Sonargraph User Manual

Version 9.7.0

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Chapter 1. Sonargraph's Next Generation - Sonargraph 9

Sonargraph 9 is built upon the experiences that hello2morrow gained during the development and support of the existing products *Sonargraph 7*, *SotoGraph* and *SotoArc*. Sonargraph 7 offers two product lines: Architect and Quality - both supporting Java. Both allow to explore and monitor technical quality aspects of software systems.

Sonargraph Quality adds to Sonargraph Architect history features (database approach) and analysis extensibility by user defined queries and metrics. Sonargraph Architect is more lightweight and integrates smoothly with a lot of different IDE's, build and quality infrastructures (e.g. Eclipse, IntelliJ, Sonar, Jenkins, Ant, Maven, ...).

SotoArc and SotoGraph are different product lines supporting C/C++ and C#. These product lines have a completely different user interface and approach to explore and monitor software systems than Sonargraph 7.

Product Family

Sonargraph consists of several products that help to ensure quality throughout the software development as shown in the following image:

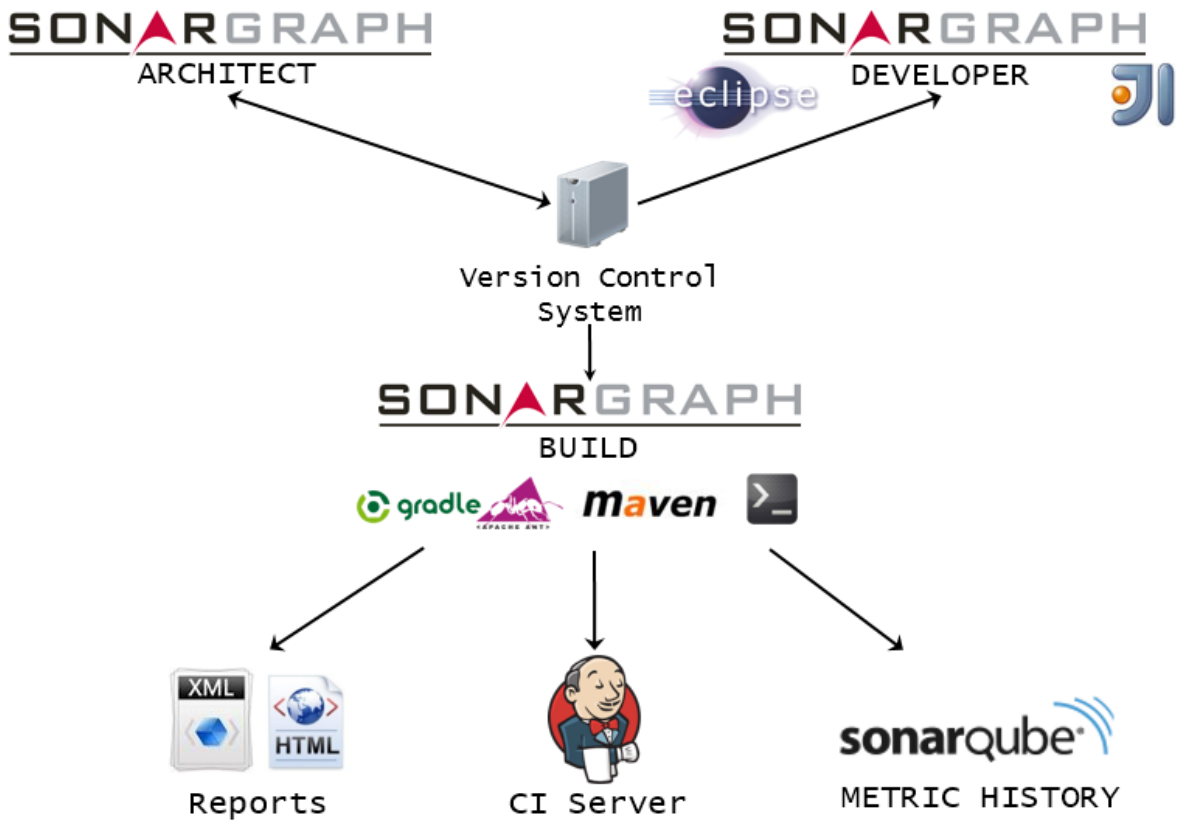


Figure 1.1. Sonargraph Products

- Sonargraph Architect allows code exploration and definition of rules, i.e. architecture, metrics, anti-patterns, thresholds, tasks, refactorings.
- Sonargraph Developer are integrations into IDEs that provide early feedback to developers. With an Developer license it is also possible to start the Sonargraph Architect application and use its advanced visualization and exploration possibilities.
- Sonargraph Build are integrations for various environments to run the quality checks on the continuous integration server.
- Further plugins exist that allow the integration of Sonargraph into SonarQube and Jenkins.

We host an Open Source project on GitHub that provides easy access to all information contained in a Sonargraph XML report and can be used for custom post-processing: *https://github.com/sonargraph/sonargraph-integration-access*

The Benefits of Sonargraph 9

Single Lightweight Platform and a Coherent Product Stack

All product lines will be replaced by one platform for statically analyzing software systems. The platform will combine the most critical features of the different existing product lines while offering one look and feel with a modern user interface and integration with all commonly used tools and platforms as before.

The most basic product will be the *Sonargraph Explorer*, offering all needed exploration and navigation features and metrics to enable the user to analyze a software system fast and thoroughly.

Sonargraph Architect will add to this a flexible way to define different architecture aspects and validate them on the fly. On top of that, products for adding history/comparison support to monitor multiple systems at once are to come.

Multiple Language Support

Sonargraph 8 supports different languages depending only on the license without the need to have different installations. There is a unified approach (i.e. one user interface) to explore and monitor systems implemented in different languages. Systems have a module structure where each module can have a different language.

Inter-module dependencies with different languages are detected where possible (e.g. by analyzing JNI calls). A generic component approach is used for all supported languages - currently Java, C#, C/C++.

Greater Parser Model Detail, Less Memory Consumption and Virtual Models

Nesting of programming elements is correctly reflected in the model. Dependencies are tracked down to method and field level offering more detailed exploration. *Sonargraph 8* has little memory consumption, as only the model coming from the different parsers is held in memory and all ‘derived’ structural elements (e.g. a layer) and their dependencies are calculated on demand. You can create multiple so-called *virtual models*. A *virtual model* is a space where the model from the parser(s) can be modified by refactorings and detected issues can be transformed into tasks or ignored. This allows the simulation of different approaches to change a given structure with different issue resolutions.

Snapshots

The complete model of a system is stored in a compact binary format. This enables fast startup times (the last snapshot is used if available) without having to perform a full re-parse. Furthermore complete systems might be compared and historically analyzed - even passed around to enable reviews based on them - by directly loading the snapshot.

Analyzers taking advantage of Multi-Processor Hardware

Analyzers calculate metrics and analyze dependency structures (e.g. cycles) and content of source files (e.g. duplicated code). These analyzers run in parallel in a multi-threaded environment providing more speed while not blocking user interaction. Once an analyzer has finished, it`s results are available to the user.

Extendable Analysis via Groovy Scripts

The user can extend the platforms functionality by writing Groovy scripts accessing the model created by *Sonargraph 9* . These scripts can either simply act as custom queries finding artifacts with specific characteristics and/or to create issues pointing to potential problems in the system or create additional metrics.

Architecture DSL

Sonargraph 9 uses a DSL (domain specific language) approach to describe the architecture. A system's architecture can consist of multiple architecture aspects which are checked in parallel.

Flexible Exploration of Dependency Structures

You are free to decide how to explore dependencies. *Sonargraph 9* offers a tree-like explorer, a graph viewer and a simple table based viewer.

Automated Updates and Flexible User Interface

Automated updates and a flexible user interface (layout and customization) are provided as *Sonargraph 9* is built upon the Eclipse Rich Client Platform (RCP). Sonargraph Build plugins for Maven and Gradle can also be configured to update automatically.

Exchangeable Quality Artifacts

The software system analysis comes with a multiple file approach. The software system is comprised of a main software system file, analyzer configurations, user defined scripts, different architecture aspects and so forth. The approach makes it easy to share valuable aspects of the analysis between software systems as well as to centralize common aspects in bigger companies.

Chapter 2. Licensing

When you start *Sonargraph* you will be asked for an activation code or a license file. For additional licensing and pricing information please contact <sales@hello2morrow.com> or <support@hello2morrow.com> and check our *web site* .

2.1. Getting an Activation Code or a License

When you have purchased a *Sonargraph* license, an activation code or a license file will be delivered to you.

There might be a program for free *Sonargraph* licenses which are time-limited and/or size-limited. Please register on our website and check the available programs.

In order to replace a valid license by a new one, choose "Help" → "Manage License..." from the user menu in the GUI-based product. *Sonargraph* licenses are bound to a named user. The usage by a different user is a violation of the license agreement.

2.2. Activation Code Based Licensing

Activation code based licensing activates *Sonargraph* licenses via Internet or a local license server by requesting a so-called ticket. Every activation code is customer specific and represents a pool of *Sonargraph* user licenses as purchased and licensed to the specific customer. Activation code based licensing technically requires that *Sonargraph* has Internet access or that a local license server is reachable. There are two types of activation code based licenses available:

1. Flexible User License (if you bought Sonargraph before version 9.0 you have flexible user licenses)

2. Floating License (new with Sonargraph 9.0)

Flexible user licenses support a feature that allows customer-driven transfer of a *Sonargraph* user license to another user after some amount of time. This works like this:

- When an activation code based license is requested, *Sonargraph* automatically requests a license ticket from the hello2morrow license server. This ticket expires after some time, for example after 30 days. During these 30 days, the use of the *Sonargraph* installation that requested the ticket is licensed (by the user who ran *Sonargraph* when the license ticket was requested). *Sonargraph* can be used during this period without any access to the Internet.

- After the ticket of a *Sonargraph* installation has expired (in our example scenario, this happens on the 31st day after the ticket has been requested), one of two things typically happen:

  1. The same *Sonargraph* installation is started again. *Sonargraph* then notices that the license ticket has expired and lets the user know about it by presenting a dialog to manually request a new ticket from the hello2morrow license server, for the same activation code or a different one if desired. The new ticket again is valid for the same time period. You can toggle the feature at ' Help → Renew License Ticket Automatically ' to have *Sonargraph* silently perform license ticket requests using the current activation code, without further user interaction.

  2. Alternatively, the user of the installation might not continue to work with *Sonargraph*; then the license is now, after the expiration of the ticket in the *Sonargraph* installation, available to some other user. The hello2morrow license server will supply a license ticket to the next user that requests one for the given activation code.

Note that the number of license tickets that can be supplied by the license server for some activation code might be more than one. For example, a company might license *Sonargraph* for 20 users. The same activation code can be used by all of them, but as soon as the 21st license ticket is requested for this activation code, this request will be denied. A new request for a ticket will only be fulfilled after one of the already supplied tickets has expired, so that at any one moment, at most 20 non-expired license tickets exist for the activation code.

It is not required that the same user requests a replacement of an expired license ticket; any user that knows the activation code can request one of the free tickets. This mechanism reduces the effort needed for license management in a changing user group.

However, in order to avoid any misuse we strongly encourage you to restrict the information about your activation code to those persons who are supposed to use *Sonargraph*.

If you have any suspicion about misuse please inform <support@hello2morrow.com> immediately. We can promptly deactivate an activation code so that any further misuse is stopped and provide a new activation code to you.

Floating licenses bind a ticket to an instance of Sonargraph while it is running. As soon as Sonargraph is terminated the license can be used by another user.

Most of our customers are using our Internet based license server, so there is no need for you to operate your own license server as long as the machines running Sonargraph have access to the Internet. If this is not the case or you want to avoid being dependent on the availability of hello2morrow's web-based license server you can request the usage of a local license server by contacting us via <sales@hello2morrow.com> or <support@hello2morrow.com>. Once your request has been approved, you can download hello2morrow's local license server and run it on your premises. If you have a *flexible user license* it is also possible to run Sonargraph with file based licenses.

2.3. Proxy Settings

I you use hello2morrow's Internet servers and Activation code based licensing, you need Internet access. If your network configuration does not allow direct Internet access, but provides access through an HTTP proxy instead, you can specify the host name and port of the proxy server. If the proxy server access is password protected, you can supply a user name and a password in order to authenticate.

For the GUI-based product, the proxy settings can be changed via "Preferences…" → "Proxy Settings" .

Check the user manual of SonargraphBuild for proxy configuration options of the build server integrations.

2.4. License Server Settings

I you use your own license server you need to configure the access to it. You must specify the host name and port of the license server.

For the GUI-based product, the proxy settings can be changed via "Preferences…" → "License Server Settings" .

Chapter 3. Getting Started

This chapter summarizes what is needed for *Sonargraph* to run, how the update mechanism works and the necessary configuration before you can start creating *software systems* .

Related topics:

- Chapter 2, *Licensing*
- Appendix B, *Tutorial - Java*

3.1. Installation and Updates

Sonargraph is built upon the Eclipse Rich Client Platform (RCP) framework. The following prerequisites must be fulfilled:

- Microsoft™ Windows™ , Mac OS-X or Linux® operating system.
- 2048 MB RAM (Win32: 1400 MB)

If the application freezes on open (splash screen), the environment variable SWT_GTK3 must be set to '0' (export SWT_GTK3=0) before launching.

Sonargraph leverages the advantages of the Eclipse Rich Client Platform update mechanism, thus, it will automatically connect to the hello2morrow update site and check for new versions at startup.

3.2. Help

The documentation for *Sonargraph* (i.e. this document) is also integrated into the product and available via the main menu entry "Help" → "Help Contents..." or by pressing the **Ctrl+F1** shortcut. It also provides a search functionality.

Dynamic / context-sensitive help is available within the application via the shortcut **F1** .

If there is no answer to your question available, contact us via the built-in feedback functionality, which can be found at "Help" → "Send Feedback..." or by sending an email to `<support@hello2morrow.com>` .

3.3. Editor Preferences

For architecture files and scripts you can set editor preferences. In the "Preferences..." menu, you find the possibility to change the editor preferences:

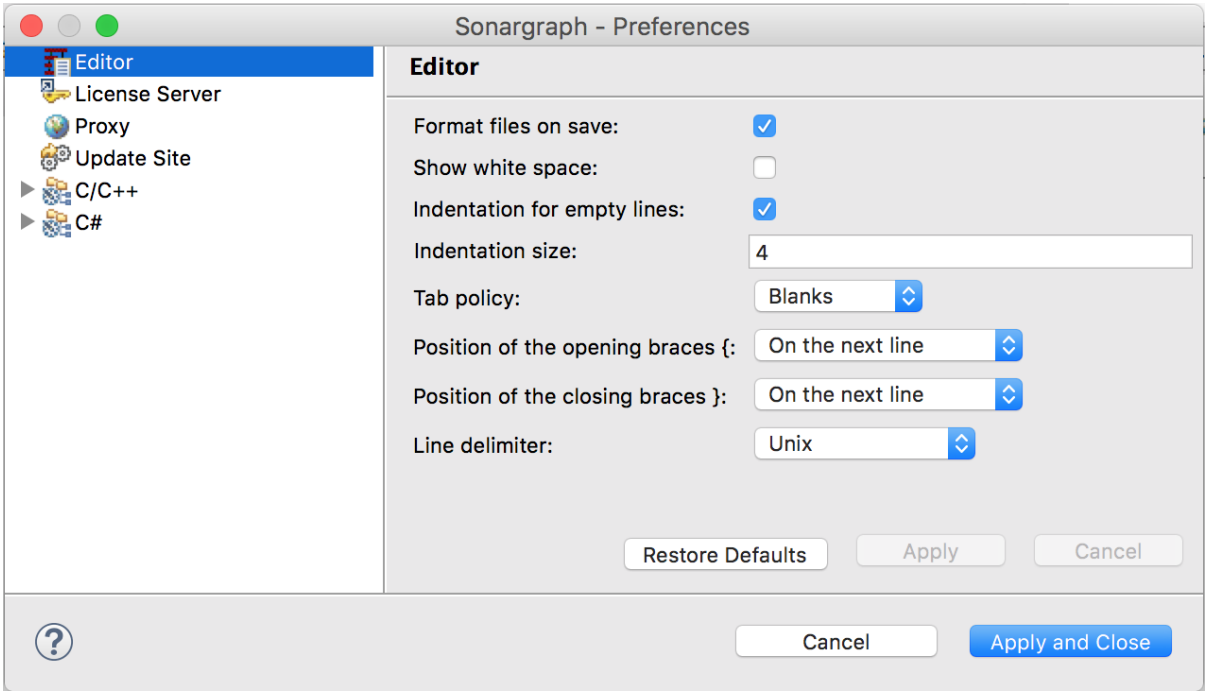


Figure 3.1. Editor Preferences

- **Format files on save** If set architecture and script files are formatted when saved, otherwise not.
- **Show white space** If set white space characters are shown with special characters, otherwise not.
- **Indentation for empty lines** If set empty lines will be automatically indented while being formatted, otherwise empty lines will stay empty.
- **Indentation size** Set the indentation size (only relevant for tab policy "Blanks").
- **Tab policy** Choose between "Blanks" to use blanks for indentation, and "Tabs" to use tabs for indentation.
- **Position of opening braces** Choose between "On the same line" to put opening braces on the same line, and "On the next line" to put opening braces to the next line.
- **Position of closing braces** Choose between "On the same line" to put closing braces on the same line, and "On the next line" to put closing braces to the next line.
- **Line delimiter** Choose between "Windows" which will end lines with CR and LF, and "Unix" which will end lines with a LF.

3.4. License Server Preferences

In the "Preferences..." menu, you find the possibility to change the license server preferences:

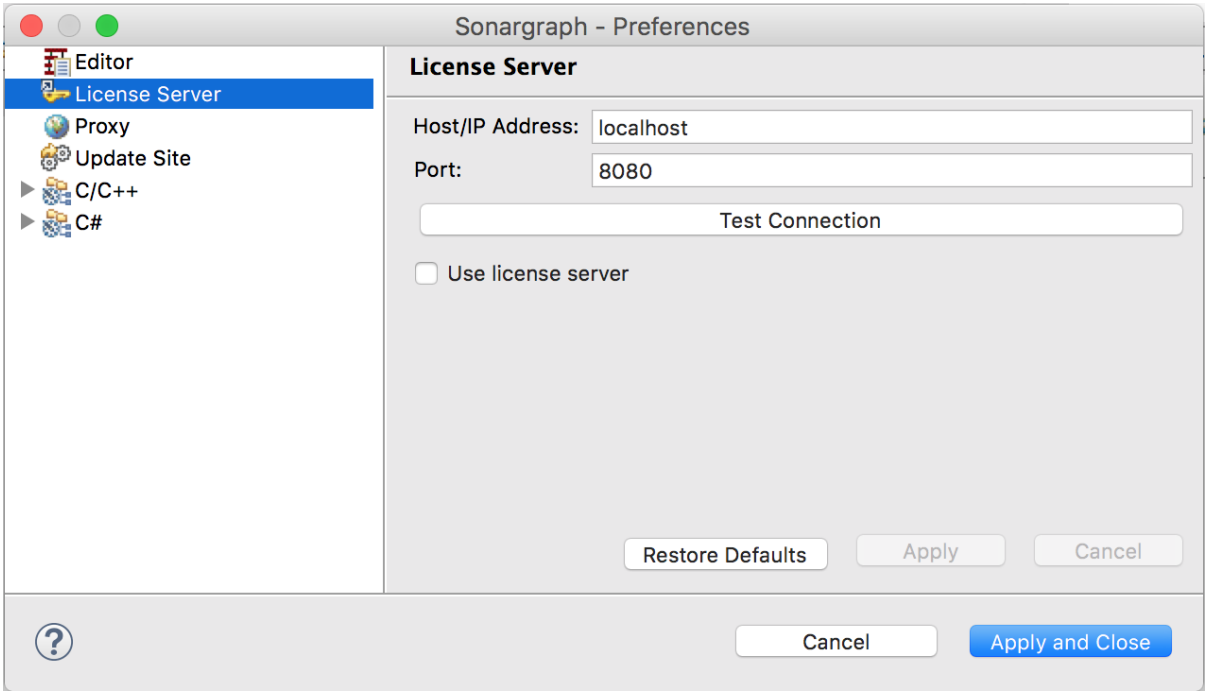


Figure 3.2. License Server Preferences

3.5. Proxy Preferences

In the "Preferences..." menu, you find the possibility to change the proxy preferences:

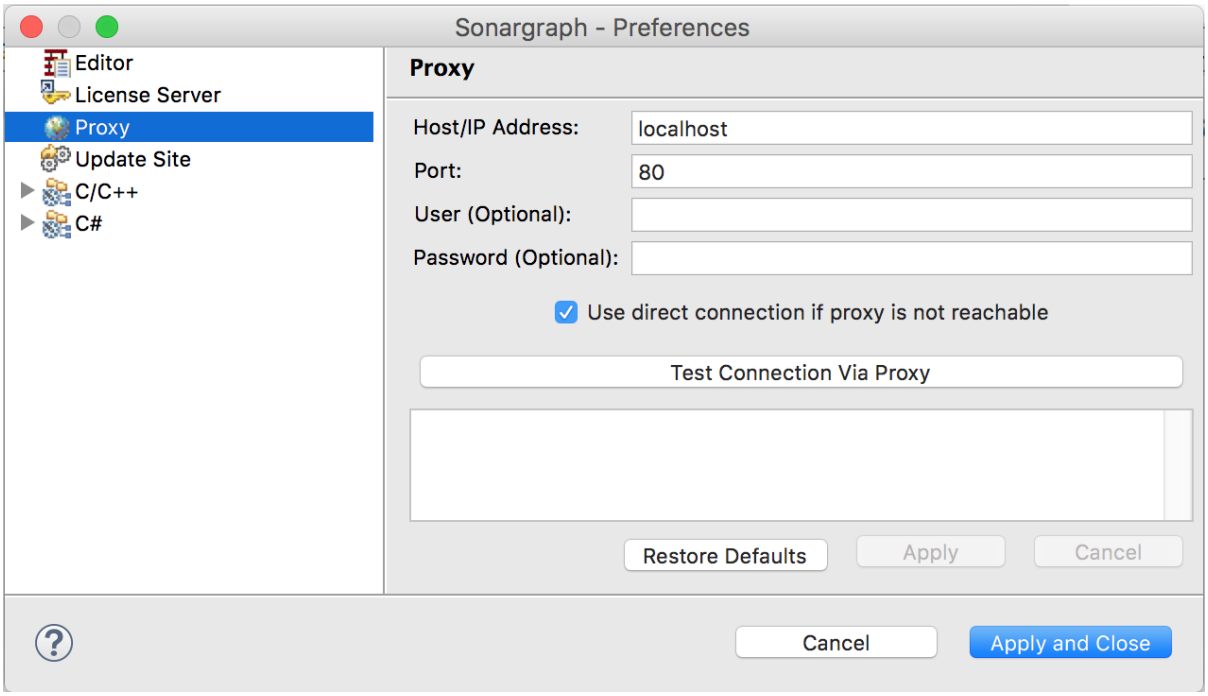


Figure 3.3. Proxy Preferences

3.6. Update Site Preferences

In the "Preferences..." menu, you find the possibility to change the update site preferences:

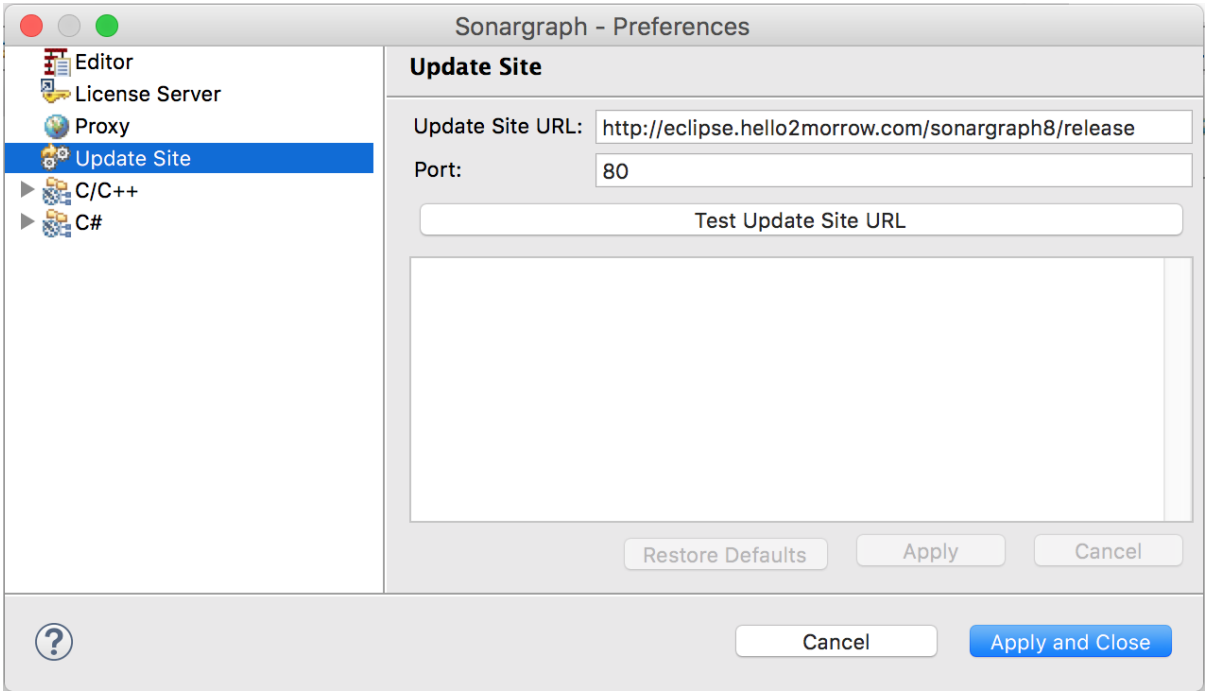


Figure 3.4. Update Site Preferences

- **Update Site URL** Use this update site to check for new releases of Sonargraph Standalone. Change this if you want to operate a local mirror of the official hello2morrow Sonargraph update site.

  Port The port number of the update site.

If a proxy is configured in Section 3.5, “Proxy Preferences” it will be used while connecting to the update site.

3.7. C/C++ Compiler Definitions

Sonargraph uses internally the *Edison Design Group (EDG) C/C++ Front End* to parse C/C++ sources. In order to emulate the behavior of your C/C++ compiler, Sonargraph needs a compiler definition. A compiler definition contains the location of the directories containing the system include files, a list of predefined macros and other options for the EDG parser defining language features and compatibility levels. You will not be able to successfully parse a software system without a proper compiler definition for your compiler. One compiler definition has to be set as the "active" definition, which will be used by default for opened *software systems* containing C/C++ modules.

Sonargraph comes with pre-defined compiler definitions that are activated by default depending on the platform *Sonargraph* is running on:

- "CLang" for Mac OS-X.
- "GnuCpp" for GNU C++ compiler on Unix based systems (Linux, Unix).
- "VisualCpp_x_y_z" for Windows based systems that have Microsoft Visual Studio Compiler installed. (x = version, y=architecture, z=processor, e.g. VisualCpp_12.0_x86_amd64)

In the "Preferences..." menu, you can manage and modify existing compiler definitions or even create new ones based on existing compiler definitions.

