFIX hawkshaw:
    <http://se-on.org/ontologies/hawkshaw/2012/02/code.owl#>
```

```
PREFIX rdfs:
    <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
```

```
SELECT
    ?result
WHERE {
    ?result <hawkshaw:invokesMethod> <java.lang/String/substring%28int%2Bint%29> .
    ?result <rdfs:type> <hawkshaw:Method> .
}
```



# EVALUATION

- ✓ Comparison with other research tools
- ✦ User study
  - 16 software evolution questions
  - Eclipse vs. Hawkshaw

# CONCLUSIONS

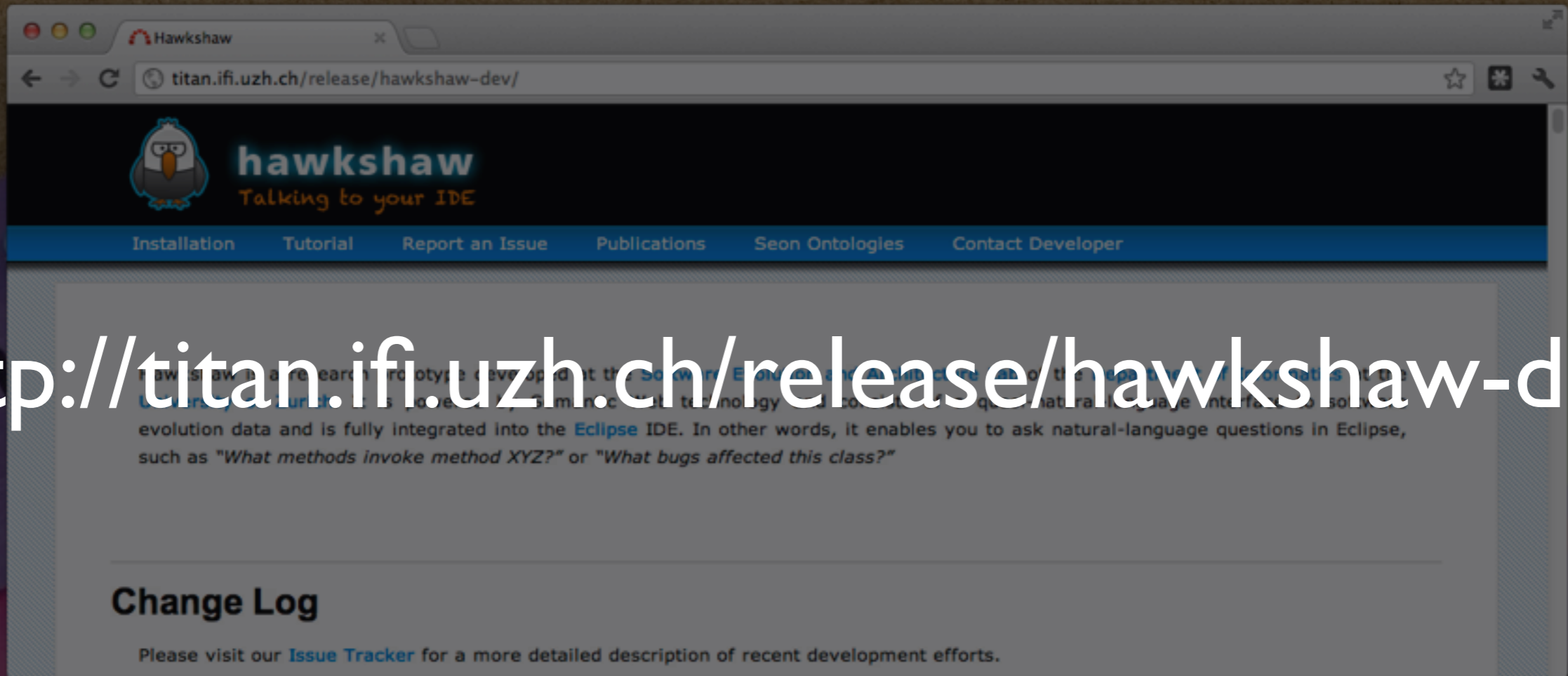
Single point of access for information needs in IDEs

Natural language queries vs complicated UIs

Semantic Web technology is gaining ground very quickly!



<http://titan.ifi.uzh.ch/release/hawkshaw-dev/>



<http://se-on.org/>