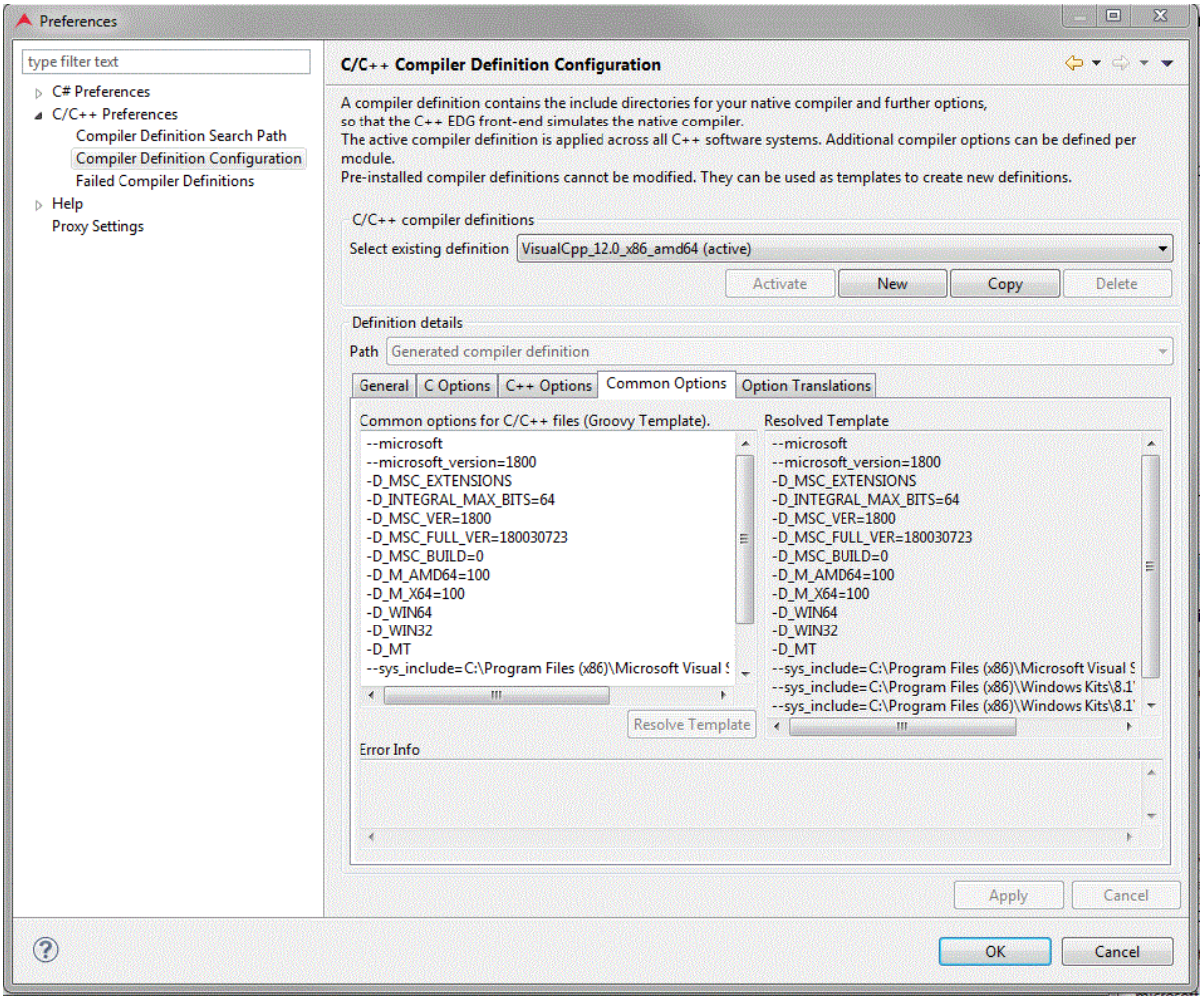


Figure 3.5. C++ Compiler Definition

The translation tab allows to define how options retrieved from imports need to be handled: For C++ modules created based on imports (e.g Makefile or Visual Studio 2010 project files (.vcxproj)), only macro (-D) and include (-I) preprocessor options will be applied. Use the translation functionality if any additional options of the imported project are required for parsing or the EDG parser uses a different value than your standard compiler.

For certain compilers it is possible to dynamically retrieve predefined macros and the include search path. To do that compiler definitions can be based on Groovy templates that invoke the compiler to query those settings. This is of course not possible for all compilers. Therefore we also have created a compiler definition wizard that will collect the information about the compiler to be emulated from you. You can invoke this wizard from the "File" → "New" → "Configuration..." menu. The wizard also supports the import of compiler definitions from Sotograph. (Previous tool from hello2morrow)

NOTE

You need to "activate" a compiler definition to use it for parsing. Just selecting a definition is not enough.

NOTE

Replacing the active compiler definition or modifying its content will force a reparse of the currently loaded *software system* as soon as the compiler definition is activated or the changes are applied.

By default, compiler definitions are stored in the *Sonargraph* home directory. These definitions are not intended to be shared. If you want to share compiler definitions across team members, it is recommended to specify a separate directory in the search path that contains these shared definitions. See section Section 3.9, “Search Path Configuration” .

3.7.1. Failed Generated Compiler Definitions

The preference page of the node "Failed Compiler Definitions" lists all the compiler definitions that could not be created. The re-generation of the compiler definitions can be forced on this page.

The re-generation can also be forced by deleting the folder <application-data>/hello2morrow/Sonargraph/cplusplus/generated and restarting *Sonargraph* .

3.8. C# Configuration

Sonargraph includes the dependencies to external assemblies (DLLs) in its analysis. The paths where the external assemblies are located need to be defined in an "Installation Profile". The preference dialog opened via the menu "Preferences..." , allows the definition of your own profiles. The definition of assembly directories is based on Groovy Templates, allowing for flexible profiles that can be shared between team members.

Sonargraph detects the installed Microsoft .NET frameworks and offers them as installation profiles.

These profiles can be used as templates to generate new profiles. The activated profile is used as default profile for all new *software systems* that contain C# modules.

For some project types you need to specify additional assemblies to be included (e.g. Windows.winmd for XAML projects). This can be done in the lower section of the preference page as shown in the screenshot below:

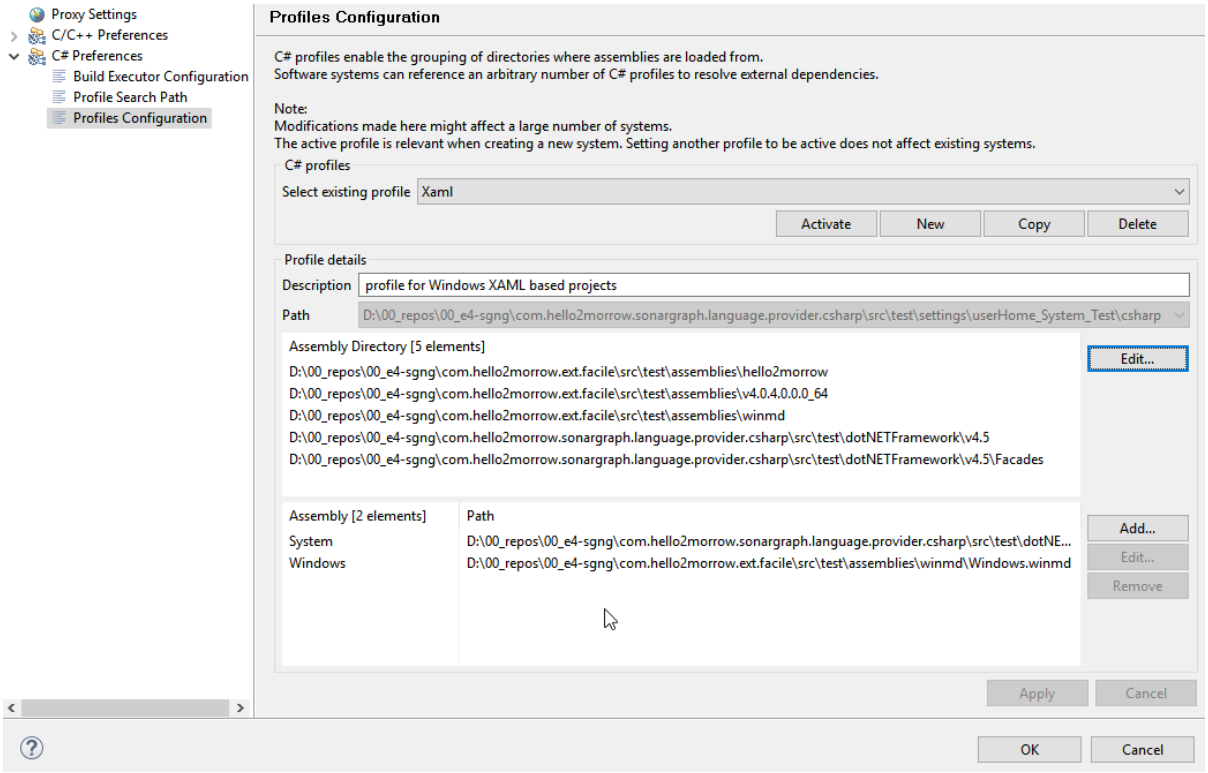


Figure 3.6. C# Profiles Configuration

NOTE

Modifying the content of a profile that is used by the currently opened *software system* will force a full reparse as soon as the profile is activated or the changes are applied.

As default, installation profiles are stored in the *Sonargraph* home directory. These profiles are not intended to be shared. If you want to share installation profiles across team members, it is recommended to specify a separate directory in the search path that contains these shared profiles. See section Section 3.9, “Search Path Configuration” .

3.8.1. C# Build Executor Configuration

Visual Studio project files (.csproj) for C# projects are processed to examine inter-project dependencies, references to external assemblies, relevant source files and pre-processor options to be used. If *Sonargraph* is executed on Windows operating system, the latest C# installation is determined and MSBuild.exe is located. On other operating systems the built-in parser is used per default. If you have xbuild installed (the MSBuild implementation of the Mono platform), define the path to its executable here.

On Windows: For most accurate results, specify the Visual Studio Developer Prompt shell that is used to build the project. This ensures that the same assemblies (DLLs) are loaded that are also used by Visual Studio. *Sonargraph* tries to locate the latest Visual Studio Developer Prompt at startup. If that is not the correct one to be used, the following MSDN page provides additional information: *https://msdn.microsoft.com/en-us/library/ms229859%28v=vs.110%29.aspx* You can right-click on the identified application and open the "save location" where you find the corresponding shortcut file. Right-click again on that file to open the properties and select the "Properties" tab. The executable can be found in the "Target" text field.

NOTE

The built-in parser is sufficient for simple Visual Studio project files. But if advanced features are used, e.g. variables like $(VSInstallDir), user profiles or conditional constructs, you need to use MSBuild or xbuild.

NOTE

A minimum "ToolsVersion" of 4.0 is required. This is fulfilled for Visual Studio 2010 and newer.

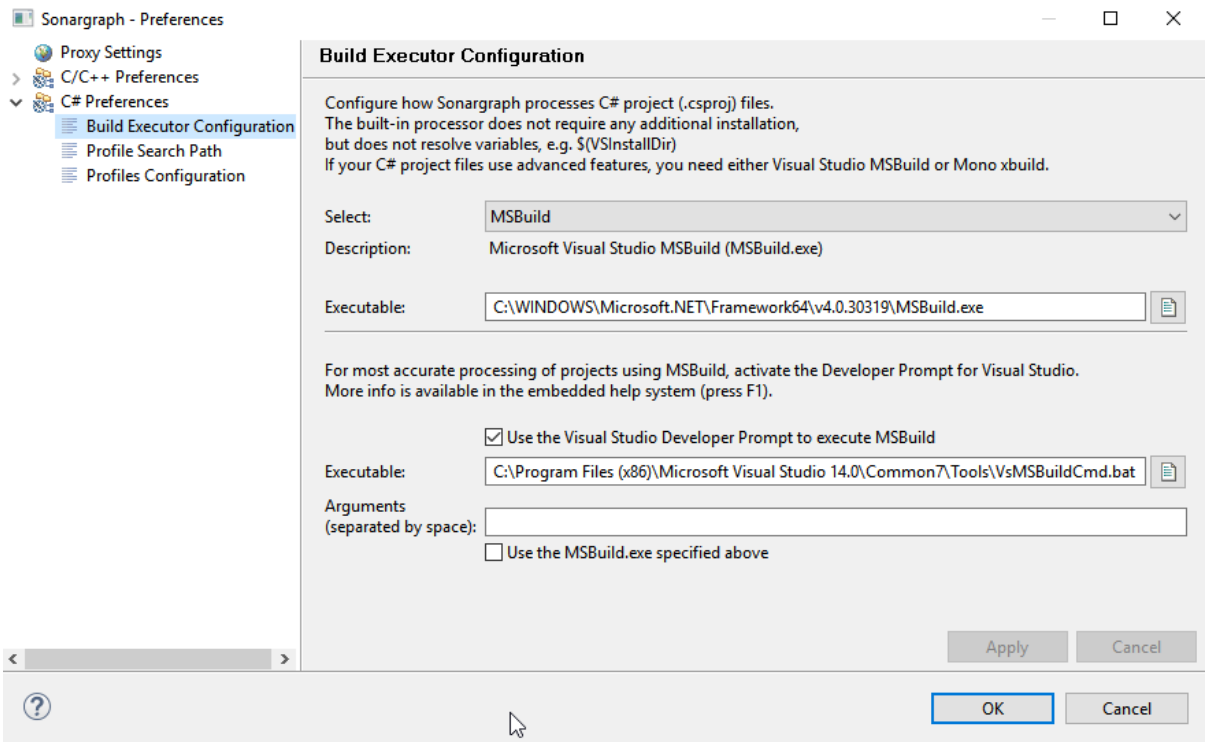


Figure 3.7. C# Build Executor

3.9. Search Path Configuration

Similar to a Java classpath, C++ compiler definitions and C# installation profiles are looked-up using search paths. The search paths contain at least one entry, which is per default located within the *Sonargraph* user-home directory. Further directories can be added to the search path that allow to share configurations between users, i.e. if those directories belong to a network drive. Those directories are searched if the configuration file is not found in the installation-specific directory.

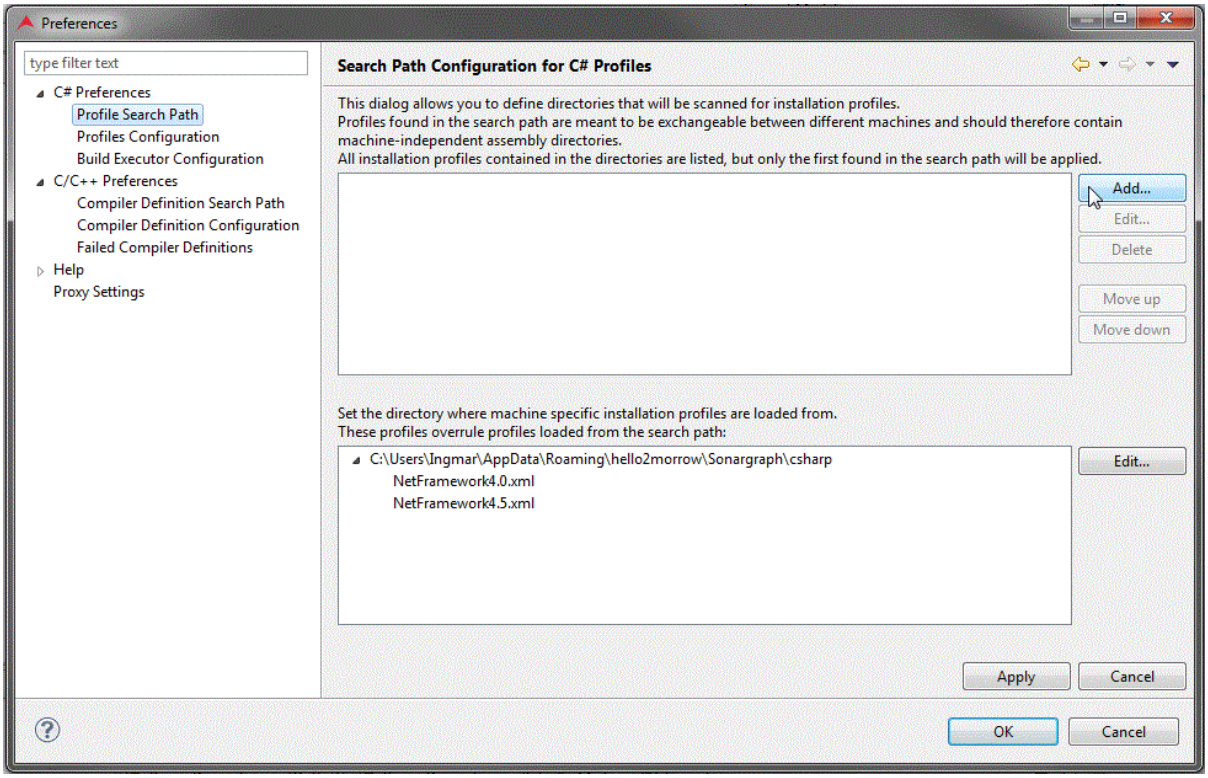


Figure 3.8. Search Path Configuration

Chapter 4. Getting Familiar with the Sonargraph System Model

The *software system* is the scope of analysis in *Sonargraph* . This chapter describes the model used by *Sonargraph* to represent a *software system* based on your code components and elements in order to fulfill different goals regarding the analysis.

4.1. Physical File Structure

The *Sonargraph software system* is physically represented in the file system by a directory <System-name>.sonargraph that contains a file named *system.sonargraph* :

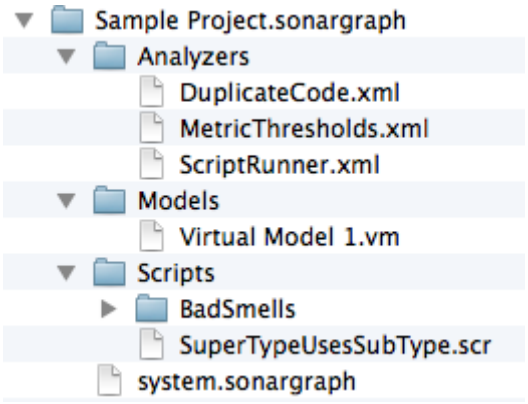


Figure 4.1. Physical File Structure

- system.sonargraph contains all information necessary to parse the code, i.e. the workspace information about modules, directories, etc. See Section 7.7, “ Managing the Workspace ” and Chapter 5, *Creating a System* .
- Analyzers sub-directory contains configuration for code duplication, metric thresholds and which of the Groovy scripts are executed automatically.
- Models sub-directory contains the *virtual model* files, i.e. the information about resolutions (todo, ignore, fix) for detected issues.
- Scripts sub-directory contains the Groovy scripts that allow custom queries.

Analyzer files and scripts are part of the Sonargraph quality model. See Section 5.1, “Quality Model”

4.2. Language Independent Model

The language independent domain model of the system is depicted in the following diagram. Domain models for specific languages are detailed in subsequent sections. Referenced types that cannot be located in the workspace are put under the "External" node. External elements are not part of the metrics calculations.

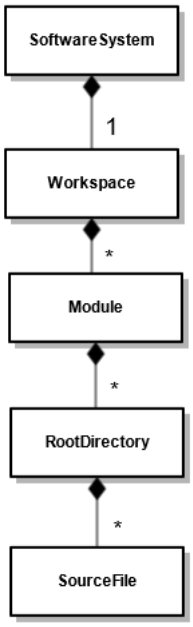


Figure 4.2. System Domain Model

4.3. Language Specific Models

The language specific models are built around the central idea of a *component* as defined by John Lakos in "Large Scale C++ Software Design": “A component is the smallest unit of physical design.”

They represent specializations of the language independent model elements. Those specializations depend, of course, on the elements of the language.

4.3.1. Java Model

Sonargraph parses the Java byte code (i.e. the .class files) for the static analysis. For a basic analysis, it is sufficient to specify the directories where the compiled byte code can be found. For a more advanced analysis like the detection of duplicate code blocks and the direct navigation to references in the source code, the source root directories are required (recommended). If the source file is available for a found type (class, interface, ...) the compilation unit is created underneath the corresponding source root directory. If no source can be found the compilation unit is created under the corresponding directory where the byte code was found. The following diagram shows the domain model for Java.

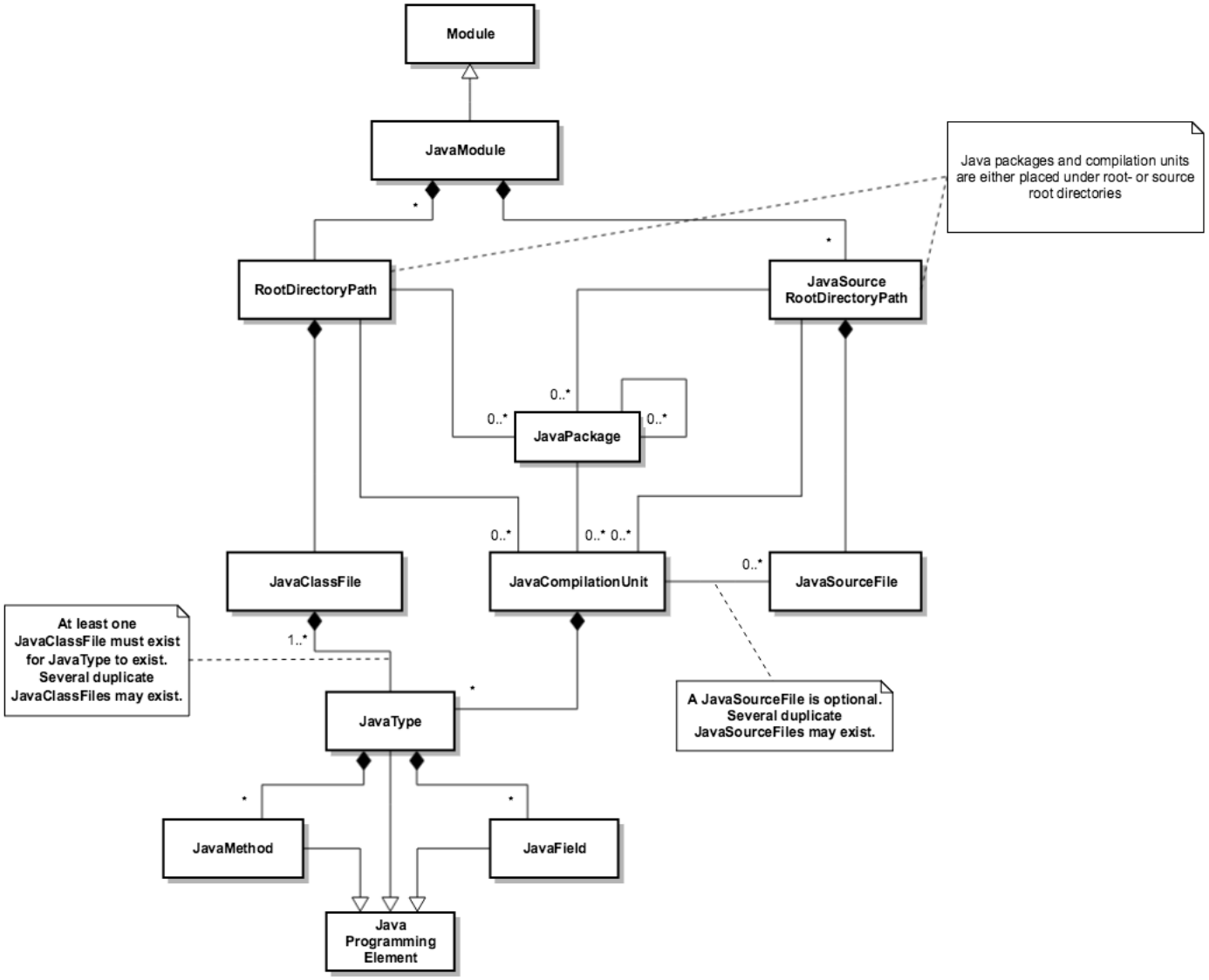


Figure 4.3. Java Domain Model

For inner classes and anonymous inner classes the correct nesting of Java compilation units is applied to types and methods respectively. This is not shown in the diagram for simplicity reasons.

All classes found in the byte code of the specified workspace are part of the system. Classes that are referenced by these classes but cannot be found in the given root directories are not part of the workspace and appear in the "External" node.

4.3.2. C++ Model

Sonargraph uses the Edison Design Group (EDG) C++ Front End for parsing C/C++ code. The EDG parser must be configured appropriately in order to simulate your native C++ compiler. The basic domain model for C++ is shown in the figure below.

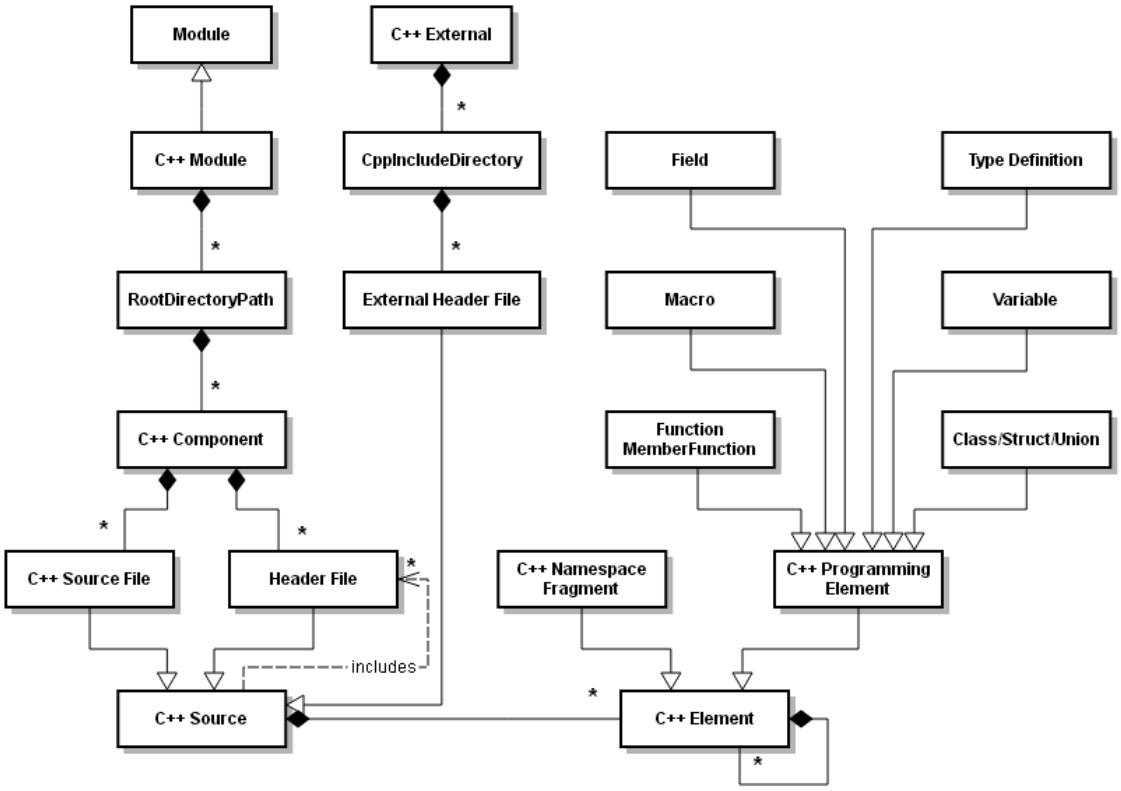


Figure 4.4. C++ Domain Model

An important difference to the model of other languages is the fact that C and C++ are using header files to declare items and source files to implement them. Associated header and source files form a logical unit that is called a component in Sonargraph. In other languages like Java components are always represented by single source files. Sonargraph is able to determine the components automatically by looking for declares relationships. If a function is declared in header "function.h"and implemented in a source file "function.cpp" Sonargraph will automatically combine the two into a component called "function". The component is anchored in the directory of the source file.

It is possible for a component to have more than one header file, if the elements implemented in a source file are declared in more than one header file. It is also possible for a component to have more than one source file, if the elements declared in a header file are implemented in more than one source file. It is nevertheless good practice to avoid those situations.

Sometimes it can happen that the automatic creation of components creates overly large components containing unrelated header and source files. That is usually caused by cross declaration, e.g. a global variable is declared in several unrelated header files. If you come over a component that contains unrelated source files you can always analyze the situation by opening the "Component Construction View". To open this view right click on a component in the navigation view and select this view from the context menu. The view will show a graphical representation of all the declares relationships within a component. Using that view it should be easy to find the rogue declarations that cause unrelated files to end up in a single component. You fix the problem by removing the rogue declarations from their header files. Instead you should include the correct header file before using the declared entity.

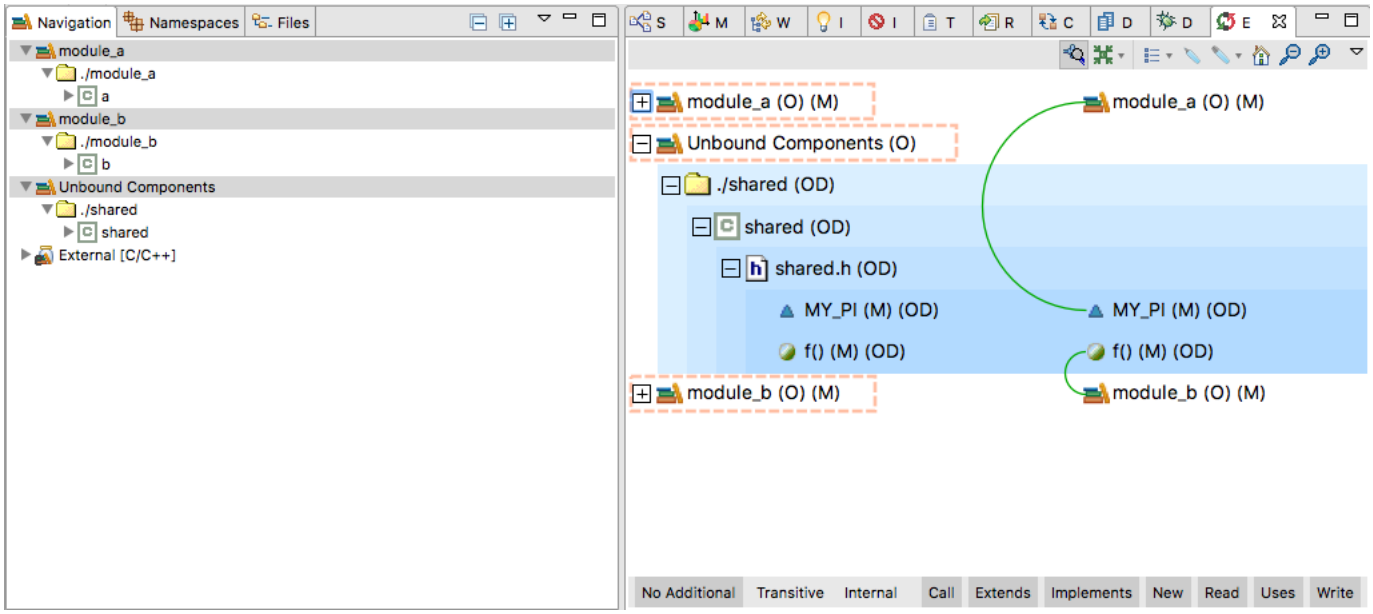
Sonargraph will attach a warning issue to components that contain more than one header file so that you can easily find components that might be containing unrelated source files. If after inspection you come to the conclusion that the source files in a component are properly related you can ignore the corresponding issue in the issues view (by right clicking on the issue and selecting "Ignore" from the context menu). Ignoring the issue will hide it from the issues view and also will suppress the warning marker that was attached to the component.

Sometimes it is also possible that a component only contains a single header file, e.g. when a class has only inline members. In that case there are situations when it will be impossible for Sonargraph to determine where to anchor such components. To solve

this problem Sonargraph will create an artificial module called "Unbound Components" and anchor the component there. The user can then right click on such components and select "Assign to module..." from the context menu. After saving the current system state that decision will be persisted. As soon as the last unbound component has been assigned to a module the artificial module will disappear.

If you imported your project from a Visual Studio solution file that problem will never occur, since Visual Studio project files explicitly assign each header file to a project.

In the example below for example the component "shared" could belong to "module_a" or to "module_b". Only the user is able to resolve that.



4.3.3. C# Model

Sonargraph parses the C# source files and relies on the existence of all referenced assemblies. Sonargraph offers C# profiles to specify the directories where assemblies are located. Types found in these referenced assemblies are put under the "External" node.

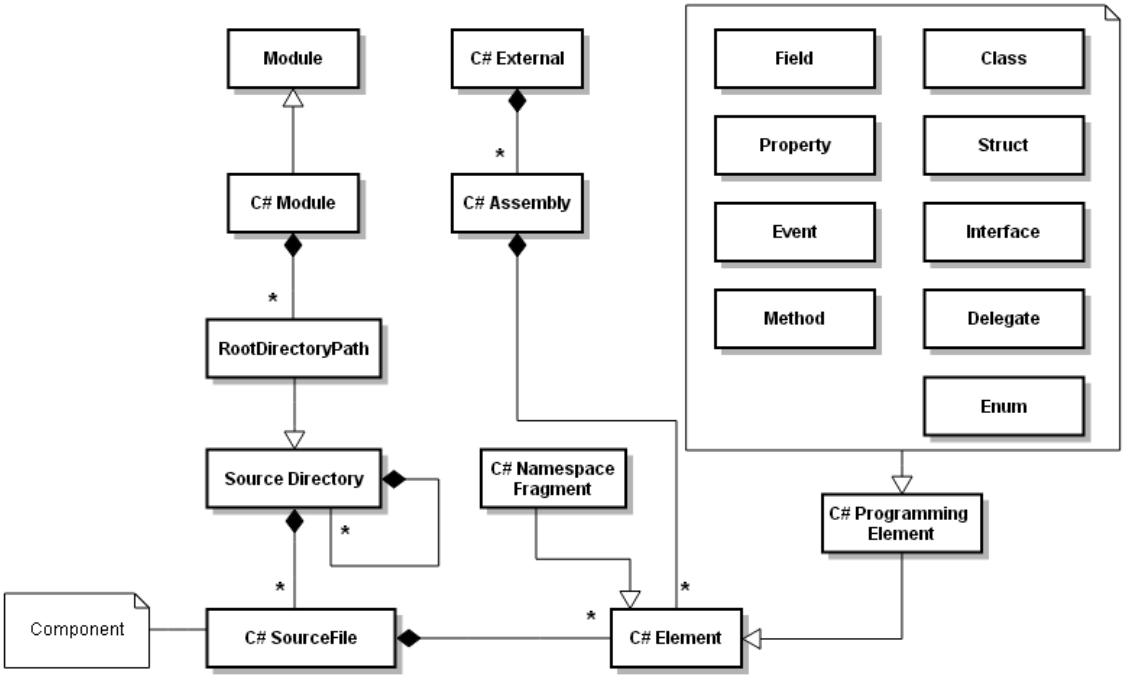


Figure 4.5. C# Domain Model

4.4. Logical Models

Besides the model that comes from each language-specific parsing process, *Sonargraph* offers two more models that contain system-based and module-based logical elements which are calculated based on the physical model. These elements are basically *logical namespaces* and logical programming elements and their calculation is explained with more detail below.

Logical Namespaces

To better understand the concept of Logical Namespaces, it is necessary first to take a look at a couple of examples of physical namespaces:

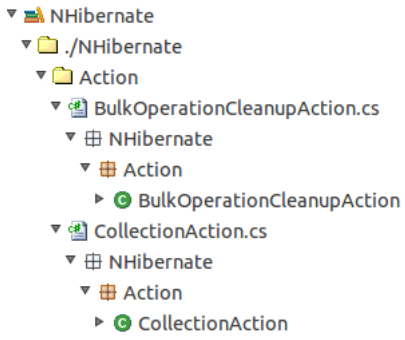


Figure 4.6. Physical Namespaces

In the image, two source files are displayed, BulkOperationCleanupAction.cs and CollectionAction.cs. The C# parser detects that below each one of them we have the namespace NHibernate.Action; on the physical level they are both independent and have no relation. On the logical level on the other hand, the content will look like this:

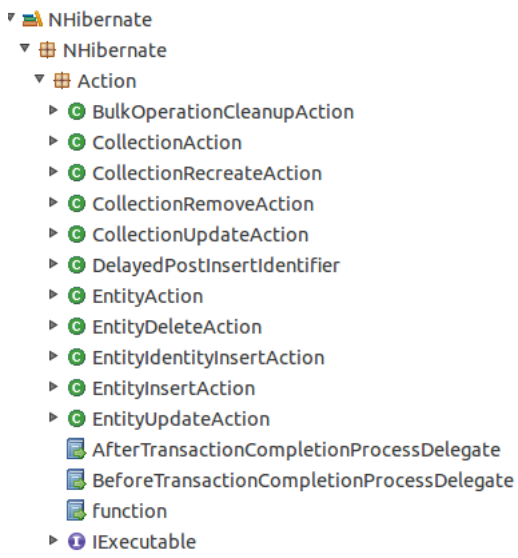


Figure 4.7. Logical Namespaces

As it can be infered from the images, *Sonargraph* maps all physical namespaces that have the same name into a single *logical namespace*. This mapping can be system-based or module-based, see Section 4.4.1, “System-Based Logical Model” and Section 4.4.2, “Module-Based Logical Model” for more information.

Logical Programming Elements

Logical Programming Elements construction from Programming Elements is not as simple as *logical namespaces* construction and it is language-specific.

- Java: Logical Programming Elements are mapped 1 on 1 to Programming Elements.
- C/C++: When programming C or C++, there are declarations/definitions for Programming Elements such as classes, structs, unions, routines, variables and namespaces. In this case, the declaration(s) and definition(s) are mapped into a single Logical Programming Element. All other Programming Elements that do not follow the declaration/definition approach will be mapped 1 on 1 to Logical Programming Elements.
- C#: Logical Programming Elements are mapped 1 on 1 to Programming Elements except for partial tyes; in their case, all partial types that contribute to the same definition are mapped into a single Logical Programming Element.

The construction of Logical Programming Elements can be system-based or module-based, see Section 4.4.1, “System-Based Logical Model” and Section 4.4.2, “Module-Based Logical Model” for more information.

4.4.1. System-Based Logical Model

After parsing the source files from any language, *Sonargraph* creates a system-based logical model based on the parser model which correspond to following diagram:

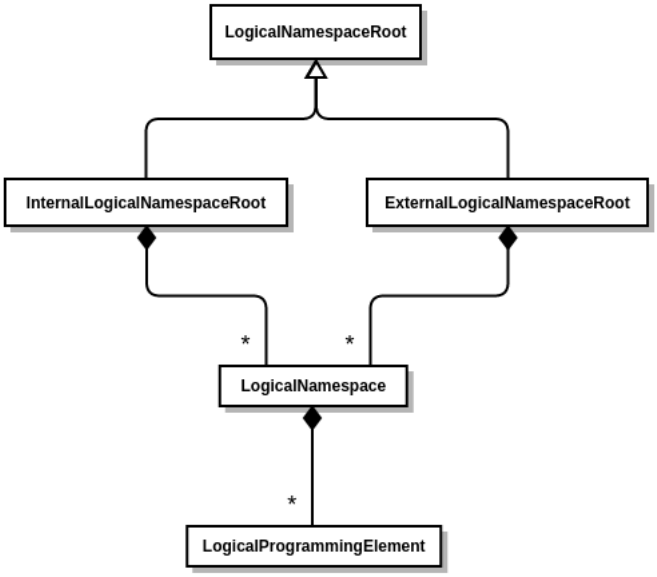


Figure 4.8. System-Based Logical Model

The system-based logical model is constructed in a way that the mapping from physical elements to logical elements occurs in the internal and external scopes separatedly meaning that the following conditions will be met:

- Given a physical element "abc" inside a module of the user code and a physical element "abc" inside the external elements, there will be a logical element "abc" belonging to the InternalLogicalNamespaceRoot and another logical element "abc" belonging to the ExternalLogicalNamespaceRoot in the system-based logical model.

- Given a physical element "abc" inside a module X of the user code and a physical element "abc" inside the module Y also in the user code, there will be a single logical element "abc" belonging to the InternalLogicalNamespaceRoot in the system-based logical model.

4.4.2. Module-Based Logical Model

After parsing the source files from any language, *Sonargraph* creates a module-based logical model based on the parser model which correspond to following diagram:

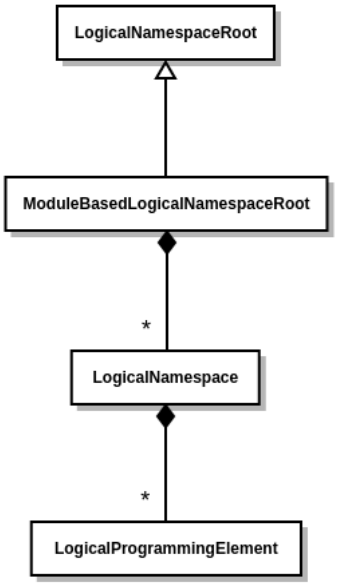


Figure 4.9. Module-based Logical Model

The module-based logical model is constructed in a way that the mapping from physical elements to logical elements occurs inside each module and in the external scope separatedly meaning that the following conditions will be met:

- Given a physical element "abc" inside a module X of the user code and a physical element "abc" inside the module Y also in the user code, there will be a ModuleBasedLogicalNamespaceRoot X containing a Logical Programming Element "abc" and another ModuleBasedLogicalNamespaceRoot containing also a Logical Programming Element "abc".
- Given a physical element "abc" inside a module X of the user code and a physical element "abc" inside the external scope, there will be a ModuleBasedLogicalNamespaceRoot X containing a logical element "abc" and another logical element "abc" belonging to the ExternalLogicalNamespaceRoot in the module-based logical model.

Chapter 5. Creating a System

Basic working units in the *Sonargraph* workspace are called *modules* . A *system* consists of one or several modules representing the *components* that your product is made up of. Each *module* contains one or several root directories pointing out to the source code or the executable artifacts.

At the menu "File" → "New" → "System..." *Sonargraph* provides different wizards to easily create *software systems* . You can either create an empty system and manually add modules to it or use one of the language based wizards.

If you need to have modules from different languages in the same system you can add those of the second language later, regardless of the type of system you have created. See Chapter 6, *Adding Content to a System*

All wizards present an initial page where you can specify the system's name, a short description for it and the local directory where you want to create the system. Optionally, you can use a predefined quality model for the new system. See Section 5.1, “Quality Model”

Sonargraph offers the following system creation wizards:

- **Manual System:** Allows to set-up a new empty system. Individual modules need to be added afterwards. See Chapter 6, *Adding Content to a System*
- **System based on C# Visual Studio Solution file:** Allows to build a system using a Visual Studio Solution file as input to load projects as modules. See Section 6.3.2, “ Importing C# Modules Using a Visual Studio Solution File ”
- **System based on C/C++ CMake JSON command file:** Allows to create a system out of a generated compile command JSON file.

  Name your new system and choose a directory to store it. In the next wizard page you need to choose the location of your JSON command file. To generate such a file you need to run cmake with -DCMAKE_EXPORT_COMPILE_COMMANDS=ON.

  The next wizard page presents the root directories found in the JSON file and allows you to fine tune those directories and sub-directories you want marked as root directories or excluded in the resulting system. You need to mark at least on root directory:

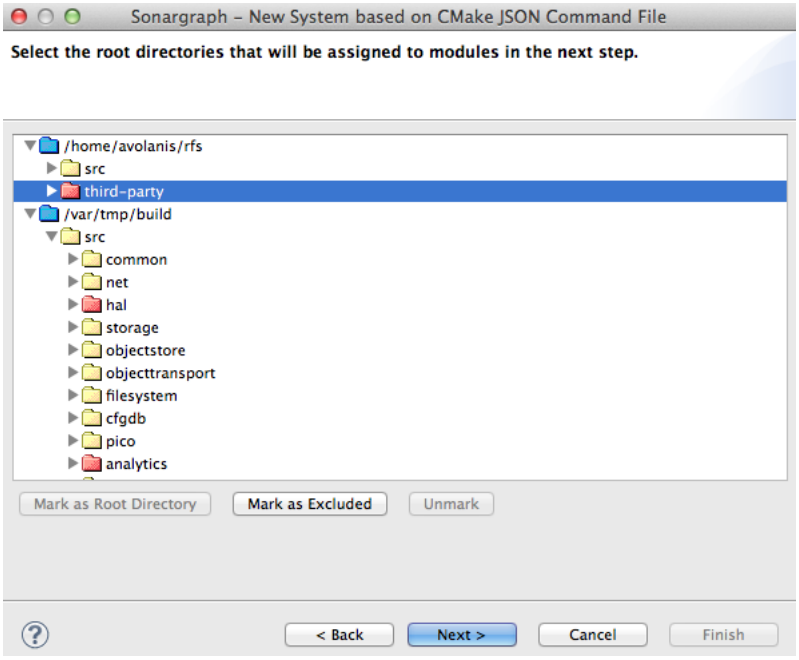


Figure 5.1. Marking root directories from JSON file

The final page of the wizard allows to give a name to each one of the modules that will be created out of the root directories marked in the previous step:

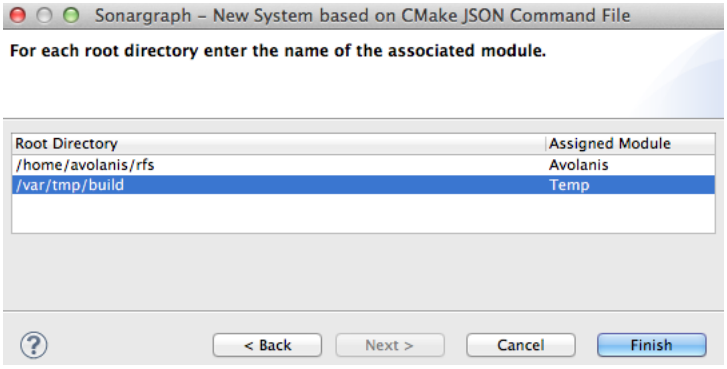


Figure 5.2. Naming modules for root directories from JSON file

- **System based on C/C++ Makefile command capturing files:** Allows to create a system using make generated capturing files. See Section 6.2.2, “ Importing C++ Modules Using Make Command Capturing Files ”
- **System based on C/C++ Visual Studio 2010 Solution file:** See Section 6.2.1, “ Importing C++ Modules from Visual Studio 2010 Files ”
- **System based on Java Eclipse workspace:** See Section 6.1.1, “ Importing Java Modules Using an Eclipse Workspace ”
- **System based on Java IntelliJ project/file:** See Section 6.1.2, “ Importing Java Modules from IntelliJ ”
- **System based on Maven POM file:** See Section 6.1.3, “ Importing Java Modules from Maven POM File ”

Most wizards are similar whether you create a new system or add modules to an existing system.

TIP

Choose a location for the Sonargraph software system close to your source code. This makes it far easier to use the system on other developer machines and build servers, because root directories will be resolved relatively to the system directory.

The software system is comprised of several plain text files and should be version controlled together with your source code, so that code and rules evolve simultaneously and everybody always has the same and up-to-date state.

NOTE

If you plan to use our Eclipse or IntelliJ plugins, place the Sonargraph system in a directory that is not part of your Eclipse workspace or IntelliJ project setup. Otherwise executing Sonargraph refactorings might easily corrupt the system's information, if the Sonargraph files are not excluded from modifications during refactoring execution.

5.1. Quality Model

Sonargraph defines a "Quality Model" as a group of settings and files aimed to help you getting started with your code analysis.

The components of the quality model are displayed in the Files view. See Section 7.6, “ Managing the System Files ”

When creating a new system you can optionally use one the pre-defined quality models that ship with *Sonargraph* . The default quality model suggested depends on the type of system you want to create: If you are creating a system manually, you get the Core quality model suggested, which contains language-independent settings and scripts. If you are creating a new software system using one of the language-based wizards, you will get a quality model customized to the corresponding programming language.

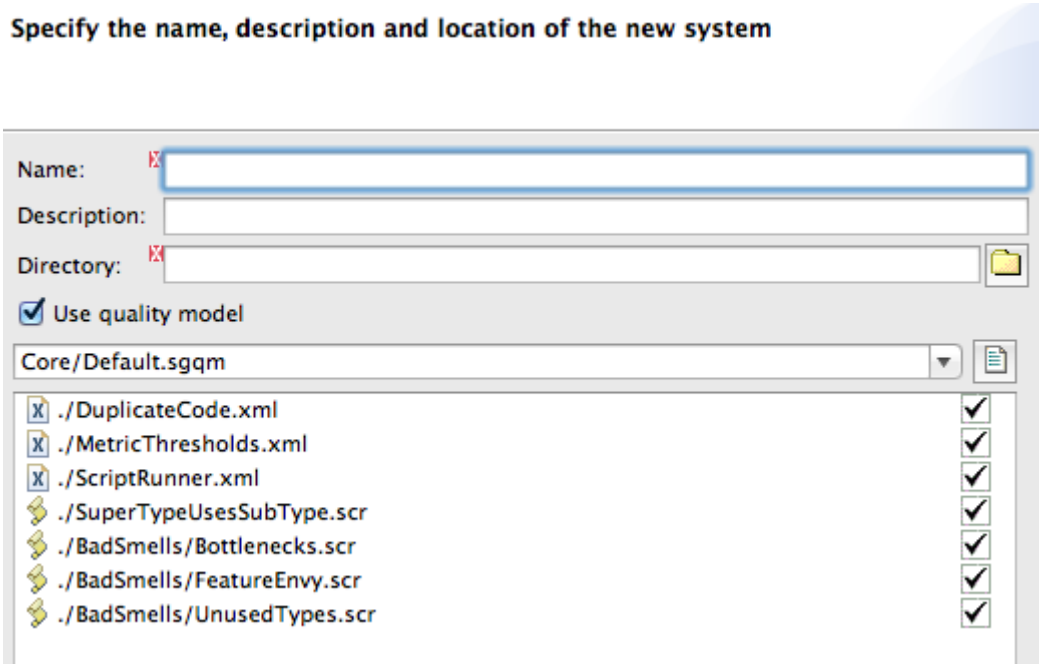


Figure 5.3. New System with Quality Model

You can include or exclude quality model elements as you see fit for each project.

5.1.1. Importing a Quality Model

You can import an external quality model file, generated with a different installation of *Sonargraph* into the current *software system* via the menu "File" → "Import Quality Model" .

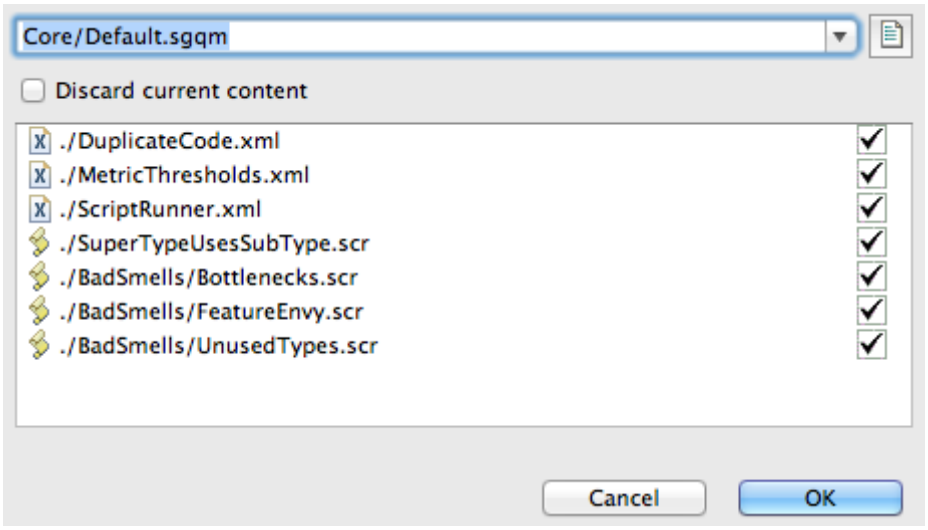


Figure 5.4. Import Quality Model

Check "Discard current content" if you want to delete all the configurations and scripts currently loaded and start afresh with the imported quality model elements.

NOTE

If don't discard your current content, quality model elements with equal names will still be overriden by the incoming elements!

5.1.2. Exporting a Quality Model

To export the currently used quality model select "File" → "Export Quality Model" :

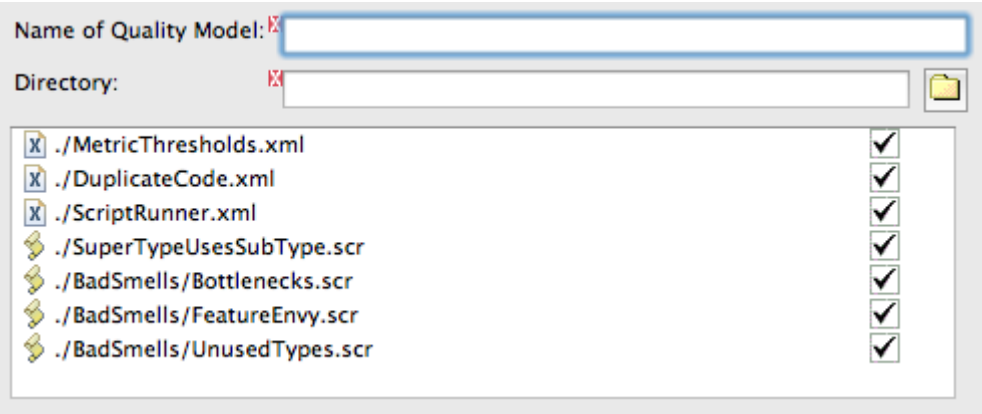


Figure 5.5. Export Quality Model

Select the quality model elements to be included in the resulting file with *.sgqm* extension.

Chapter 6. Adding Content to a System

Sonargraph supports both the manual creation of programming language specific *modules* and the usage of external sources like Eclipse or IntelliJ workspaces, Visual Studio solution or project files to setup the workspace automatically.

The following sections describe the different ways you can add content to a *software system* .

6.1. Creating or Importing a Java Module

After a *software system* has been created, there are currently several ways to set up Java modules: Importing modules from an Eclipse workspace, from an IntelliJ project folder or file, from a Maven POM file and manually.

6.1.1. Importing Java Modules Using an Eclipse Workspace

You can import Eclipse projects as modules into an existing *Sonargraph* project or while creating a new system.

To import Eclipse projects as modules directly into an already existing *Sonargraph* project use "File" → "New" → "Module" → "Java Modules from Eclipse Workspace" .

Select the location of the Eclipse workspace you want to import projects from. You can choose those projects and root directory paths that should be imported and those that should not. The imported Eclipse projects become modules in the *Sonargraph* workspace.

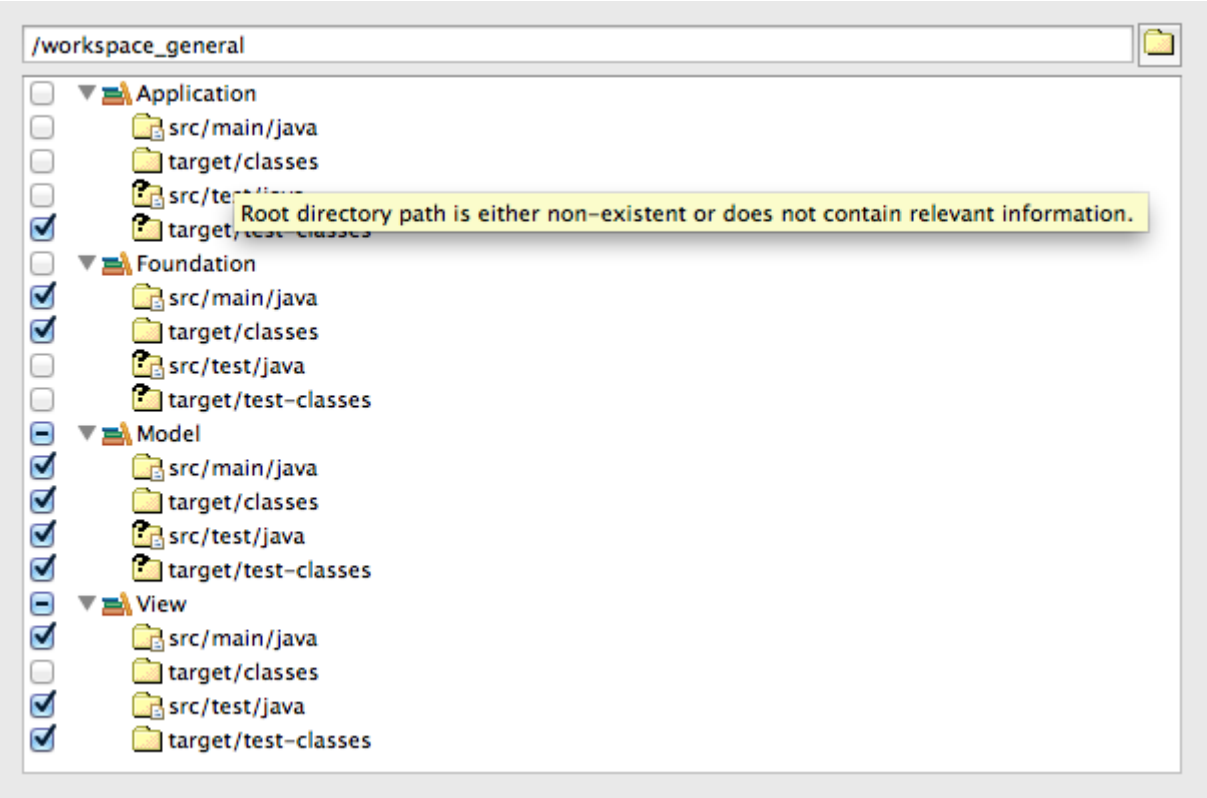


Figure 6.1. Importing Java Modules Using an Eclipse workspace

Sonargraph will let you know about content that is already in the *software system* , empty or irrelevant directory paths and dependencies between modules.

6.1.2. Importing Java Modules from IntelliJ

You can import IntelliJ modules into an existing *Sonargraph* project or while creating a new system.

To import IntelliJ modules directly into an already existing *Sonargraph* project use "File" → "New" → "Module" → "Java Modules from IntelliJ project/file"

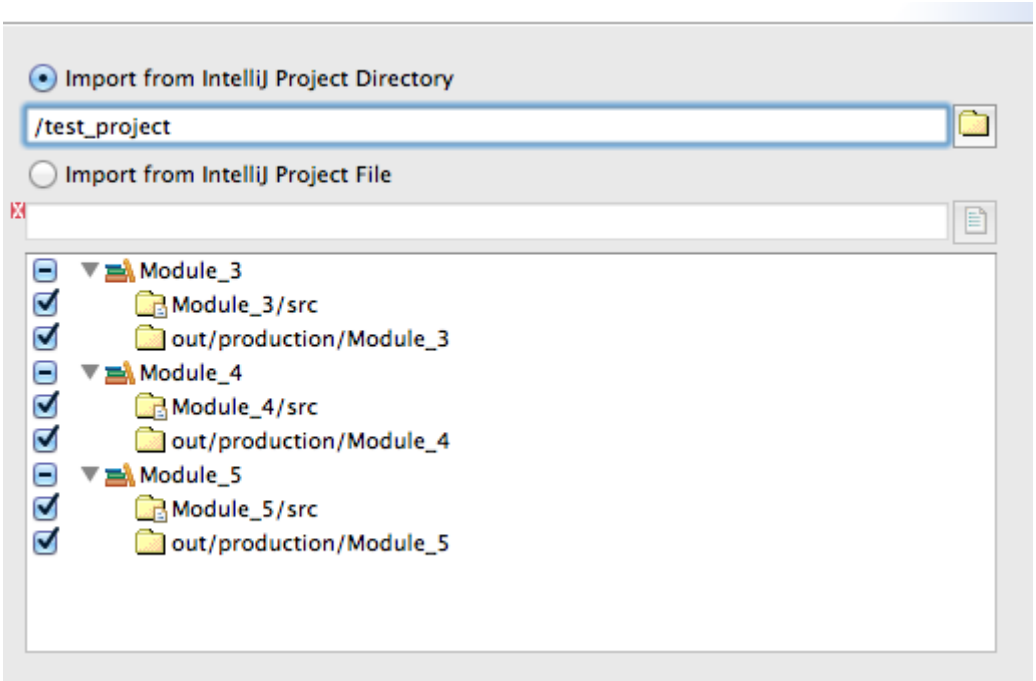


Figure 6.2. Importing Java Modules from IntelliJ

Select either the IntelliJ project or file to import content from. Then you can choose those projects and root directory paths that should be imported and those that should not.

Sonargraph will let you know about content that is already in the software system, empty or irrelevant directory paths and dependencies between modules.

6.1.3. Importing Java Modules from Maven POM File

Sonargraph supports importing content from projects based on versions 2 and 3 of Maven. Select the wizard at "File" → "New" → "Module" → "Java Modules from Maven POM file"

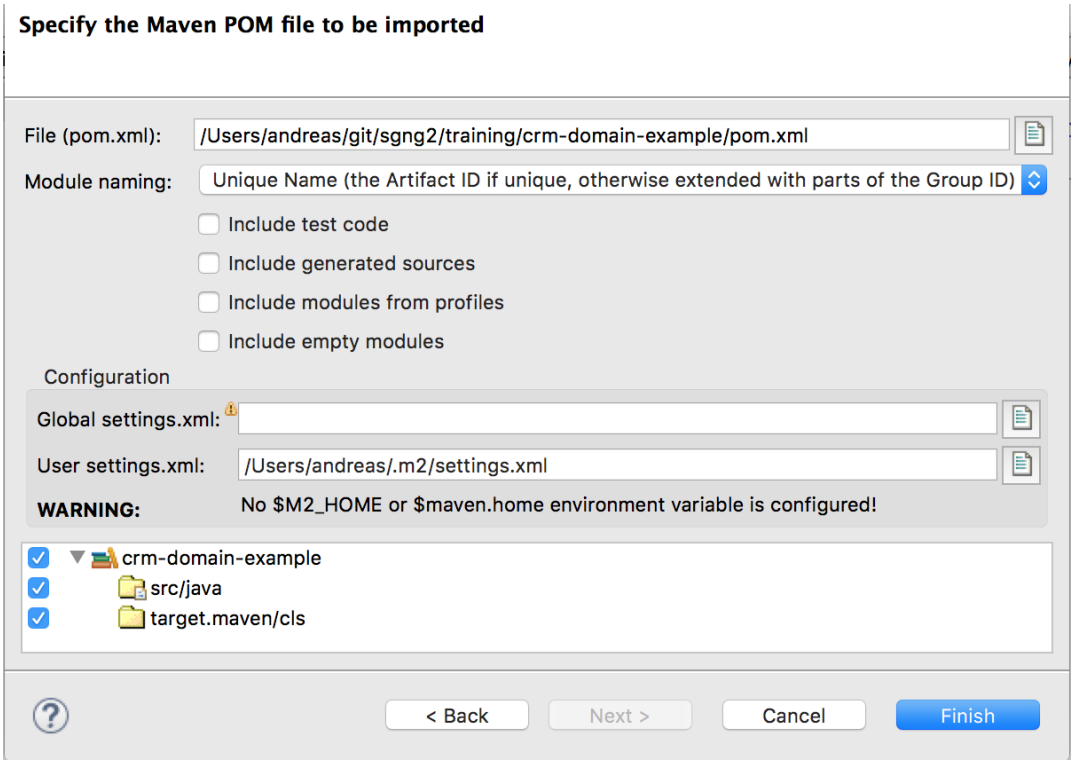


Figure 6.3. Importing Java Maven Modules

Select the Maven POM file you want to use as source for the modules of the new project. You can optionally choose to import test code referenced by the POM file and include modules defined for Maven profiles.

Sonargraph reads the global Maven settings file from ${M2_HOME}/conf/settings.xml. If ${M2_HOME} does not exist the configuration is read from ${maven.home}/conf/settings.xml.

M2_HOME or maven.home is an environment variable referencing the local Maven installation directory.

M2_HOME or maven.home must be set before *Sonargraph* is started.

Sonargraph reads the user specific Maven settings file from ${user.home}/.m2/settings.xml

user.home is a system property already set by the JVM to the home directory of the user.

See *Online Maven Settings Reference* for more details.

NOTE

Changes to the configuration of the global and user settings.xml are persisted in your user preferences. Clearing the paths is not persisted.

You can decide to remove both the global and user settings.xml for the import if all required information is contained in the imported Maven POM.

NOTE

If your Maven build uses Tycho, this importer tries to get source and class directories from build.properties files.

6.1.4. Creating a Java Module Manually

Select "File" → "New" → "Module" → "Java Module" . Alternatively, the context menu in the Navigation and Workspace views can be used.

Sonargraph relies on the Java byte code for its static code analysis. For the ability to show dependencies in the source code, the source directories must be provided as well. Source Root Directories and Class Root Directories can be added individually using the corresponding context menu entries.

Alternatively, a dialog is available via the context menu "Manage Java Source/Class Root Directories/Archives..." that allows the automatic detection of Source and Class Root Directories. The detected directories can be assigned to Java Modules via drag and drop.

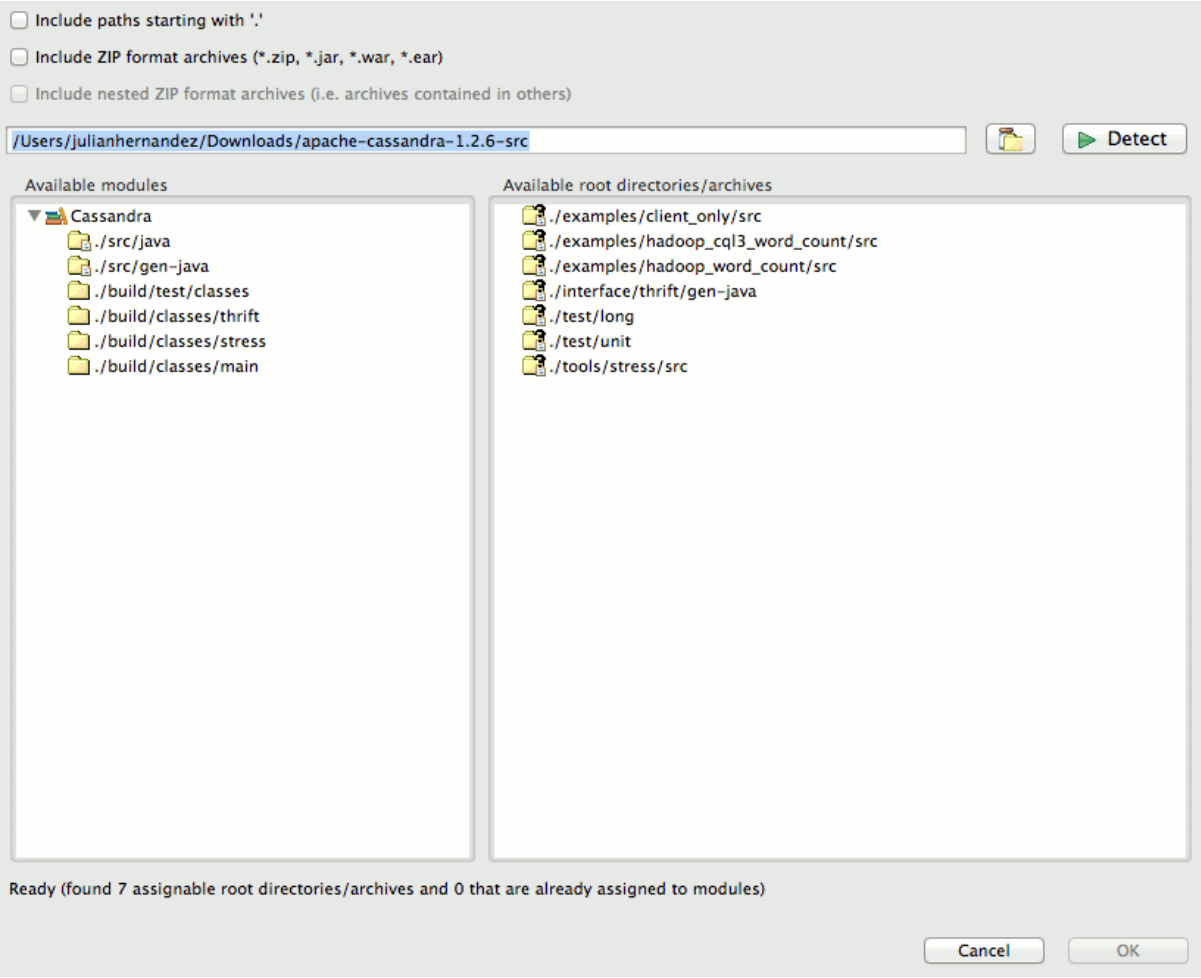


Figure 6.4. Manage Root Directory Path

6.2. Creating or Importing a C++ Module

After a *software system* has been created, there are several ways to set up C++ modules: Import from a Visual Studio 2010 Project file (.vcxproj), import via Makefile command capturing files or manual module creation.

6.2.1. Importing C++ Modules from Visual Studio 2010 Files

Via the menu entry "New" → "Module" → "C/C++ Module from Visual Studio 2010 Project file" a C++ module can be created based on a .vcxproj file. Select the project file and the required configuration. The same approach applies for creating a system based on a Visual Studio Solution file (.sln) as shown in the following screenshot:

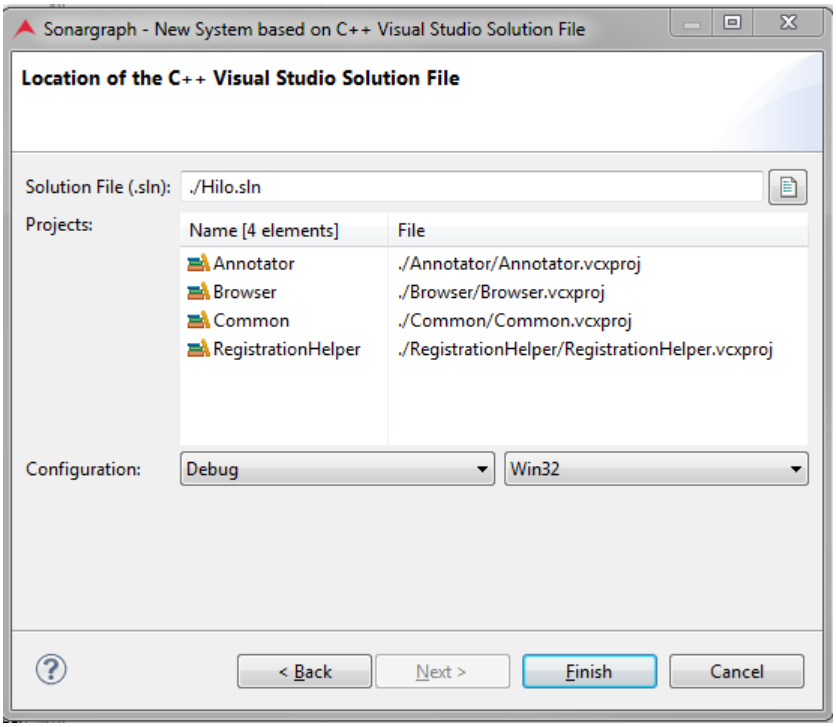


Figure 6.5. Create C/C++ System Based on Solution File Import

6.2.2. Importing C++ Modules Using Make Command Capturing Files

Select "New" → "Module" → "C/C++ Modules from Make command capturing files"

You will have to do a complete rebuild of your system while passing a special shell to the 'make' command. The special shell will create raw files named 'h2m-capture.txt' for each 'Makefile' that executes compile commands during the make process. These files contain a complete list of the compile commands and are used to extract the right options for the C/C++ parser. Sonargraph will then translate these files into files named 'h2m-capture-rel.txt' Do not delete the translated capturing files, instead add them to your version control system. They are used each time Sonargraph opens your system. If you change options or add or remove files from your build you have to repeat the capturing process. Please note, that your top level 'Makefile' must be either in the same directory as the Sonargraph system or in a sub-directory of that directory. Here are the commands you need to execute on the level of your top-level 'Makefile':

Example 6.1. Command Capturing Process

```
SG_DIR=<replace with Sonargraph installation directory>
$SG_DIR/bin/h2mcs clean
make clean
make <optional-targets> SHELL=$SG_DIR/bin/h2mcs
```

After executing those commands you should find 'h2m-capture.txt' files in the relevant project directories. 'make clean' can be replaced with another command you use to force a complete rebuild of your system. On Windows platforms the capturing process currently only works in combination with Cygwin.

Once the 'h2m-capture.txt' files have been generated you can choose which of them you want to use to create the modules.

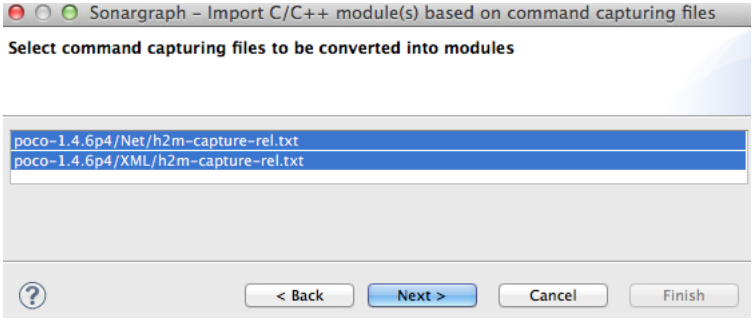


Figure 6.6. Choosing C++ Modules to Import from Capturing Files

If you want, you can change the name and configuration for each of the modules by editing the corresponding fields.

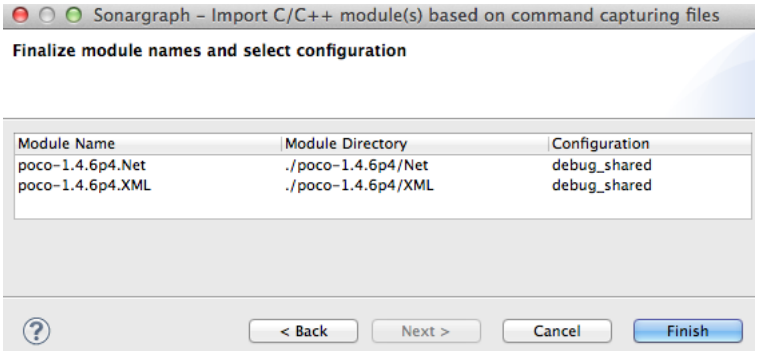


Figure 6.7. Renaming and Configuring C++ Modules to Import from Capturing Files

6.2.3. Creating a C++ Module Manually

Via the menu "New" → "Module" → "C/C++ Module" a plain C++ module can be created. The next step is to define the source root directories via the context menu in the Workspace view (see Section 7.7.1, “ Definition of Component Filters, Modules and Root Directories ”) or via the menu "File" → "New" → "Root Directory" → "New Root Directory..." .

For configuration of additional compiler options, select the menu entry "System" → "C/C++ Manual Module Configuration..." . This dialog allows to configure options using Groovy templates.

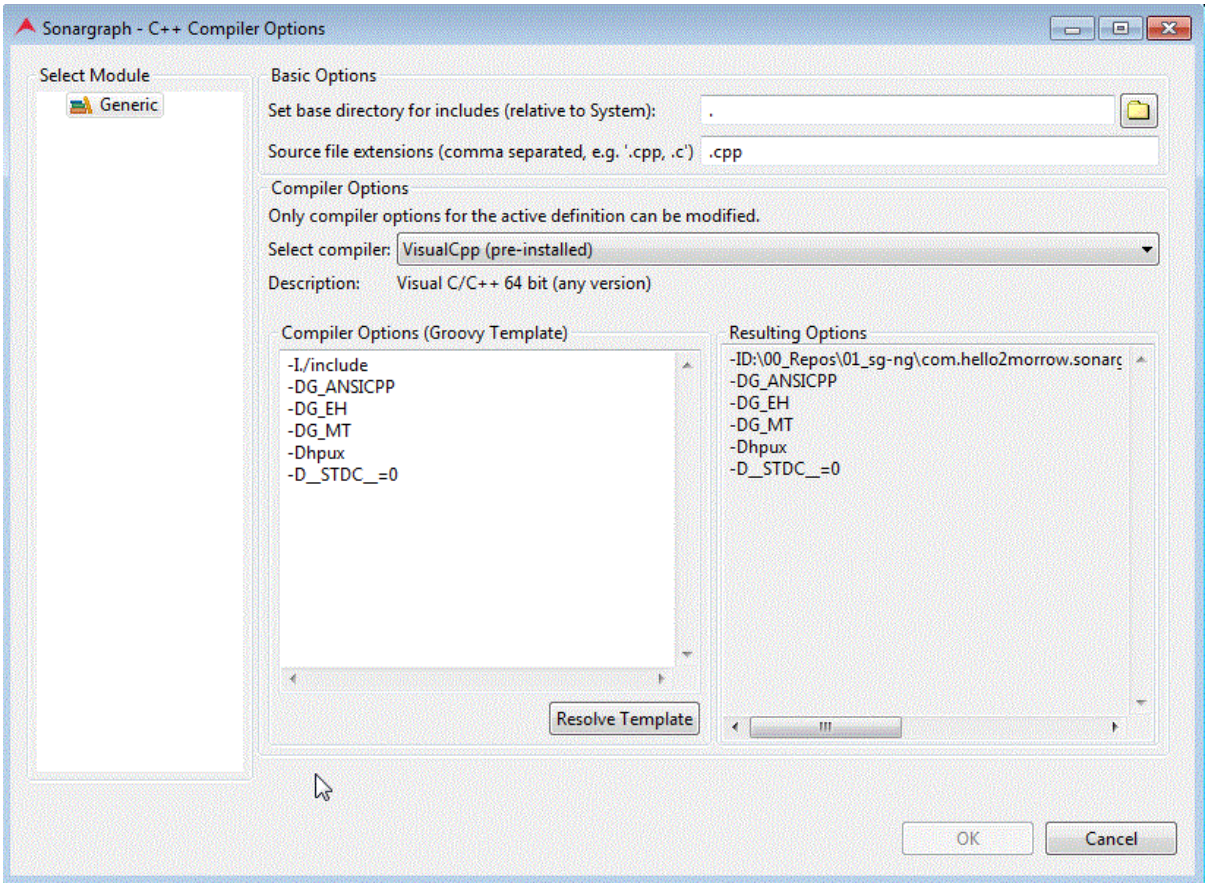


Figure 6.8. C++ Manual Module Configuration

6.3. Creating or Importing a C# Module

After a *software system* has been created, there are several ways to set up C# modules: Import from a Visual Studio Project file (.csproj), import from a Visual Studio Solution file (.sln) and manual module creation.

6.3.1. Importing C# Modules Using a Visual Studio Project File

You can import C# modules from a Visual Studio project file either when creating a new system using the corresponding wizard or selecting "File" → "New" → "Module" → "C# Module from Visual Studio Project file" if you want to add a module to an existing system.

Select the .csproj file and adjust the configuration and platform combination if necessary.

6.3.2. Importing C# Modules Using a Visual Studio Solution File

You can import C# modules from a Visual Studio solution file either when creating a new system using the corresponding wizard or selecting "File" → "New" → "Module" → "C# Module from Visual Studio Solution file" if you want to add modules to an existing system.

Select the location of the solution file (.sln) to have *Sonargraph* search for projects to import. Select your preferred configuration and platform combination.

Support for Visual Studio Shared Projects

If the solution file contains references to *Shared Projects* an additional wizard page is offered where the root project needs to be selected. This root project and all referenced projects will be automatically imported. If additional projects should be analyzed within the same system, you can import them later individually. The "Status" text field shows the output produced by the build executor.

NOTE

The C# build executor is used to analyze the project dependencies. The XML project parser has only limited capabilities, for advanced configurations you are better off using MSBuild or xbuild. See Section 3.8.1, “C# Build Executor Configuration” for more details.

6.3.3. Creating a C# Module Manually

Via the menu entry "File" → "New" → "Module" → "C# Module" a plain C# module can be created. The next step is to define the source root directories via the context menu in the Workspace view or via the menu "File" → "New" → "Root Directory" → "New Root Directory..." . See Section 7.7.1, “ Definition of Component Filters, Modules and Root Directories ” for more details.

6.3.4. C# Module Configuration

After creating a C# system or creating modules, it might happen that some referenced assemblies cannot be resolved. The following screenshot shows how these errors are displayed in the Issues view.

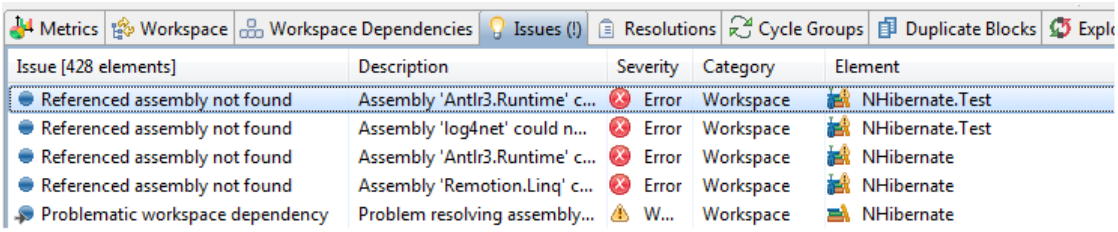


Figure 6.9. Missing C# Assemblies

Before the system can be parsed, the errors need to be resolved.

First, make sure that you are able to build the project locally on your system with your usual build system. If you are using MSBuild or xbuild, check the preferences for the build executor as described in Section 3.8.1, “C# Build Executor Configuration”. For those two executors, Sonargraph starts them as external process to extract all required info. This should be sufficient for most C# project types. If assemblies are missing, specify their paths on the installation profile level. See Section 3.8, “C# Configuration”.

Search paths for missing assemblies can be added using the menu entry "System" → "Configure C# Module(s)..." . Preprocessor symbols and external alias are read-only for imported modules.

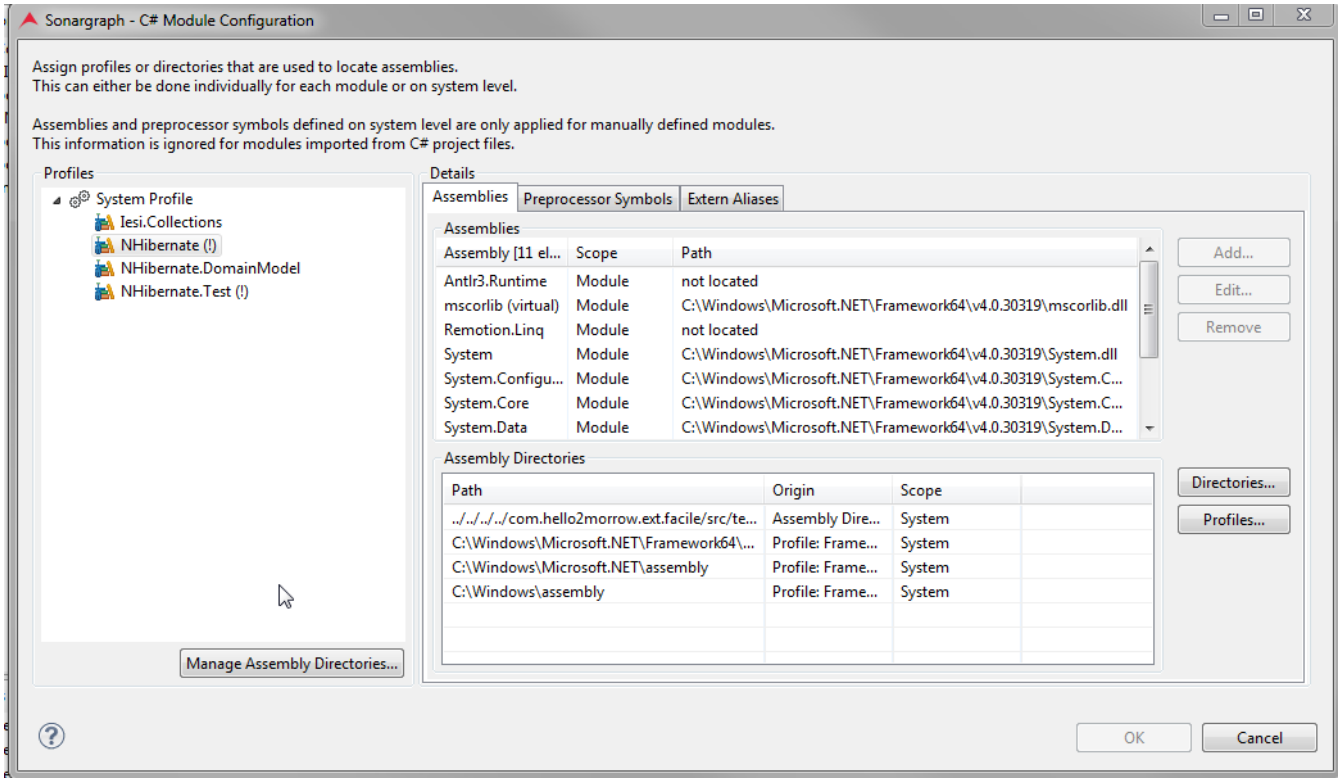


Figure 6.10. C# Module Configuration

Modules that contain unresolved references to assemblies are marked with "(!)". If a module is selected in the treeview on the left side, all referenced assemblies are shown with their paths on the right. Assemblies marked as "(virtual)" are referenced by the module indirectly (mscorlib.dll, System.dll, System.Core.dll): The reference is not present in the C# project file but is automatically added.

The lower part shows the paths that are used to locate referenced assemblies. The search path is constructed and searched in the following order:

1. The directories defined on module level.

2. The directories of referenced installation profiles on module level.

3. The directories defined on system level.

4. The directories of referenced installation profiles on system level.

If you have already defined installation profiles as described in Section 3.8, “C# Configuration” , you can add them as references by selecting "Profiles...". Or you can add individual directories via "Directories...".

You can also let *Sonargraph* search for assembly directories. Open the dialog via the button "Manage Assembly Directories..." and specify a directory where the search is started. Found directories can be assigned to either the system or module profiles by dragging them from left to right.

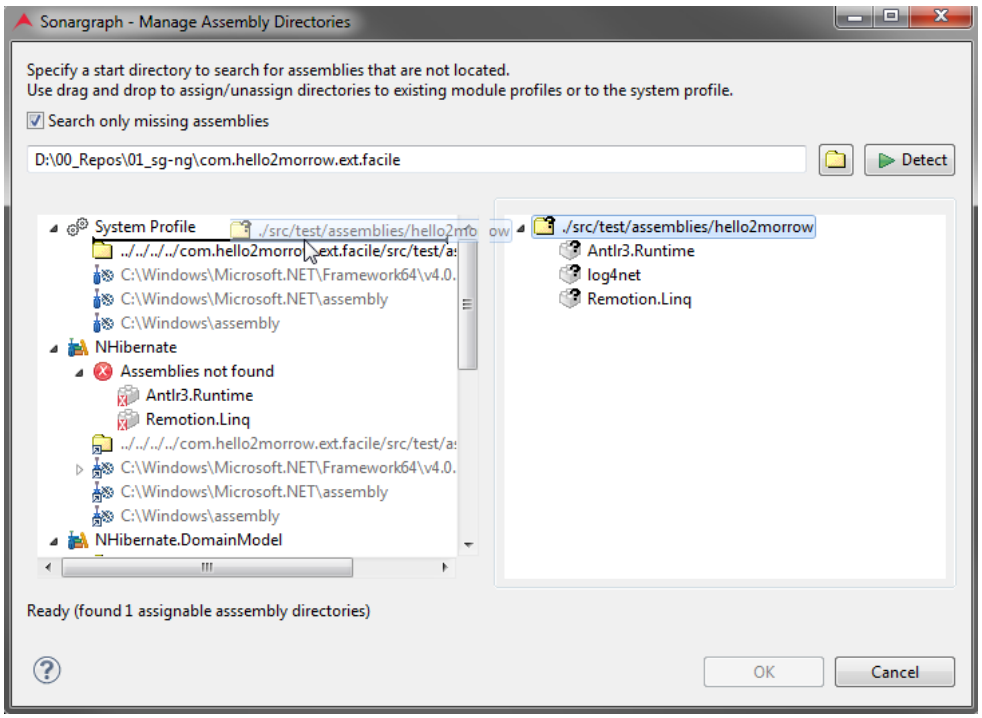


Figure 6.11. Locate Missing C# Assemblies

WARNING

Sonargraph does not support different versions of core assemblies (mscorlib, System, System.Core) to be used within the same software system. The easiest way to ensure that all modules use the same framework assemblies, assign the required installation profiles on system level. All modules will then use the same folders to look-up assemblies.

NOTE

Assembly dependencies are automatically determined and located by MSBuild or xbuild executors. If MSBuild or xbuild is configured as the build exector (see Section 3.8.1, “C# Build Executor Configuration”), missing assemblies need to be added on system or installation profile level (see Section 3.8, “C# Configuration”). Any additional assembly directories on module level are ignored.

NOTE

If your project does not reference external assemblies explicitly (e.g. for "Windows Store App" projects), references pointing to .NETCore libraries are automatically loaded from .NETFramework folder, to avoid clashes with assemblies that are referenced explicitly by other projects contained in the same system. This can lead to parser warnings, because some external types or methods might not be present in the .NETFramework assemblies.

Chapter 7. Interacting with a System

This chapter describes how the views of *Sonargraph* can be used to interact and explore a system and conduct basic use cases like examining duplicates and cyclic dependencies. More advanced functionality like adding custom metrics or defining an architecture are explained in their own chapters.

7.1. User Interface Components

There are different graphical components in the main application window:

7.1.1. Menu Bar

Contains menu entries that allow the execution of system-wide actions or commands that are applicable for the current selection; the meaning of the categories is the following:

- **File:** Contains commands for creating, loading and saving systems as well as exporting or importing Quality Models (See Section 5.1, “Quality Model”), creating Microsoft Excel, HTML and XML reports.
- **Edit:** Contains commands for undoing and redoing the last performed operations, editing and deleting components and perform system-wide searches.
- **System:** Contains commands that allow re-reading the current *system* from the disk (and re-checking it), perform system configuration and changing language specific module settings such as where source and compiled files are being searched for.

  Additional entries allow creation of fix, ignore or TODO issues.
- **Window:** Provides access to the different views of *Sonargraph* and the preference pages to modify installation-wide settings.
- **Help:** This menu provides access to the online and dynamic help, allows management of license information, allows to send feedback to the *Sonargraph* developers and provides general information about the installation.

7.1.2. Tool Bar

Figure 7.1. Tool Bar

Allows to access the most common operations. It is always visible regardless of the active view. It offers the following actions:

- **Refresh** : If there is currently no representation of the system in memory it performs a full parse. If the model exists, it performs a "delta refresh" to update the in-memory content with the latest state from the disk. The synchronization of the model with the disk content is normally not done automatically on startup, because this can take a considerable amount of time. However, it can be specified that on opening the software system, a synchronization should be performed automatically by checking the menu item "System" → "Refresh On Open" .
- **Clear** : Drops the memory representation of the system under consideration. After performing this action a full parse of the system is required to resume with the analysis.
- **Navigate Backward/Forward** : Allows to navigate backward and forward in the history of recently performed actions across the application.
- **Manage Virtual Models** 

: Allows to change the current *virtual model* or create a new one. (See Section 8.1, “Using Virtual Models for Resolutions ”)

7.1.3. Notifications Bar

Figure 7.2. Notifications Bar

The notification area is located in the bottom area. It informs about the current operation being performed with both a text feedback and a progress bar. On right side, you find notifications about different situations going on in the application that may be of interest to you such as proximity of license or support expiration date and proximity to reaching the limit of available elements per the active license. Specifically:

- The icon indicates that there is at least one information notification available.
- The icon indicates that there is at least one warning notification available.
- The icon indicates that there is at least one error notification available.
- The icon indicates that there are no notifications available at this time.

To bring up notifications just click once on the icon.

7.2. Common Interaction Patterns

The following interaction patterns (called gestures) are common across the *Sonargraph* application:

- **Single clicking** on an element normally means to select it; holding the control key (command key on Mac) while clicking normally aggregates the selection elements, and holding the SHIFT key normally selects all elements between the current one and the last selected one.
- **Double clicking** not only selects the element but, if possible, shows it in a view that is best suited to inspect it or edit it. It is important to note that a double click gesture will show the selected element in another view only if at least one of the following two conditions is fulfilled:
  - Element is associated with a single source file: Elements like C/C++, Java and C# source files, types, structs, methods, and functions among others fulfill this conditions. For other elements like namespaces, packages or directories it is not possible to associate them with a single source file.
  - There is a single possibility of navigation: If the selected element only offers one view to navigate to, then the double-click gesture will show the element in that view, otherwise, it will not meet this condition.
- **Right clicking** on elements normally presents a context menu with element-specific actions. Some of the most common interaction patterns available with right-click are showing elements in different views, exporting tables to Excel and exporting graphics as images to the file system among others.
- **Drag and drop** is used in several different contexts in *Sonargraph* to perform different operations: filters can be re-organized in the Workspace view. Nodes can be re-arranged for better appreciation in the Graph and Cycle views while holding the SHIFT key pressed. Dragging and dropping the mouse cursor while holding the SHIFT key and the primary modifier key of the platform (CTRL on Windows/Linux and CMD on Mac) pressed in the Workspace Dependencies view allows to specify a new dependency between two nodes (see Section 7.7.2, “ Managing Module Dependencies ”).

7.2.1. Special Graphic Elements Decorations

Across the *Sonargraph* is common to find two decorations:

- * : A star behind the name of an element means that the description of such element has been changed locally but not yet saved to disk: The in-memory representation and the disk representation of the system are not identical.

- ! : An exclamation mark behind the name of an element generally means that this element needs your attention or requires you to take some action on it.

7.3. Sonargraph Workbench

The default workbench of *Sonargraph* is divided into 4 regions. However, as *Sonargraph* is built upon Eclipse's Rich Client Platform you can always re-arrange views as you like.

The following image shows these regions and the subsequent sections explain each one of them:

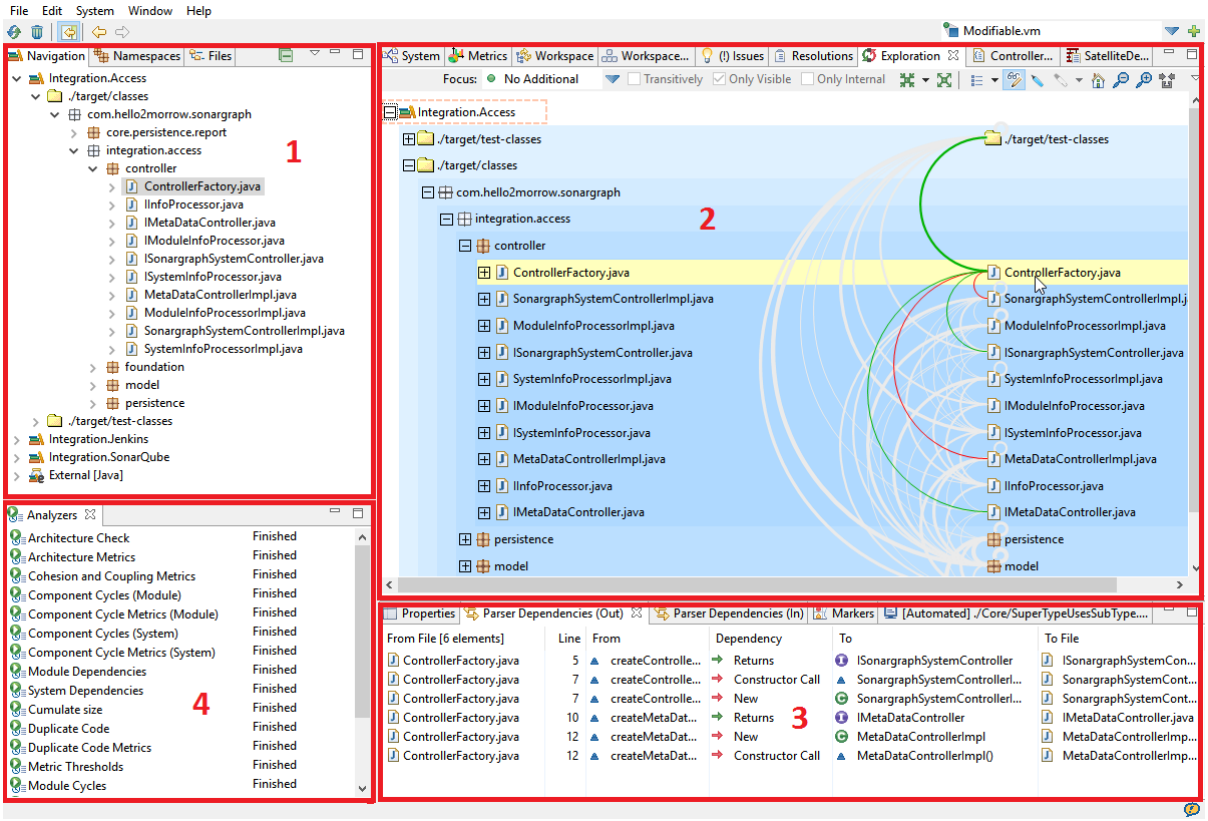


Figure 7.3. Sonargraph Workbench

1. **Master Views:** Located at the upper left hand side of the workbench, provide control over the system structure and the files that make it up. All Master views offer the following operations:

   - **Collapse All** : Collapses the whole tree of elements.

   - **Link** : Selecting it specifies if the selection in the current Master view should be synchronized as far as possible with the selection in the currently selected Slave view.

   The Navigation and Namespaces views offer a "View Menu" option which can be used to specify whether the elements of the tree are to be displayed in a flat mode or in the hierarchy induced by their dot-separated full paths. Exclusive to the "View Menu" option of the Namespaces view is the possibility to choose between system-based or module-based representations.

2. **Slave views:** Located at the upper right hand side of the workbench provide ways to manage and explore the *components* of the system under consideration. The slave views have the capability of responding to selection from the master views.

3. **Auxiliary views:** Located at the lower right hand side of the workbench, provide support to some of the slave views to expand their system exploring capabilities.

4. **Information views:** Located at the lower left hand side of the workbench, they provide general information about the properties of the selected elements and the status of the analyzers running over the system model.

7.4. Navigating through the System Components

The Navigation view presents the directory -or archive- structure of the source and/or binary files of the loaded *system* as it has been determined from the workspace defined for the modules of the system.

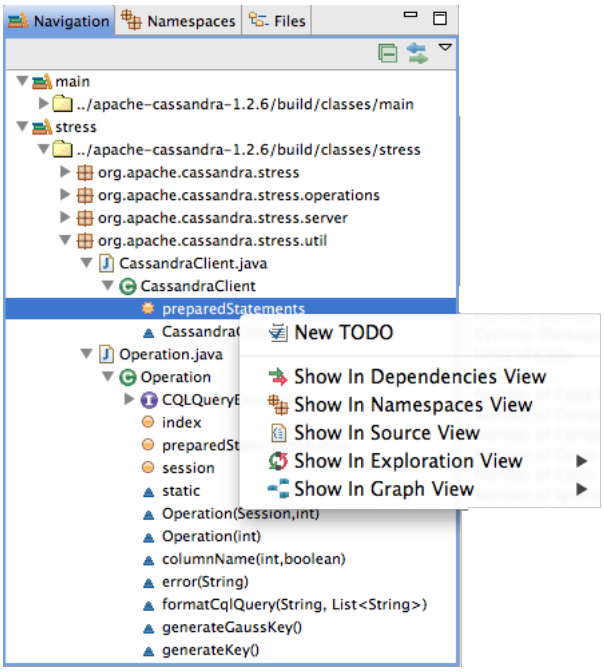


Figure 7.4. Navigation View

The context menu interaction gives you options to inspect elements in suitable slave views or perform element specific actions such as creating a TODO task (see Section 8.4, “ Defining Fix And TODO Tasks ”).

7.5. Exploring the System Namespaces

In order to be able to see and explore the logical models calculated by *Sonargraph* (See Section 4.4, “Logical Models”), users can rely on the Master view called Namespaces view.

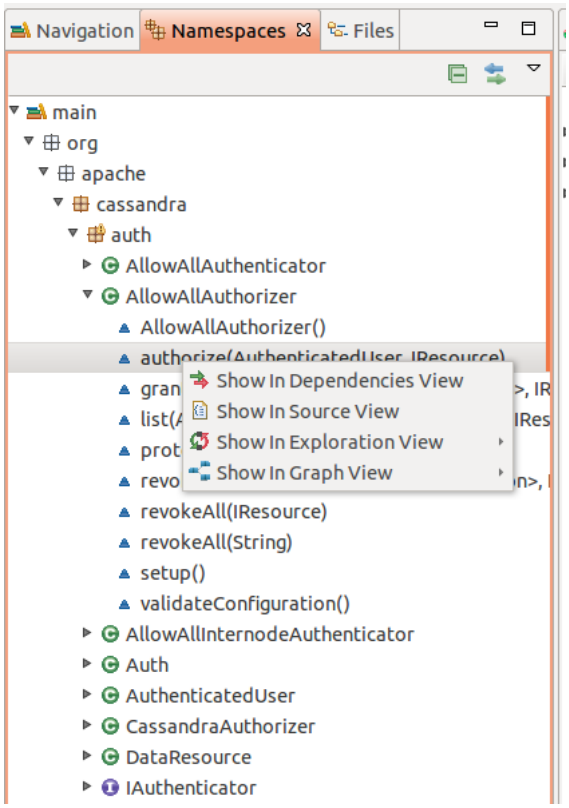


Figure 7.5. Namespaces View

As shown in figure “Namespaces View” , the logical elements that appear in Namespaces view also offer interactions for exploration and source code visualization when it is the case.

This single view provides access to both system-based and module-based logical models. To choose which logical model you want to see, use the view menu:

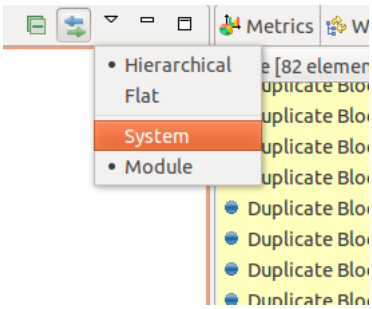


Figure 7.6. Logical Model Selection

Besides choosing which logical model to see, the Namespaces view also offers the possibility to change the *logical namespaces* presentation from flat to hierarchical and vice versa.

7.6. Managing the System Files

The Files view represents the structure of the files that make up the current *software system* .

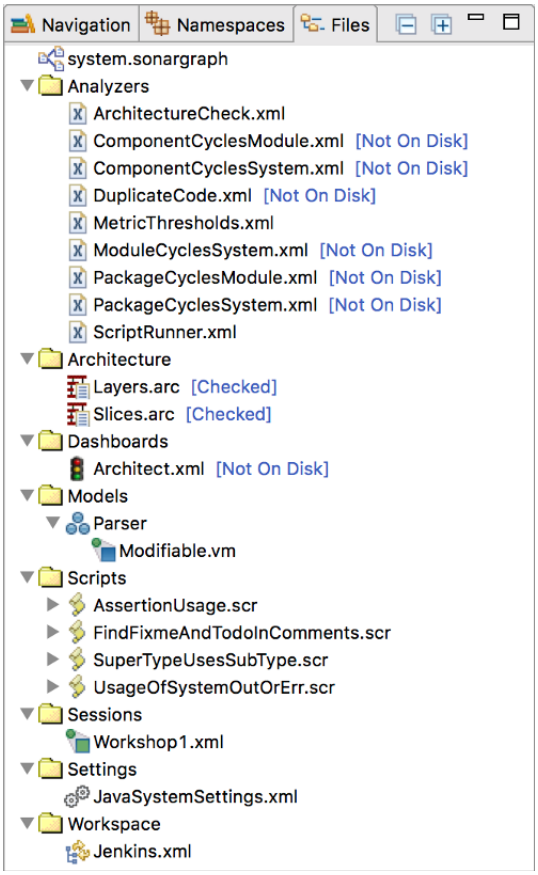


Figure 7.7. Files View

Those files are:

- **System File:** Named as "system.sonargraph", represents the current *software system*.
- **Analyzers:** Contains available configuration files of analyzers. A double click opens the corresponding configuration page. Alternatively the configuration pages are reachable via "System" → "Configure...".
- **Architecture:** Contains architecture files. A new architecture file can be created using the context menu of the "Architecture" folder. Existing architecture files can be added/removed from the architecture check also via their context menu.
- **Dashboards:** Currently, the file underneath is not modifiable and the content shown in the System view is fixed. In the future, the content displayed in the System view will be configurable.
- **Models:** Contains *virtual models* of the current *software system* (see Section 8.1, “Using Virtual Models for Resolutions ”). These files only get modified when altering the set of resolutions and/or refactorings.
- **Scripts:** Contains scripts that can be executed for the current *system*. Those scripts have been added by either using a quality model (see Section 5.1, “Quality Model”) or they have been created manually (see Chapter 10, *Extending the Static Analysis*).
- **Sessions:** Contains session models.
- **Settings:** Contains language specific settings.
- **Workspace:** Contains workspace profiles.

The files presented in the Files view get a star symbol (*) when they are modified as explained in Section 7.2.1, “ Special Graphic Elements Decorations ”

7.7. Managing the Workspace

The Workspace is a key concept in order to be able to set up and manage correctly a *Sonargraph software system* . Depending on the workspace definition, *Sonargraph* will be able to detect the source files (and class files when applicable) that will will be used as input for the parsing process and generation of the domain models.

7.7.1. Definition of Component Filters, Modules and Root Directories

The Sonargraph workspace consists of the following elements that can be managed via the Workspace view:

- *Production Code Filter*: Is used in order to exclude test code from the analysis. The filter is *component* based and processes all internal components. External components for which all incoming dependencies come from excluded internal components are also marked as excluded. Outgoing dependencies from non-excluded internal components to internal excluded components are marked with the issue 'Dependency to Excluded Internal Component'. This might indicate a problem since non-test code should not reference test code.

- *Issue Filter*: Is used in order to exclude portions of the code to no longer generate analysis issues (e.g. cycles, threshold violations, ...). This is useful in case you have legacy or generated code that you are not able to adapt or don't want to adapt. The filter is also *component* based and processes all internal non-excluded components.

- *Module*: Is the top-most element and the root container for all the user-defined elements of a *Sonargraph software system* . Modules are equivalent to Eclipse projects, Maven modules, Visual Studio projects or IntelliJ projects and they contain at least one Root Directory Path.

- *Root Directory Path*: Corresponds to a location on the user's file system and is the top-most directory where the search for source files (and class files when applicable) will take place.

- *External*: Is the root container for elements that are used from within the user code but do not belong to any of the modules of the *software system* .

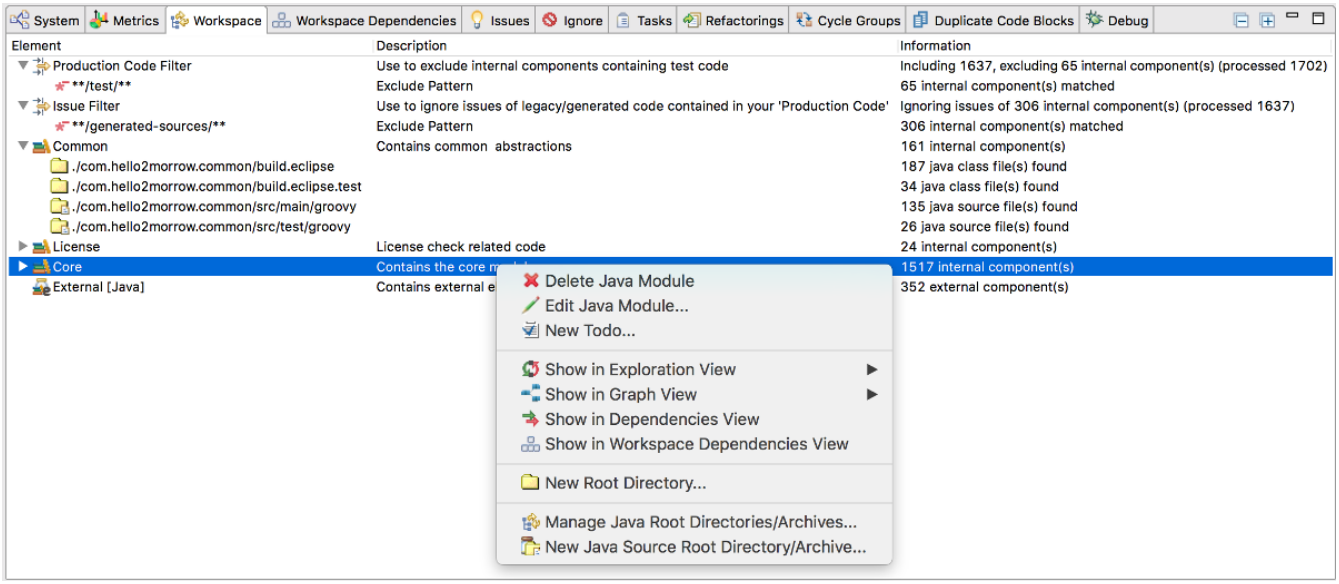


Figure 7.8. Workspace View

What you need to know about the workspace filters (Production Code and Issue Filter):

- The filters use the 'Workspace Filter Name' of the components to produce matches with include and exclude patterns. The 'Workspace Filter Name' can be found in the *Properties* view when selecting a component. The name has the following

structure: [Module]/[Root Directory]/[Physical Path]/[Component name without extension]. The name 'Events/src/com/app/events/Event' would refer to the component 'Event' in the directory 'com/app/events' in the root directory 'src' in the module 'Events'.

- The patterns support the following wildcards: ?=any character, *=any sequence between dots or slashes, **=any sequence. Both filters have a built-in '**' include pattern. So it might be enough to add exclude patterns. If needed you can define your own include patterns (disabling the built-in one). The include pattern(s) define which components pass and the exclude pattern(s) subtract from that set.

- With the Search dialog you can check which programming elements have been excluded and which ones are ignoring issues. To bring it up select "Edit" → "Search..." .

As seen in the previous image, the Workspace view offers interactions to create, edit and delete the workspace elements if necessary.

7.7.2. Managing Module Dependencies

Dependencies between modules that have either been defined manually or that have been generated automatically during the import/synchronization with external project files are visualized in the Workspace Dependencies View. It is important to note that if the Workspace Dependencies were calculated by the *software system* as a result of the synchronization process, it is not possible to modify them, nor delete or add more dependencies.

When Workspace Dependencies can be added manually, a dependency between modules might be created by pressing SHIFT and the primary modifier key of the platform (CTRL on Windows/Linux and CMD on Mac) and dragging a line with pressed left mouse button from source to target module.

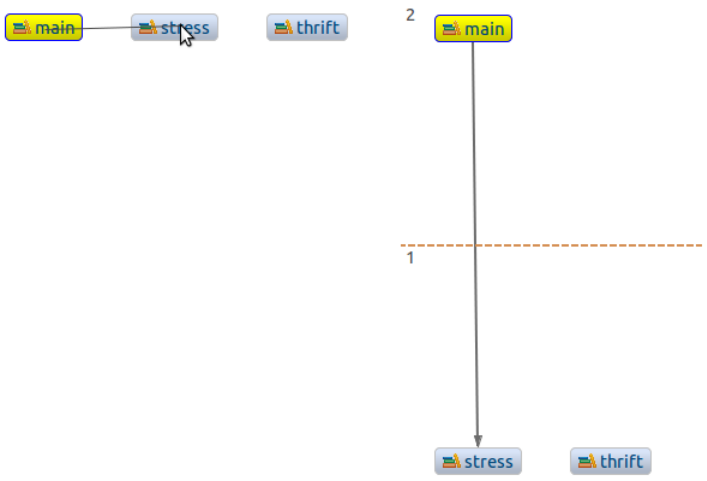


Figure 7.9. Defining a Manual Workspace Dependency

Similarly, if Workspace Dependencies are manually defined, they can also be deleted via context-menu or double-click interactions.

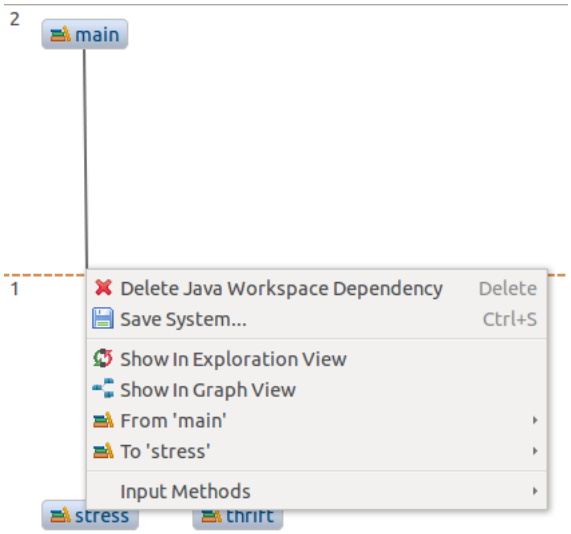


Figure 7.10. Defining a Manual Workspace Dependency

7.7.3. Creating Workspace Profiles for Build Environments

Workspace profiles help to solve the following problem for Java systems: If a workspace has been set up using for example an Eclipse workspace import, these root directories likely do not exist on the build server but only on a developer's machine. (Integration of SonargraphBuild on the build server is described in more detail in the user manual of SonargraphBuild.) In order to run the same checks with *Sonargraph* on the build server, a workspace profile defines tranformation of root directories. Currently this applies only to Java class root directories. The transformation is done using an arbitrary number of profile patterns that consist of regular matchers and replacement expressions. The profile name can then be applied in the SonargraphBuild configuration.

Each profile pattern consists of three parts:

1. **Module name matcher**: Regular expression matching module names. Only if this pattern matches, the module's root path will be applicable for tranformation by this profile pattern.

2. **Root path matcher**: Regular expression matching against the identifying path of roots of the matched module.

3. **Root path replacement**: This pattern defines the new path that will be used to create a new root directory for this module and replace the existing path. Capturing groups that are used in the module name and root path matchers are accessible.

The two matchers are logically combined, so the capturing groups' indices of the root path matchers do not necessarily start at 1, but depend on the number of capturing groups in the module name matcher. Alternatively, named capturing groups can be used, as illustrated in the following example:

Let's assume that every module of the system has the same layout and has a root path with the identifying path "./target/classes", but you need to map that path to "./target/<module_name>-0.0.1-SNAPSHOT.jar". The three parts that make up the profile pattern can be defined as shown in the following screenshot. A detailed explanation is given below the screenshot.

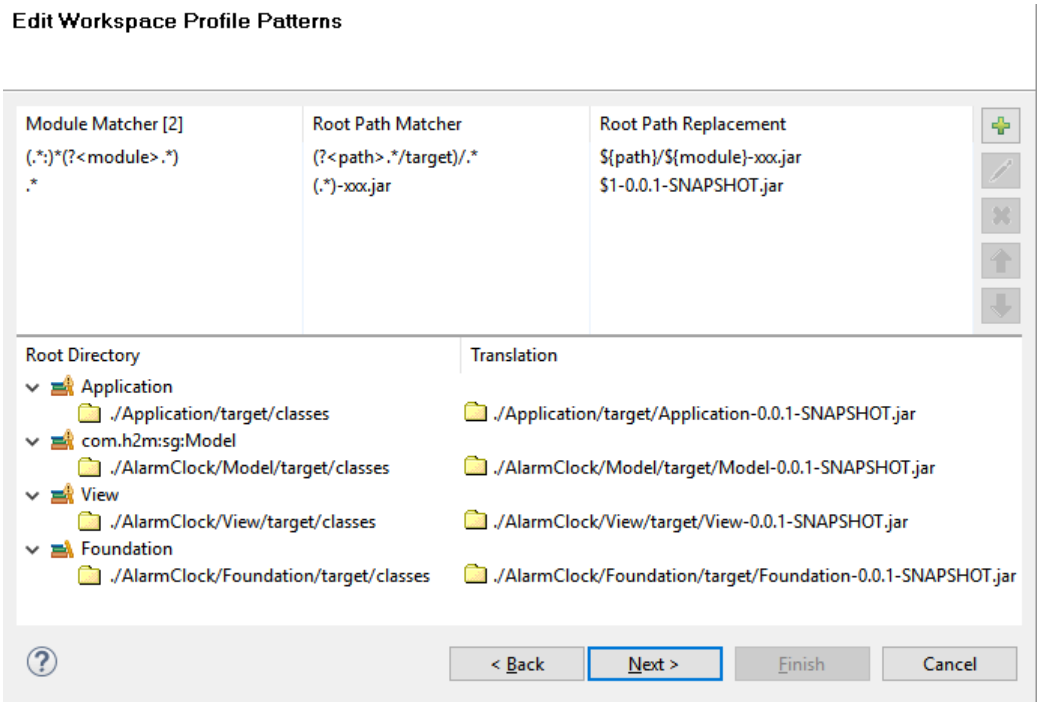


Figure 7.11. Creating Workspace Profile

1. **Module name matcher**: "(.*:)*(?<module>.*)" - This regular expression matches all module names and keeps the module name in a named capturing group "module" that allows re-using the module's name for the JAR file. If the module has been created by a Maven import and the name matches the schema groupId:artifactId, the groupId will be omitted by the first optional capturing group.

2. **Root path matcher**: "(?<path>.*/target)/.*" - This regular expression matches against the identifying path of roots of the matched module. The part that needs to be re-used is made available via another named capturing group "path".

3. **Root path replacement**: "${path}/${module}-xxx.jar" - This pattern defines the new root path that replaces the match. The named capturing groups are used to insert the part of the original path that needs to be re-used and also the module name.

The next pattern replaces the "xxx" string with the correct version using a "standard" unnamed capturing group. It is a matter of taste if you want to split the transformation into several profile patterns or do it in one step.

NOTE

All root directories must be mapped! If profile patterns result in the same mapping for different root directories of the same module, only one directory will be created. Otherwise the same rules apply as for the standard software system workspace: It is not possible that the same root directory is used by different modules.

TIP

More info about the regular expression capabilities can be found in the JavaDoc of *java.util.regex.Pattern* and its section about *capturing groups*.

Related topics:

- Chapter 14, *Build Server Integration*

7.8. Analyzer Execution Level

Analyzer execution levels have been introduced in *Sonargraph* 9.6.0. Depending on the currently set level not all analyzers are executed. Depending on the goal of a session this results in a smoother user interaction. The user can select one of four levels (Full, Advanced, Basic, Minimal) by System → Analyzer Execution Level .

The list of Analyzers to be run for each level depends on licensed features and languages, and can be shown by System → Analyzer Execution Level → Description... .

Note

This setting is stored between sessions.

Note

If the level is not set to 'Full' not all possible issues and metrics are available.

The Analyzers, their Analyzer Execution Level, and their current state are show in Analyzers View.

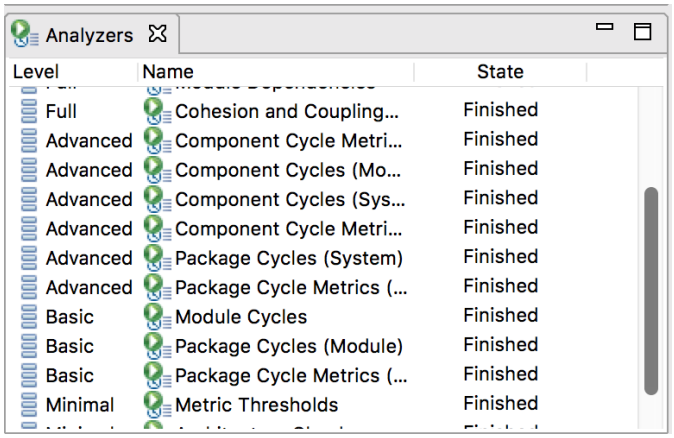


Figure 7.12. Analyzers View

Related topics:

- The Analyzer Execution Level may also be set in *Sonargraph* Eclipse Plugin Section 15.1.4, “ Setting Analyzer Execution Level ” .
- The Analyzer Execution Level may also be set in *Sonargraph* IntelliJ Plugin Section 15.2.1, “ Assigning a System ” .

7.9. Analyzing Cycles

The cycles analysis capability of *Sonargraph* is leveraged by the Cycle Groups, Cycle and Exploration views. The first one is used to list cycle groups and the *components* involved in those and the other two allow to inspect in detail those cycle groups.

7.9.1. Revising Cycle Groups

Cycle Groups are containers for elements participating in a cycle. This view gathers those cycle groups found during system analysis by the Cycle analyzer and groups them according to scope (system or module) and element level (e.g. component, namespace, package, ...).

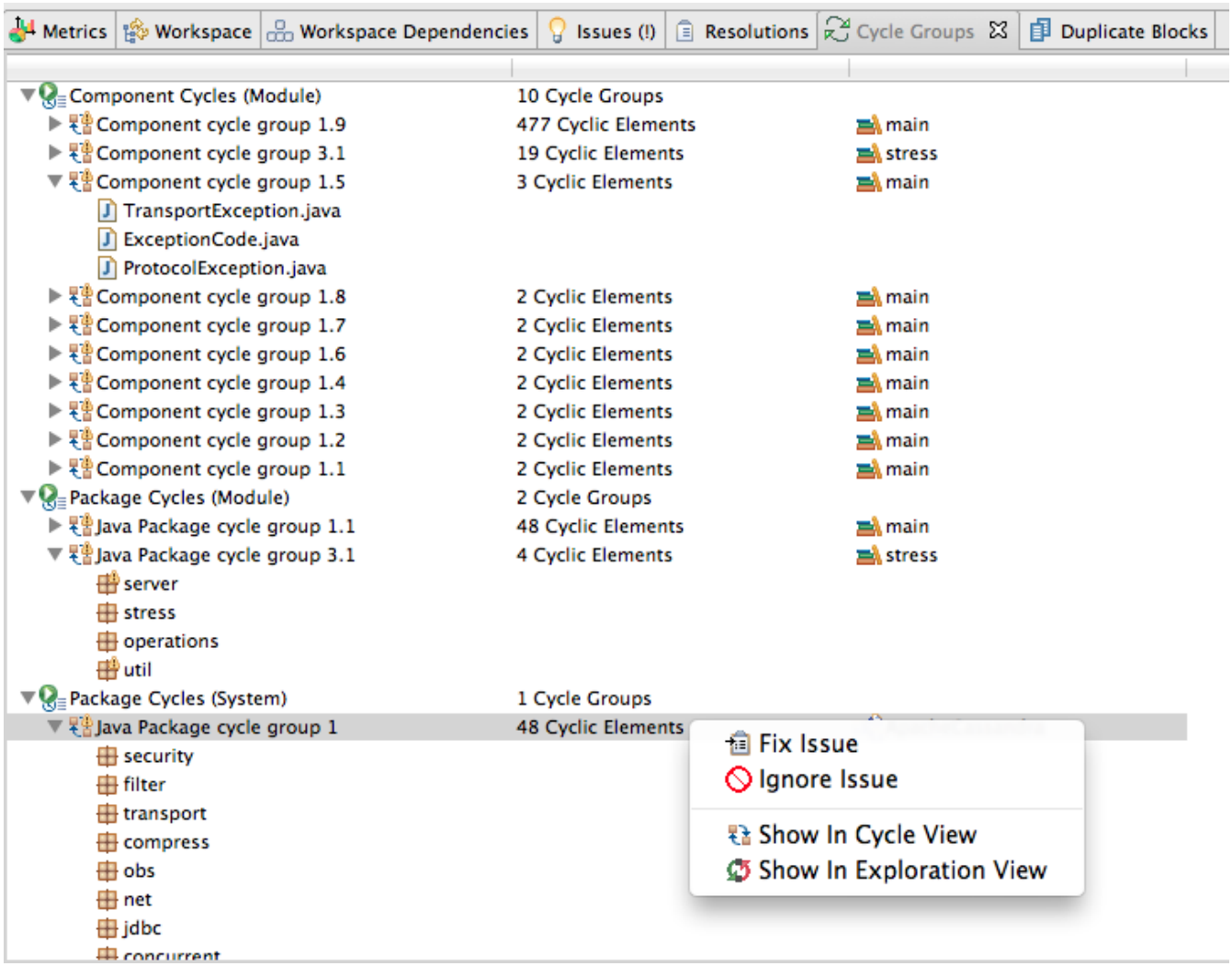


Figure 7.13. Cycle Groups View

The first column references, in different tree based levels, the category, a unique cycle group identifier and the elements participating in the cycle. The second column informs about the number of elements involved in the cycle group and finally, the third column shows the corresponding module name (for module based cycles) of the cycle or the system name.

Sonargraph considers cycles as issues, as they greatly contribute to the structural erosion of the code base. Thus, using right-click on a cycle group you can define resolutions in order for it to be addressed by the team (see Chapter 8, *Handling Detected Issues*).

The context menu for a cycle group also offers options to visualize the cyclic elements in specialized views such as the Exploration view (see Section 7.10, “Exploring the System”) and the Cycle View (see Section 7.9.2, “ Inspecting Cyclic Elements ”).

7.9.2. Inspecting Cyclic Elements

When choosing to examine a cycle group in the Cycle view, it allows to inspect in detail the dependencies between the cyclic elements belonging to the selected group. Selecting a node or an arc allows to use the support of the Parser Dependencies (In and Out) auxiliary views to point out to where in the code base the associated dependencies are being generated. Context menu is also enabled for arcs and nodes.

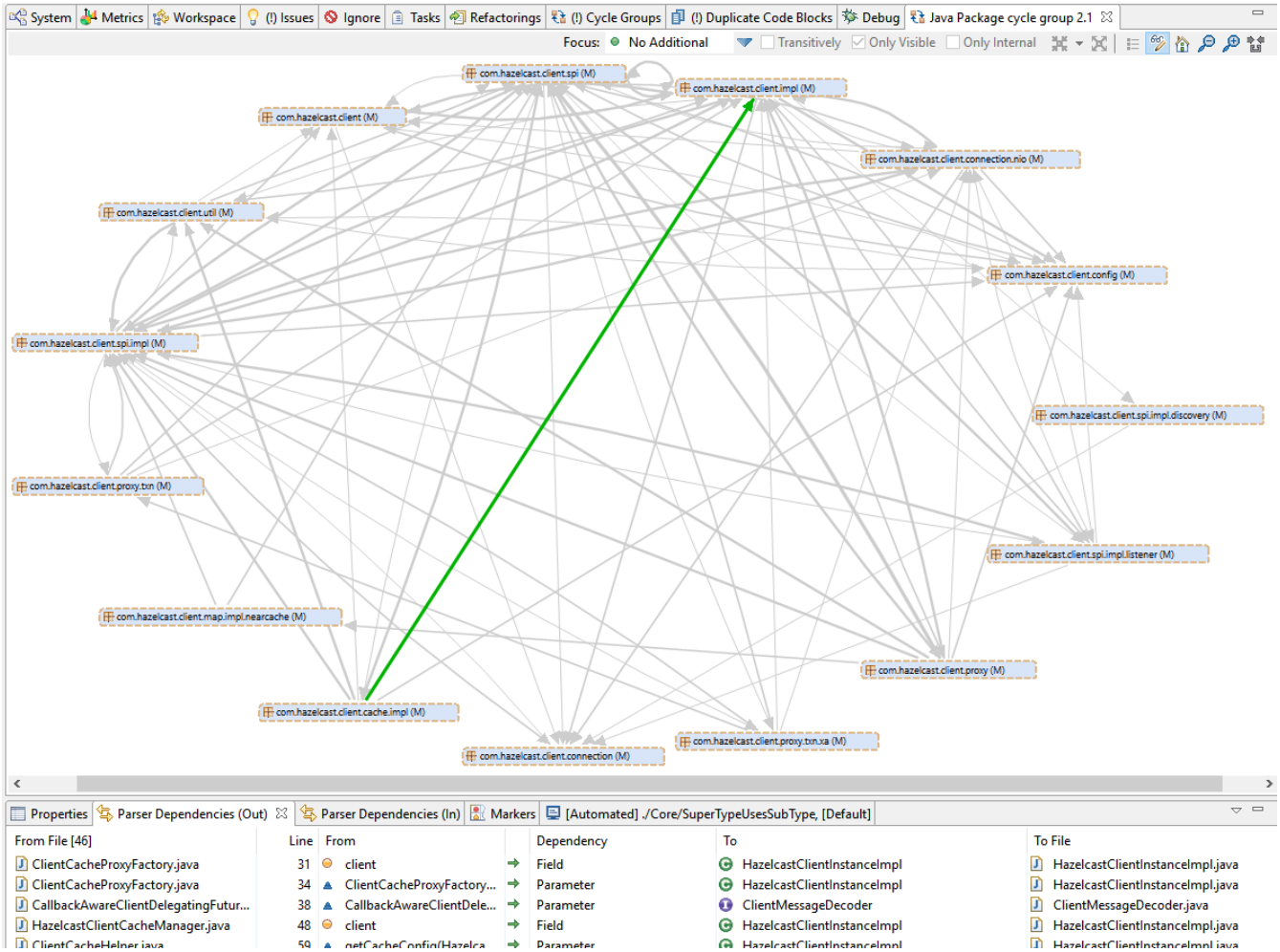


Figure 7.14. Cycle View

The Cycle view supports the same graphic exploration interactions as the Exploration, Graph and Workspace Dependencies views. More details are described in Section 7.10.1, “ Concepts for System Exploration ” .

7.9.3. Breaking Up Cycles

The Cycle Breakup view can be opened via the context menu of the Cycle view. The context menu must be requested without a selection (right click on the background).

Pressing "Compute" calculates a breakup set of edges to completely remove the given cycle. The algorithm used was presented in 'Combinatorial Algorithms for Feedback Problems in Directed Graphs' written by Camil Demetrescu and Irene Finocchi. The authors summarize the algorithm as follows:

Roughly speaking, our algorithm tries to find a compromise between two (somewhat opposite) approaches, i.e., removing light arcs, that is, arcs with small weight, and removing arcs belonging to a large number of cycles. Indeed, light arcs are convenient to be deleted as they contribute to breaking cycles, yet increasing the weight of the feedback set only to a limited extent. On the other hand, if a heavy arc belongs to a large number of cycles, it may be convenient to choose it instead of a numerous set of light arcs.

The "Breakup" table shows edges from top to bottom representing the removal order and the effect on cyclicity and number of cyclic nodes.

Dragging edges to the "Remove" table instructs the algorithm that these should be explicitly removed without considering the number of parser dependencies. Drag them back to the "Breakup" table to remove this configuration. Edges to be explicitly removed can also be dragged from the corresponding cycle view into the "Remove" table. This table may be sorted by clicking on the corresponding column header. Violating edges will be removed first by the algorithm. If more edges are contained in the

"Remove" table than are necessary to break-up the cycle, the breakup set is overdefined. Those unnecessary edges are indicated by a light-grey background color.

Pressing "Remove Violations" moves all violating edges to the "Remove" table.

Dragging edges to the "Keep" table instructs the algorithm that these should be kept if possible. If no more edges are left to remove even those that should be kept are considered. Drag them back to the "Breakup" table to remove this configuration. If the algorithm needs to consider edges as removal candidates that should be kept, the edges are analyzed from bottom to top (i.e. the topmost edge is the last to be considered). This order can be changed in the "Keep" table by dragging edges up or down. Edges that should be kept but need to be removed are highlighted in both tables with a yellow background color.

Changing the set of edges to be explicitly removed or kept requires a re-computation. This is indicated by a grey background color in the "Breakup" table and an (again) enabled "Compute" button.

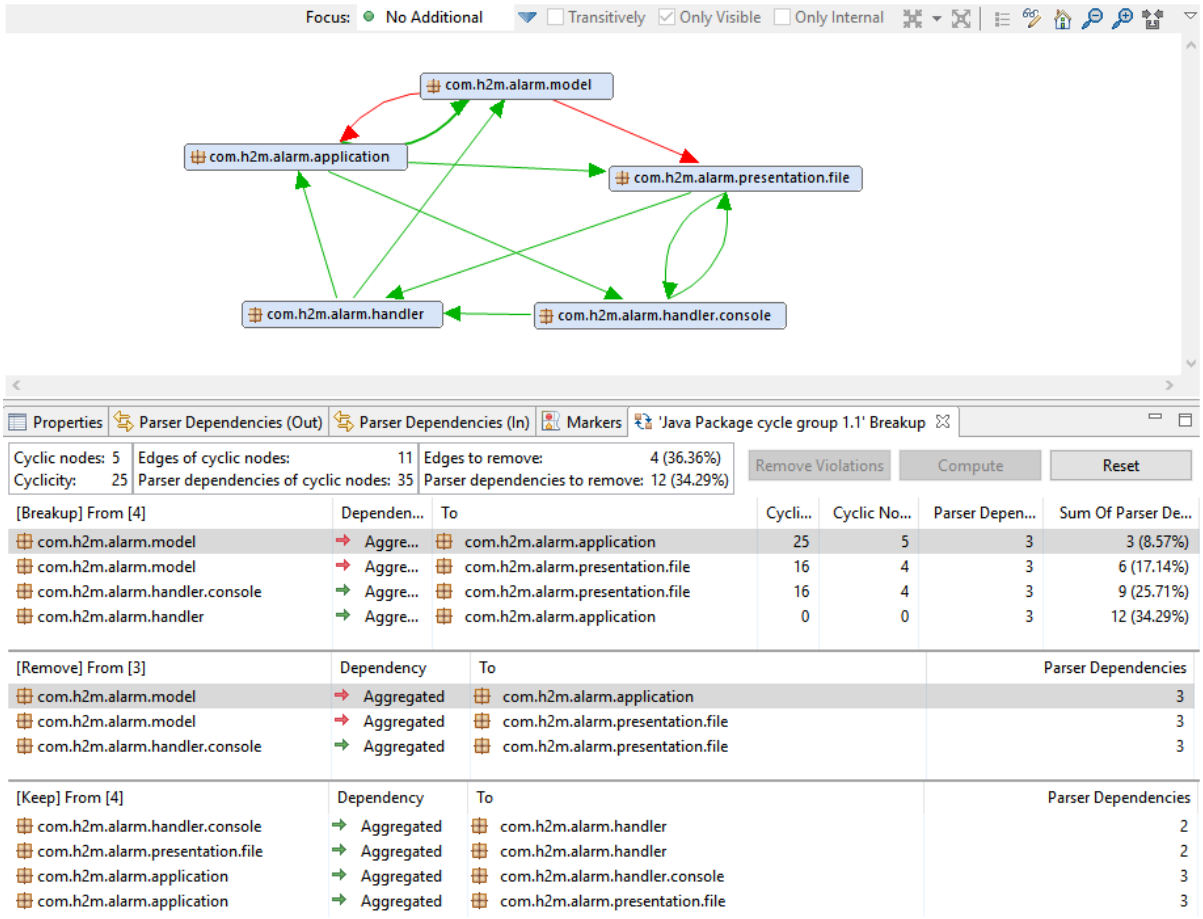


Figure 7.15. Cycle Break Up View

7.10. Exploring the System

Sonargraph offers a set of views such as Exploration, Graph and Dependencies views to allow users to explore the elements that make part of a *software system* and the dependencies between them. The following sections describe these views in detail and how to interact with them in order to make the most out of *Sonargraph*

7.10.1. Concepts for System Exploration

Before digging into the details of each view for system exploration (Exploration, Graph and Dependencies views), it is important to know some concepts and operations that apply to all of them and even to some other views (Workspace Dependencies and Cycle views). Dominating these concepts and operations when using the views allows users to extract a great amount of valuable information that can be used to make decisions about *software systems* .

7.10.1.1. Focus Concept

For Exploration, Graph, Cycle, Workspace dependencies and Include Dependencies view, the focus concept is the key element to understand how these views are created and how they can be modified to make a deeper analysis of the dependencies between elements. Any of these views (Except for the Workspace Dependencies view when there are not workspace elements in the system) will have at least one element in focus and any number of elements not in focus.

- Elements in Focus : Elements that are the center of the analysis. Dependencies will be calculated for these elements according to the selected focus mode. When an Exploration or Graph view for example is requested by the user for a set of selected elements, these elements will be the ones in focus.
- Elements not in Focus : Elements that appear as a result of the calculation of the dependencies for the elements in focus. They appear in the views because they are the end-point of a dependency from or to an element in focus but they are not the active part of the dependency analysis.

7.10.1.2. Focus Modes

When creating a new Exploration, Graph, Cycle, Workspace Dependencies view or using the focus operation inside them, one of the following focus modes can be selected:

- No Additional Dependencies : Only the selected elements and the dependencies between them are going to be part of the displayed content.
- Incoming Dependencies : The selected elements plus the elements that directly depend on them will be part of the displayed content along with the dependencies between all of them.
- Outgoing Dependencies : The selected elements plus the elements which they depend on will be part of the displayed content along with the dependencies between all of them.
- Incoming and Outgoing Dependencies : The selected elements plus the elements which they depend on and the elements that directly depend on them will be part of the displayed content along with all the dependencies involved.

7.10.1.3. Transitive Dependencies

Sometimes it is required to analyze relationships between elements beyond the direct dependencies. For this reason, *Sonargraph* offers the option of taking into account the transitive dependencies for the focus operations. To better understand this concept assume a system with the following dependencies between elements A, B, C, D and X:

- Element A depends on element B: A -> B
- Element B depends on element X: B -> X
- Element X depends on element C: X -> C
- Element C depends on element D: C -> D

Taking element X as a reference for this example, we can express the relationship between A and X as A -> B -> X and the relationship between X and D as X -> C -> D. For this relationships the following statements are true:

- X has a transitive incoming dependency from A
- X has a direct incoming dependency from B
- X has a direct outgoing dependency to C
- X has a transitive outgoing dependency to D

7.10.1.4. Exploration and Graph-based Views Properties

Besides the input elements and the focus mode, Exploration and Graph-based views need the following 3 properties to be created:

- Transitivity: Users must indicate whether they want to see transitive dependencies for the supplied input or not. See Section 7.10.1.3, “ Transitive Dependencies ”
- Only Internal: If selected, all elements under the External node will be excluded from the view.
- Dependency types: Users might want to focus the analysis on certain types of dependencies. The lower section in the dialog allows the selection of the dependency types that will be considered for view creation or focus operations.

7.10.1.5. Creating Views Exploration and Graph Based views

Quick View Creation

Exploration and Graph-based views can be created by right clicking on a selection of elements, selecting the view to open and providing one of the four focus modes from the context menu.

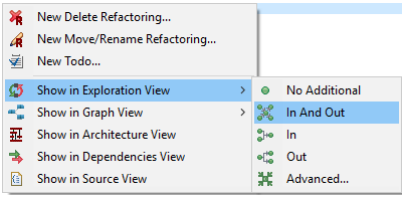


Figure 7.16. Quick View Creation

A new view will be created with the supplied focus parameter, only direct dependencies (not transitive), both internal and external elements and all the parser dependency types available.

Advanced View Creation

If more configuration options are need upon view creation, users can right click on a selection, select the view to open and click on 'Advanced...'. That will open the Advanced View Creation dialog where all available options can be configured.

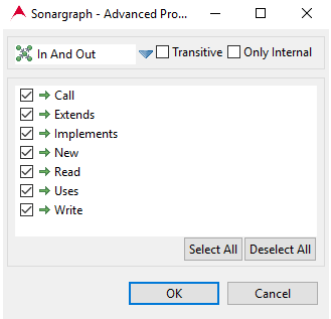


Figure 7.17. Quick View Creation

The dialog shown in the previous image shows the advanced representation creation dialog where focus mode, properties and dependency types can be specified prior to creation. See: Section 7.10.1.2, “ Focus Modes ”, Section 7.10.1.4, “ Exploration and Graph-based Views Properties ”

7.10.1.6. Applying Focus

Since Exploration and Graph-based views can display an overwhelming amount of information, it is possible to perform focus operations on these views in order to reduce the amount of displayed information to a set of nodes and edges that the user wants to focus his attention on. Focus operations are performed by using the focus toolbar.

Figure 7.18. Focus Toolbar

Focus Properties

The focus operation requires the combination of the Exploration and Graph-based properties (See Section 7.10.1.4, “ Exploration and Graph-based Views Properties ”) and the following properties of its own:

- Selection: Users can focus a view using the selected or unselected elements. It is also possible not to use a selection, in which case, only the dependency types will be modified.

- Only Visible : If selected, only nodes and edges visible at the time of the focus operation will be considered, otherwise, all the model will be used for the focus operation.

Quick Focus

The focus button in the focus toolbar offers a dropdown menu with 4 options to perform a quick focus operation.

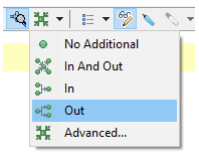


Figure 7.19. Focus Dropdown Menu

As the image shows, there is one menu entry for each focus mode. These menu entries can be used to perform quick focus operations which will use the current selection, the current value of the 'Only Visible' button, the focus mode of the menu entry and keeps all the other properties of the current view (dependency types, only internal and transitive).

Advanced Focus

If more configuration is needed to perform a focus operation, users can push directly the focus button in the focus toolbar or use the 'Advanced..' menu entry in the dropdown menu of this same button. Any of these operations will open the 'Advanced Focus' dialog which allows the configuration of all view and focus properties.

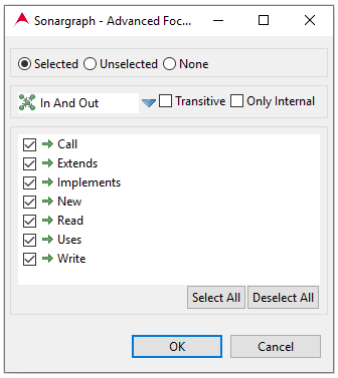


Figure 7.20. Advanced Focus Dialog

7.10.1.7. Semantics of Colors

Architecture and Colors

When a license in use contains the *Sonargraph* Architecture feature, the Exploration, Graph, Cycle and Dependencies views will use a set of colors to show whether the edges (or dependencies in the case of the Dependencies view) contain architecture violations or not.

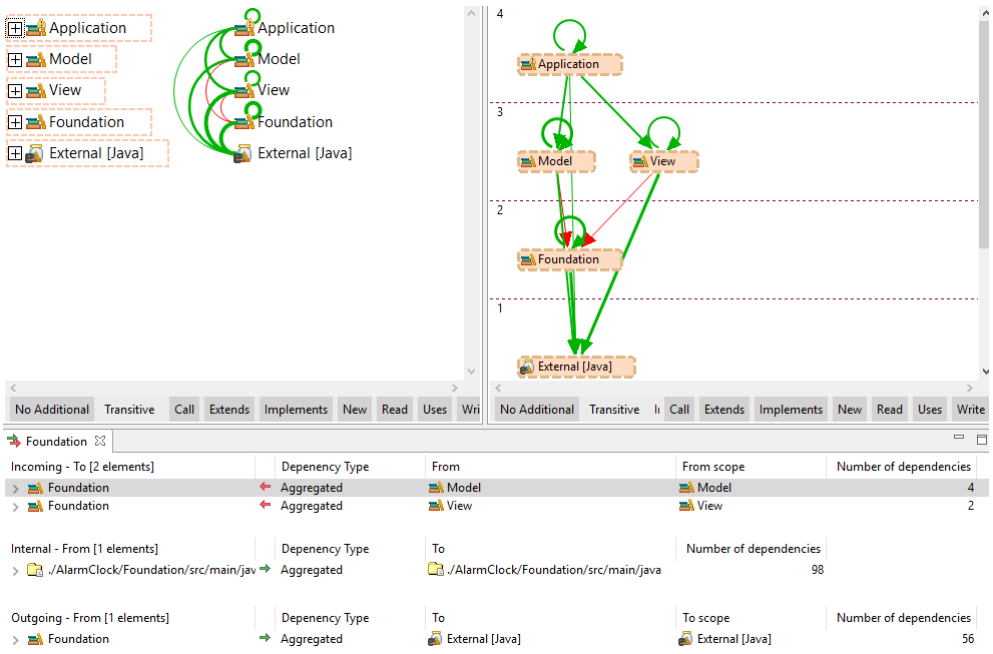


Figure 7.21. Semantics of Colors

- Green Color: All underlying dependencies comply with the architecture.
- Yellow Color: At least one but not all of the underlying dependencies create architecture violations.
- Red Color: All underlying dependencies create architecture violations.

Besides these 3 colors, views can eventually show some dependencies that will always be grayed. This means that these dependencies are not taken into account by the architecture check, thus they are neither allowed nor violating dependencies.

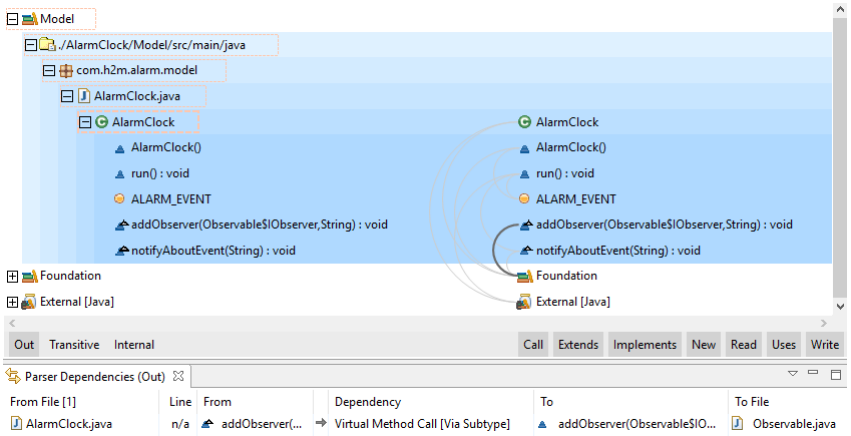


Figure 7.22. Architecture Independent Dependencies

Selection and Colors

In the case of the Exploration Graph and Cycle views the selection will cause edges to display or hide their architecture-related color. If a node is selected, its incoming and outgoing edges will reveal their architecture-related color, all other edges will be grayed. If an edge is selected, it will be the only one revealing its architecture related color and the rest of them will be grayed. This is of course assuming that a license containing the *Sonargraph* Architecture feature is installed, otherwise, incoming and

outgoing edges of selected nodes as well as selected edges will have a darker gray color whereas all other edges will have a lighter gray color. This is also the case for Workspace Dependencies and Include Dependencies views, where edges will always be presented in gray-scale colors.

7.10.2. Tree Based System Exploration

The Exploration view offers the possibility of using a tree representation to learn about the structure and interdependencies among the structural elements of the *software system* :

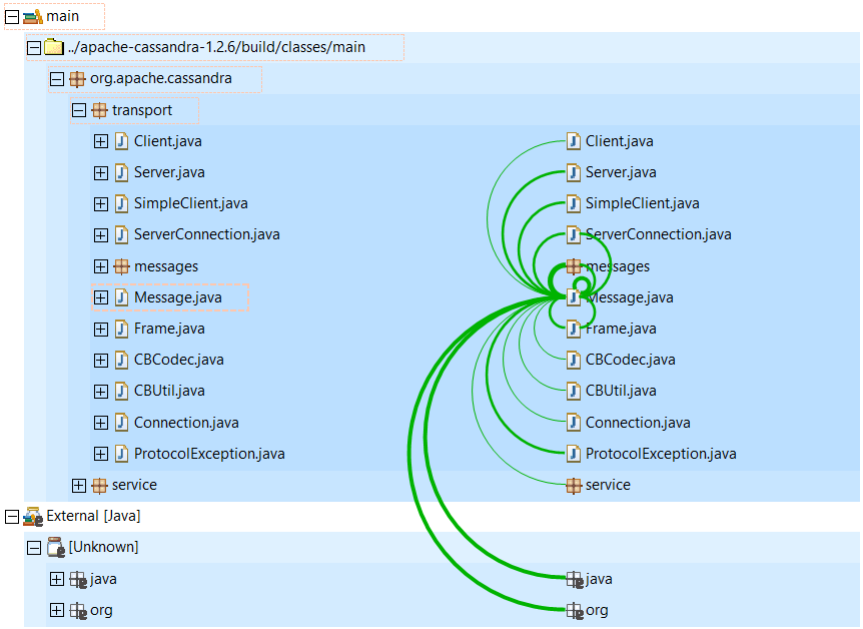


Figure 7.23. Exploration View

Typical questions are:

- What are the dependencies between some layers, subsystems, packages or types?
- What is the reason for some unexpected dependency?
- How can one decouple a given pair of package trees?
- Where is package X or file Y located in the package tree?

The exploration view provides a number of means supporting you to:

- Get an overview of your *software system* on a high abstraction level.
- Drill down to answer specific questions.
- Zoom in and out of the Sonargraph model tree by expanding and collapsing nodes.
- Define focus so that irrelevant information is hidden.

7.10.2.1. Drilldown

One of the most powerful features of the Exploration view is the Drilldown. Users can expand the nodes that appear in the view in order to see the dependencies between the children of the expanded object and the rest of the elements that make part of the content of the view.

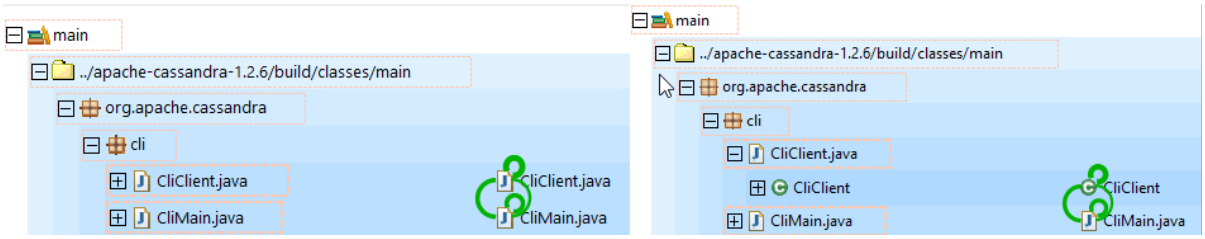


Figure 7.24. Before and After Drilldown

As expected, nodes in the Exploration view can also be collapsed in order to see de dependencies of the collapsed nodes with the rest of the elements present in the view.

It is important for users to note that the expand operation will behave differently for nodes that are part, or are children of the input used to generate the view and for elemets that are not related to the input. For the first ones, they will be expandable if they have children elements and the expand operation will show all children even if they have no dependencies at all. For the second ones, they will only be expandable if at least one of the children has dependencies to other elements in the view and only the children that do have dependencies will be shown; the ones that do not have dependencies will be omitted.

7.10.2.2. Extending the Focus

In an Exploration view, it is possible to extend the focus. In other words, it is possible for a group of elements not in focus to become elements in focus, thus expanding the dependency calculation of the view with the dependencies for the selected elements according to the current focus mode of the view.

To better illustrate the "Extend Focus" operation, assume the following Exploration view:

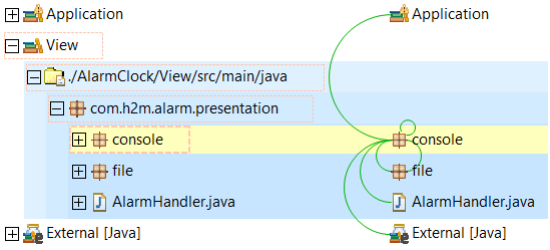


Figure 7.25. Sample Exploration view

This view has been created by selecting the "console" namespace with focus mode "In and Out", that is, showing incoming and outgoing dependencies. Let's suppose that for whatever reason, "AlarmHandler.java" becomes an element of interest of the user that created this view and it is important to see how it is related to the elements in the view other than "console". This can be achieved by right clicking on the element and selecting "Focus" → "Extend Focus (Only Visible)"

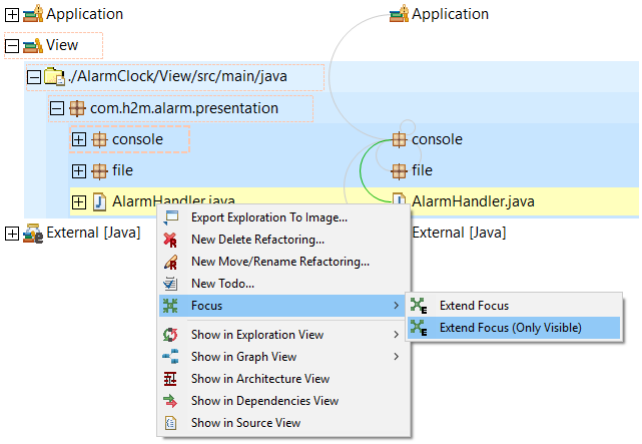


Figure 7.26. Extend Focus Menu

The result of this operation is having both "console" and "AlarmHandler.java" as elements in focus and the rest of the visible nodes as element not in focus.

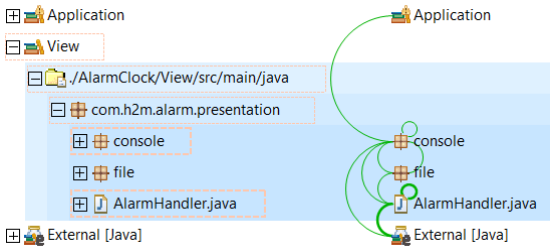


Figure 7.27. Extend Focus Result

7.10.2.3. Removing Elements From Focus

Conversely to the Extend Focus operation, it is possible to remove elements from the focus. In other words, it is possible to convert an element that is an active part of the dependency calculation into an element that is only an endpoint of a dependency from/to others element in focus. If there are no dependencies at all involving the elements removed from focus, they will disappear from the Exploration view.

To better illustrate the "Remove From Focus" operation, assume the following Exploration view:

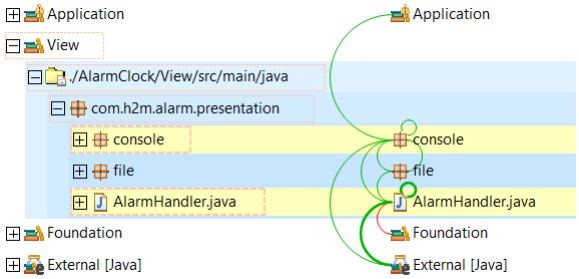


Figure 7.28. Sample Exploration view

This view has been created by selecting the "console" namespace and "AlarmHandler.java" with focus mode "In and Out", that is, showing incoming and outgoing dependencies. Let's suppose that for whatever reason, "AlarmHandler.java" is no longer important for the dependency analysis and we want to make of it a passive element in the dependency calculation at most. This can be achieved by right clicking on the element and selecting "Focus" → "Remove From Focus"

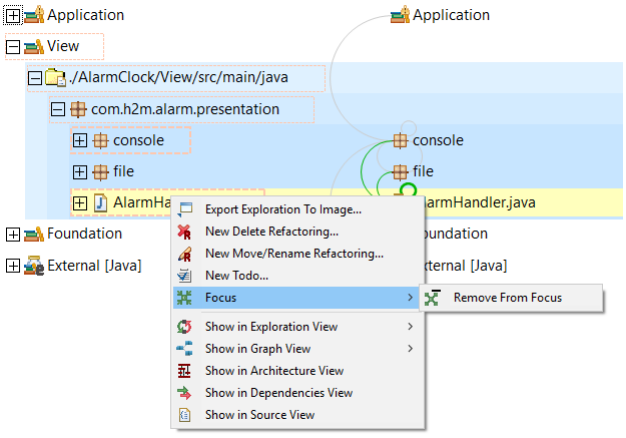


Figure 7.29. Extend Focus Menu

7.10.2.4. Interaction with Auxiliary Views

The Exploration view offers interaction with the Auxiliary views of *Sonargraph* (Parser Dependencies in and out views to be precise). This interaction allows to see the underlying parser dependencies that are represented by the arcs in the view. Auxiliary views can be used in two ways from the Exploration view:

- Arc selection: By selecting an arc and having the Parser Dependencies (Out) view in front, it is possible to see the underlying parser dependencies for that specific arc.

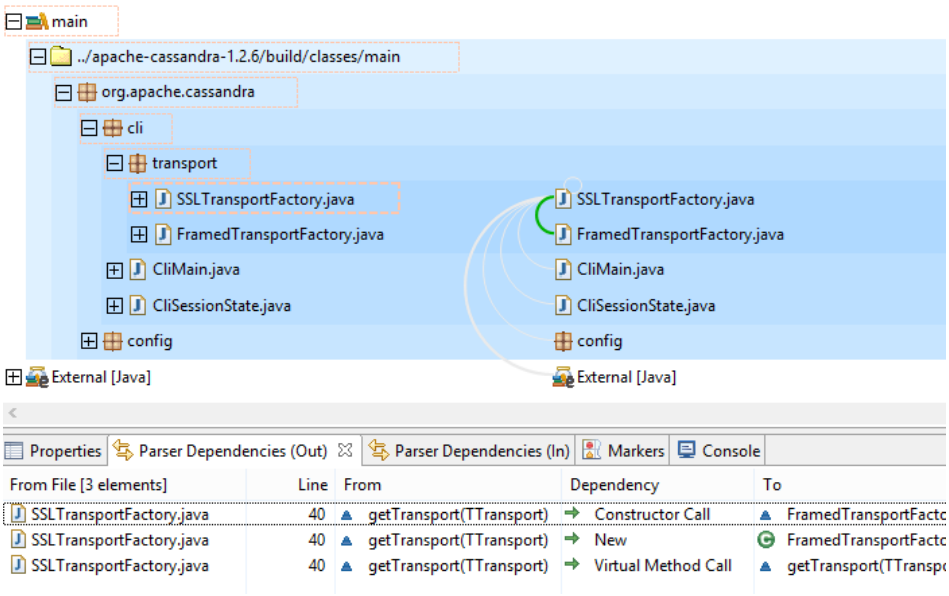


Figure 7.30. Underlying Parser Dependencies for Arc

- Element selection: By selecting only one element and having the Parser Dependencies (In) or (Out) in front, it is possible to see the underlying incoming or outgoing parser dependencies of the arcs that come into the node or go out of it.

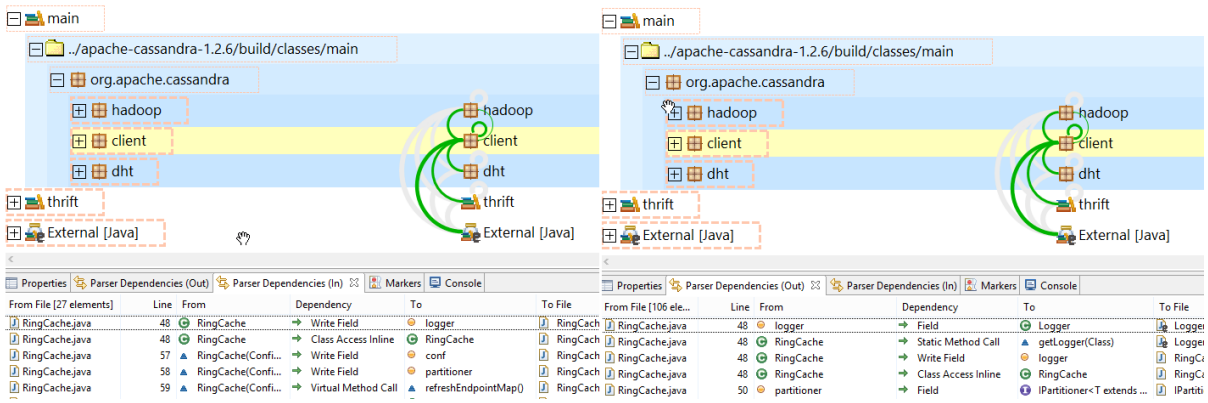


Figure 7.31. Incoming and Outgoing Parser Dependencies

- View option synchronization: Parser Dependencies views (in and out) support the synchronization of the 'Show only violations' view option with the current value of this same option in the Exploration view.

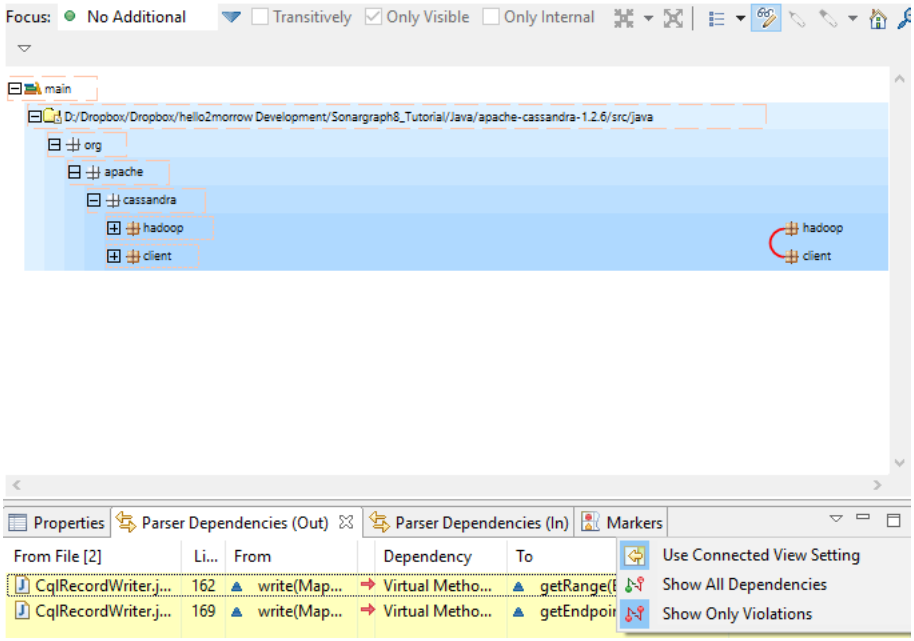


Figure 7.32. View option synchronization

To enable this feature select 'Used Connected View Setting' in the Parser Dependencies view and *Sonargraph* will set the correct value from the Exploration view.

7.10.2.5. Expand Dependency to Component Level

The Exploration view offers the possibility of showing dependencies between all kinds of elements of the parser model, however, users might find very valuable to see how *Components* are related in a *software system* . For this reason, *Sonargraph* offers the possibility of showing the underlying dependencies between Components for an arc by double-clicking on it.

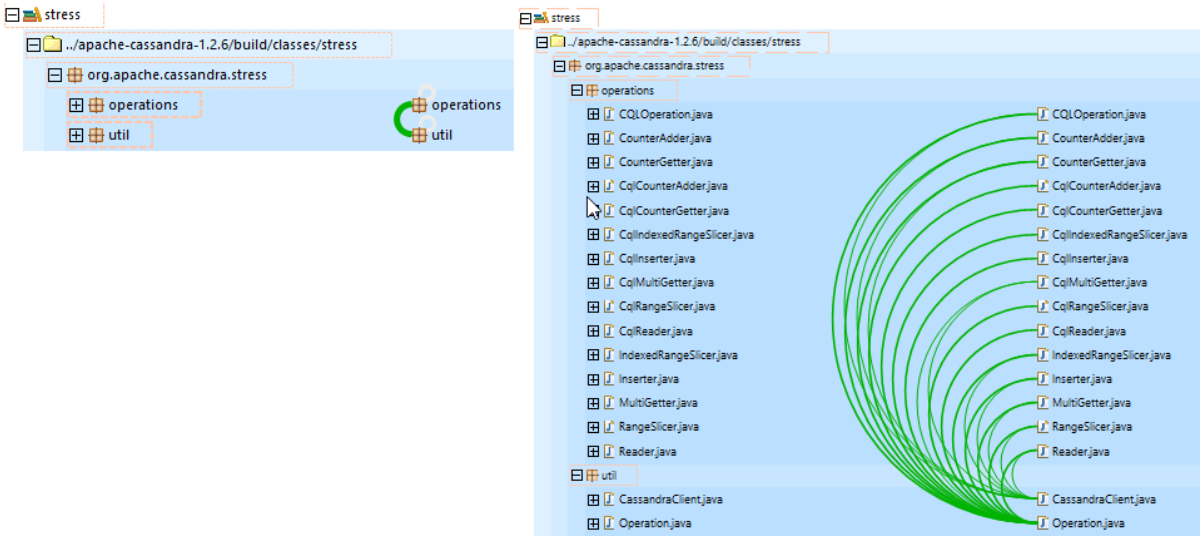


Figure 7.33. Expand Dependency to Component Level

Expanding an arc to component level will be available for all arcs except those whose both end-points have a component as parent, meaning that there are no underlying dependencies between components for that arc.

7.10.2.6. Context Menu Interactions

Sonargraph offers navigation possibilities from the Exploration view to other views in order to extract the greatest amount of valuable information from the software system analysis. To see the navigation posibilities, select a single arc or an arbitrary number of nodes and press right-click button.

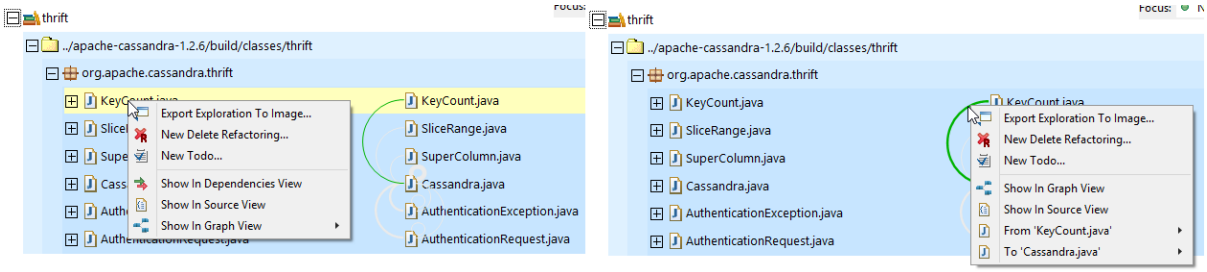


Figure 7.34. Context Menu Interactions

7.10.2.7. View Options

To change the way the content is displayed in the Exploration view, the options that are located at the right hand side of the view's toolbar can be used.

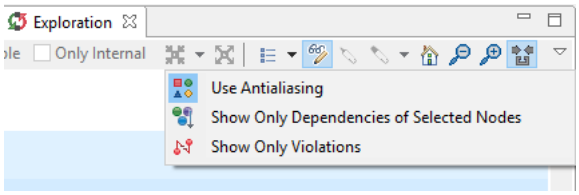


Figure 7.35. View Options

- Highlight Input : When activated, an orange-dashed box will be drawn for the nodes used as input to create the view.
- Adjust Zoom Automatically : When activated, the view will automatically zoom in or out when the its size changes in order to try to fit as much as possible its content to the available size.
- Use Antialiasing : When activated, the edges will look smoother and better defined, however, it is recommended to deactivate this option when running *Sonargraph* on low-end hardware.
- Show Only Dependencies Of Selected Nodes : When this option is activated, only the incoming and outgoing arcs of the selected elements will be shown, the rest will be hidden. If there is no selection, all arcs will be shown.
- Show Only Violations : When this option is activated, only arcs containing architecture violations are shown. If all underlying parser dependencies of the arc are violations, then the arc will remain unchanged. If the arc has both violating and non-violating parser dependencies, it will change from yellow to red and the width will be adjusted with the weight of the violating dependencies.
- Hide Self Arcs : When activated, edges whose from and to end-points are the same node will be removed from the view.
- Auto Expand : When activated, expand operations that result in the expanded node having only one child will cause this single child to be expanded. This will happen recursively until at least 2 children are found or there are no more elements to expand.

7.10.3. Graph Based System Exploration

The graph based system exploration allows users to take an arbitrary selection of elements and create a graph representation with nodes and edges to find out what their overall interaction looks like:

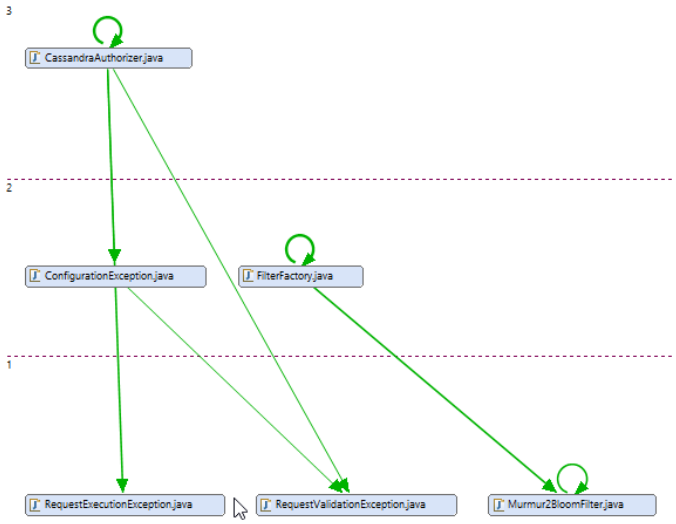


Figure 7.36. Graph View

By default, the graph perspective presents a levelized layout which comes handy to visualize the levels in which the software system elements are classified according to their dependencies to each other.

7.10.3.1. Levels

Showing levelized content is a unique feature of the Graph view in relation to other views in the application. When a Graph view is requested, *Sonargraph* organizes nodes in a way that given each edge of the graph and both From and To end-points of the edge, the From end-point will always be in a greater level than the To end-point.

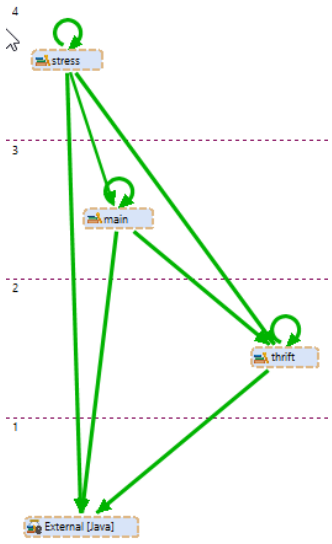


Figure 7.37. Levels in Graph View

This way of layouting immediately gives the user an idea of how strong or weak is the coupling among the selected elements that form the content of the view and how modifications will impact elements that belong to different levels.

7.10.3.2. On Demand Cycle Groups

When creating a Graph view for an arbitrary selection of elemens, it is possible that there are cyclic dependencies among the elements that make part of the content of the view. In this case, it would be impossible to define levels among the elements that

belong to a cycle and with all of them belonging o a same level, the readability of the graph would decrease. To avoid this effect, *Sonargraph* gathers all elements that form cycle groups into elements called "On Demand Cycle Groups".

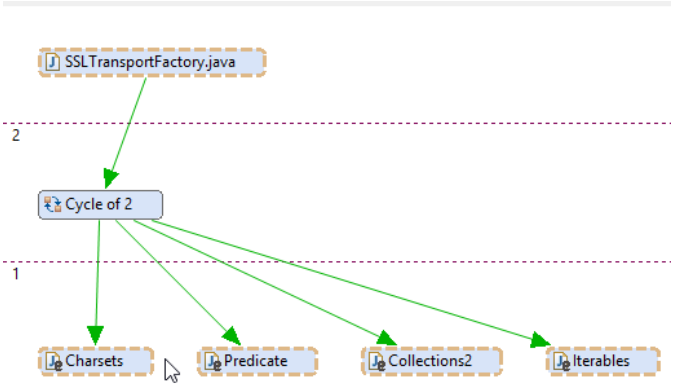


Figure 7.38. On Demand Cycle Groups

For a quick reference of the elements that are involved in an On Demand Cycle Group, hover the node with the mouse and a tooltip with appear with the list of cyclic elements. For a detailed view of the cyclic elements and the dependencies involved, right-click on the node and select "Show in Cycle View"

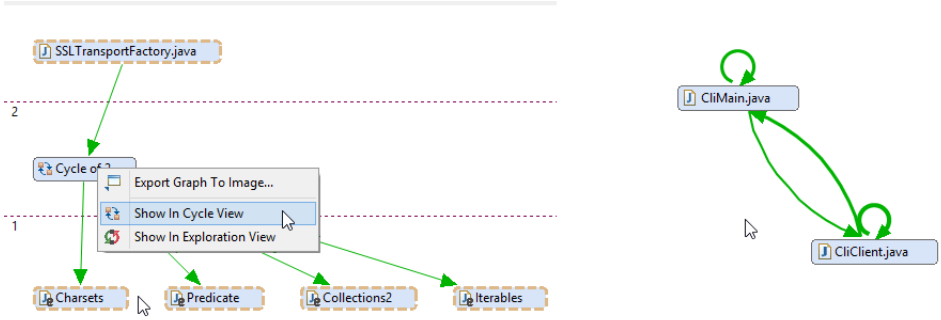


Figure 7.39. On Demand Cycle Groups

7.10.3.3. Interaction with Auxiliary Views

The Graph view offers interaction with the Auxiliary views of *Sonargraph* (Parser Dependencies in and out views to be precise). This interaction allows users to see the underlying parser dependencies that are represented by the edges in the view. Auxiliary views can be used in two ways from the Graph view:

- Edge selection: By selecting an edge and having the Parser Dependencies (Out) view in front, it is possible to see the underlying parser dependencies for that specific edge.

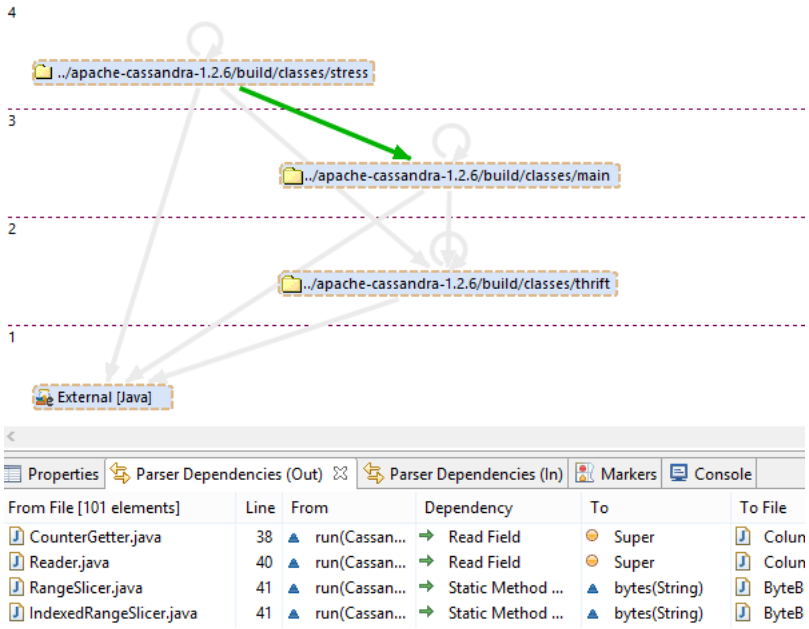


Figure 7.40. Underlying Parser Dependencies for Edge

- Element selection: By selecting only one element and having the Parser Dependencies (In) or (Out) in front, it is possible to see the underlying incoming or outgoing parser dependencies of the edges that come into the node or go out of it.

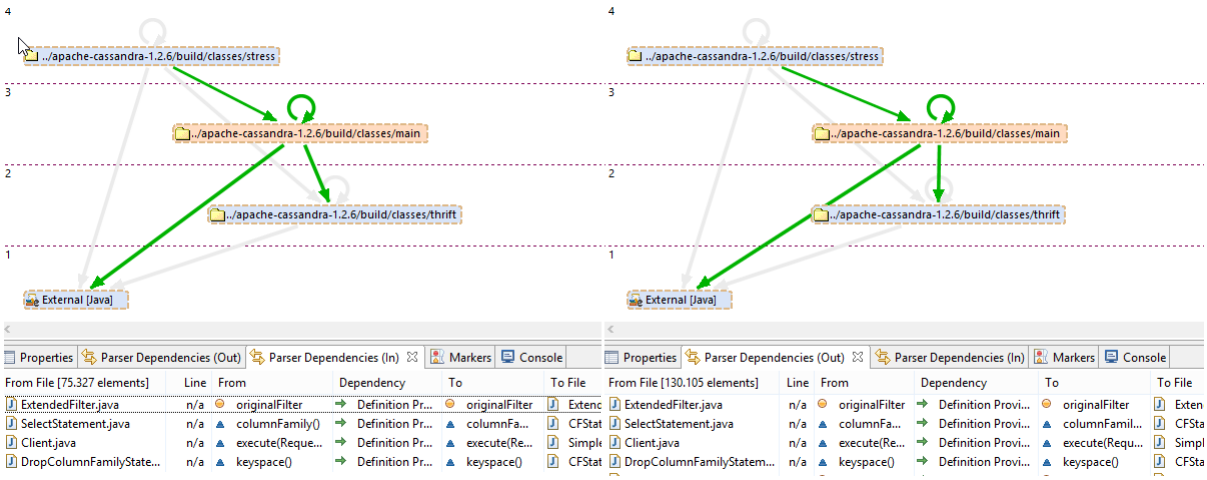


Figure 7.41. Incoming and Outgoing Parser Dependencies

- View option synchronization: Parser Dependencies views (in and out) support the synchronization of the 'Show only violations' view option with the current value of this same option in the Graph view.

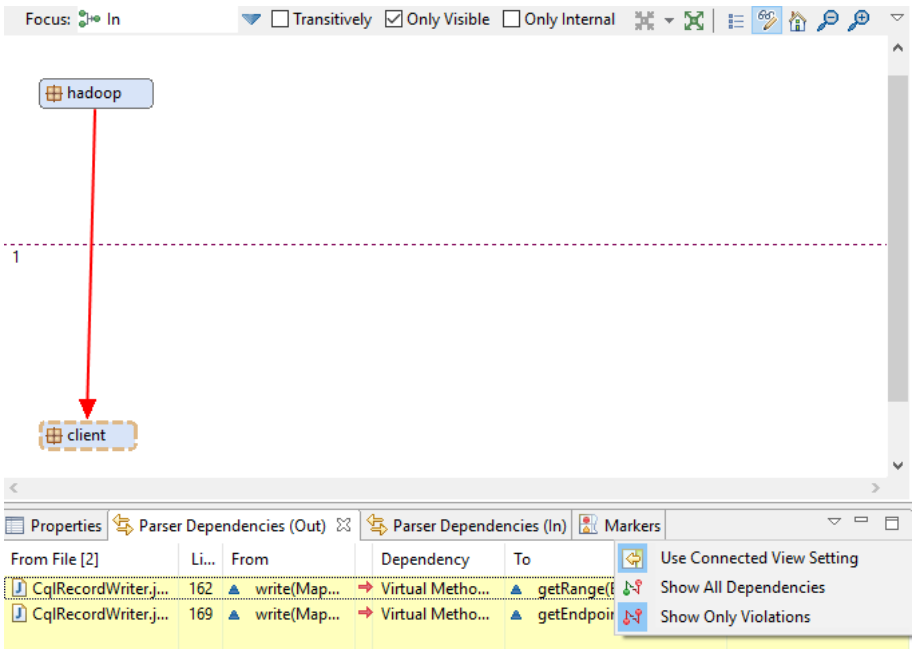


Figure 7.42. View option synchronization

To enable this feature select 'Used Connected View Setting' in the Parser Dependencies view and *Sonargraph* will set the correct value from the Graph view.

7.10.3.4. Context Menu Interactions

Sonargraph offers navigation possibilities from the Graph view to other views in order to extract the greatest amount of valuable information from the software system analysis. To see the navigation possibilities, select a single edge or an arbitrary number of nodes and press right-click button.

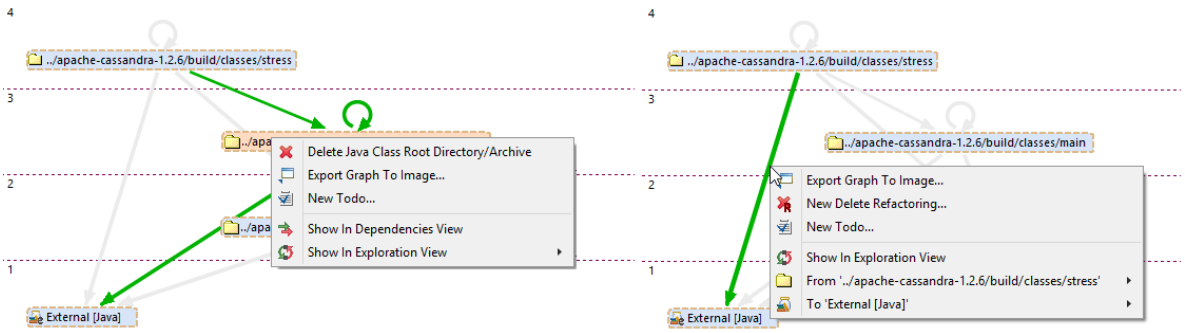


Figure 7.43. Context Menu Interactions

7.10.3.5. Type Based Graph

When selecting a Type (e.g. classes or enums), the regular Graph view will show incoming and outgoing dependencies of the selected elements to all kind of programming elements (fields, methods functions etc). To perform specific analysis like Java hierarchy graphs, it is necessary to show the dependencies between Types (Java classes in this case) that aggregate the underlying parser dependences to other programming elements than are children of types. To show a Type-based graph, select a Type in the navigation view and select 'Show in Graph View (Type-Based).

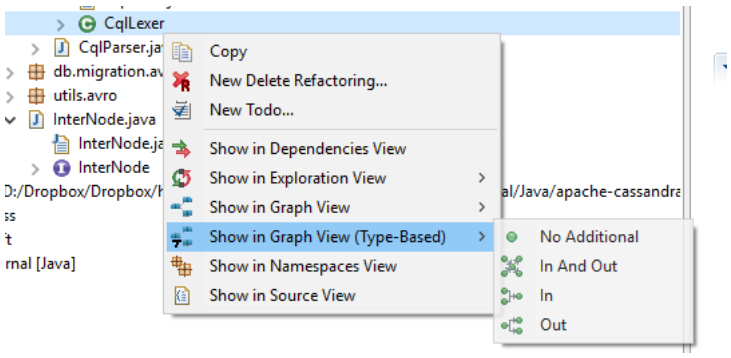


Figure 7.44. Show Type-based Graph view

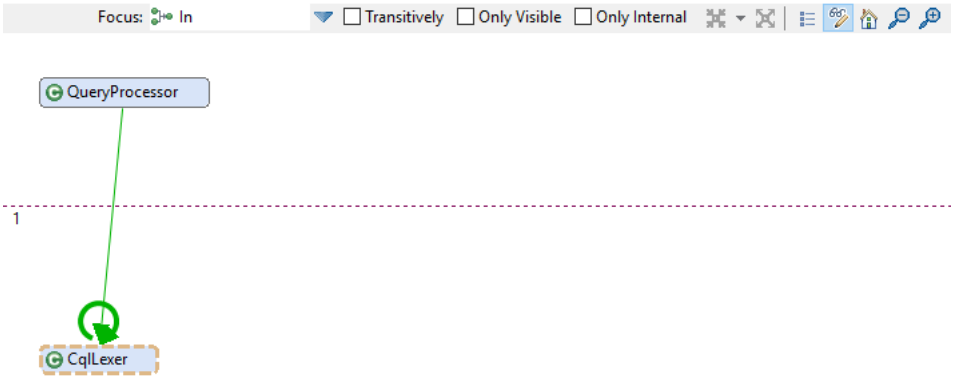


Figure 7.45. Type-based Graph

7.10.3.6. View Options

To change the way the content is displayed in the Exploration view, the options that are located at the right hand side of the view's toolbar can be used.

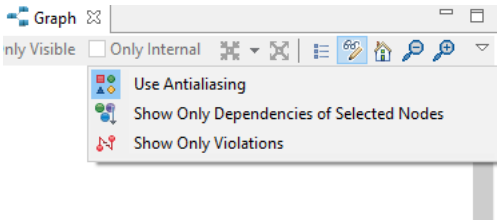


Figure 7.46. View Options

- Highlight Input : When activated, an orange-dashed box will be drawn for the nodes used as input to create the view.
- Use Antialiasing : When activated, the edges will look smoother and better defined, however, it is recommended to deactivate this option when running *Sonargraph* on low-end hardware.
- Show Only Dependencies Of Selected Nodes : When this option is activated, only the incoming and outgoing arcs of the selected elements will be shown, the rest will be hidden. If there is no selection, all arcs will be shown.
- Show Only Violations : When this option is activated, only arcs containing architecture violations are shown. If all underlying parser dependencies of the arc are violations, then the arc will remain unchanged. If the arc has both violating and non-

violating parser dependencies, it will change from yellow to red and the width will be adjusted with the weight of the violating dependencies.

- Hide Self Arcs : When activated, edges whose from and to end-points are the same node will be removed from the view.

7.10.4. Tabular System Exploration

Sonargraph also offers the possibility of exploring the system in a tabular way through the Dependencies view. By selecting a single element of the parser model, users can observe and explore its incoming, internal and outgoing dependencies.

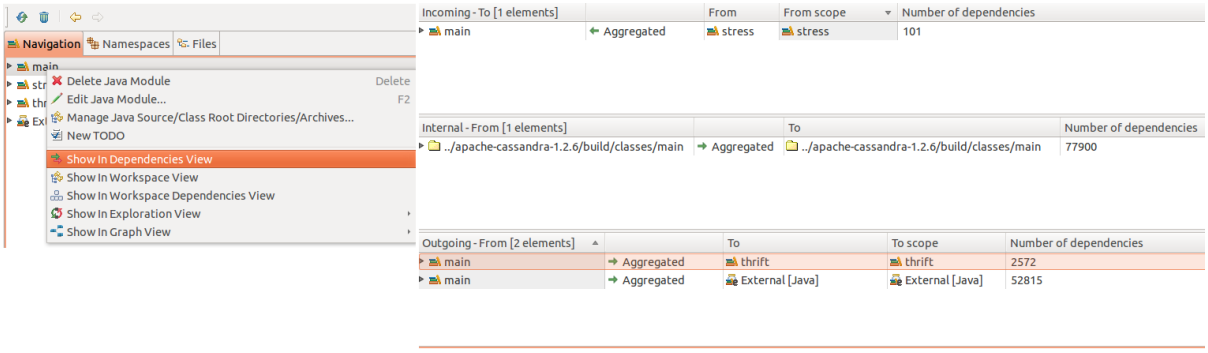


Figure 7.47. Dependencies View

7.10.4.1. Drilldown

One of the most helpful features of the Dependencies view is its capability to allow users to drilldown from the dependencies between the top-most elements in the model to the dependencies between the finest-grained elements in the parser model.

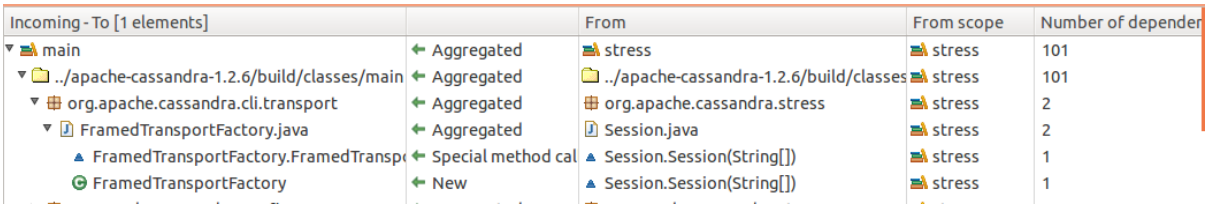


Figure 7.48. Drilling Down Dependencies

It is important to note that as seen in the previous figure, some elements that belong to the parser model are not taking into account when drilling down in the Dependencies view in favour of readability. For example, packages "org", "apache", "cassandra" and "cli" do not play one role in the drilling down other than providing a context for the element that is really makes part of the content which is "transport". This apply as well for other structures that allow nesting such as Namespaces and Directory paths in C/C++ and C# parser models.

In a similar way, when the Dependencies view is requested for an element that allows nesting, the selected element will take part in the content of the view only if it has elements of a different kind as children, otherwise, it will be omitted. Similarly, all children of the selected element that fulfill the same condition will be displayed for this request.

7.10.4.2. Interaction with Auxiliary Views

The Dependencies view offers interaction with the Parser Dependencies (Out) auxiliary view of *Sonargraph* . This interaction allows users to see the underlying parser dependencies that correspond to each entry in the incoming, internal and outgoing dependencies tables. By selecting only one dependency and having the Parser Dependencies (Out) in front, it is possible to see its underlying parser dependencies.

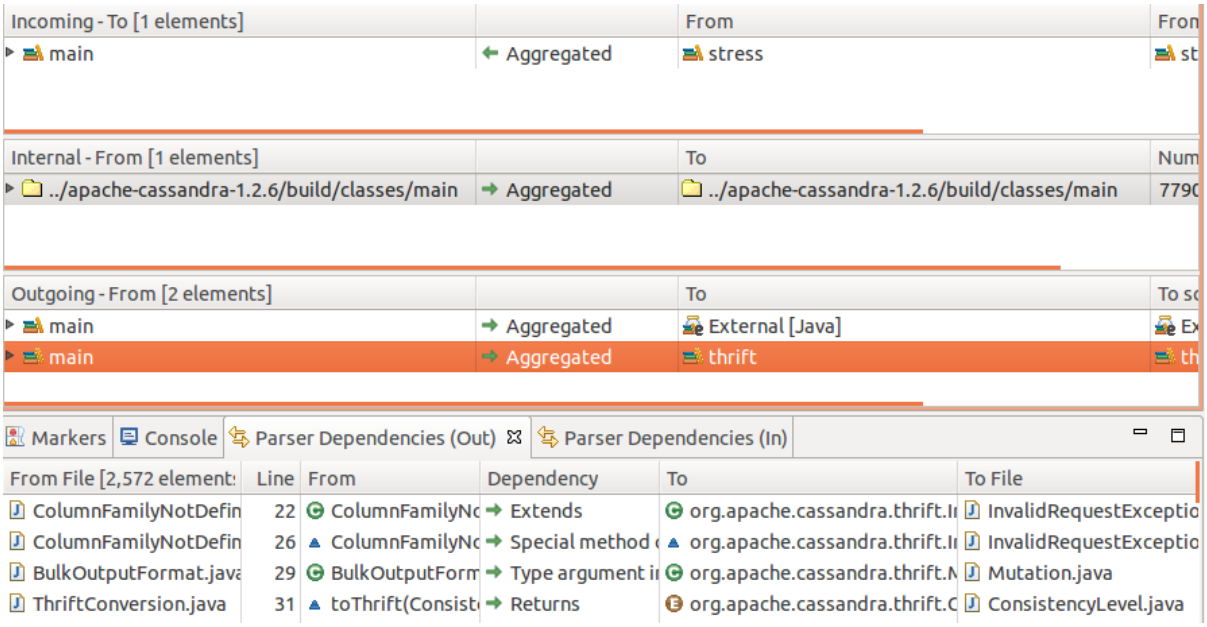


Figure 7.49. Interaction with Auxiliary Views

7.10.4.3. Context Menu Interactions

Sonargraph offers navigation possibilities from the Dependencies view to other views in order to extract the greatest amount of valuable information from the software system analysis. To see the navigation posibilities, righ-click any dependency in the view and select whether the interaction should consider the From or the To end-point of the dependency. Depending on the selected end-point, navigation possibilities will show up.

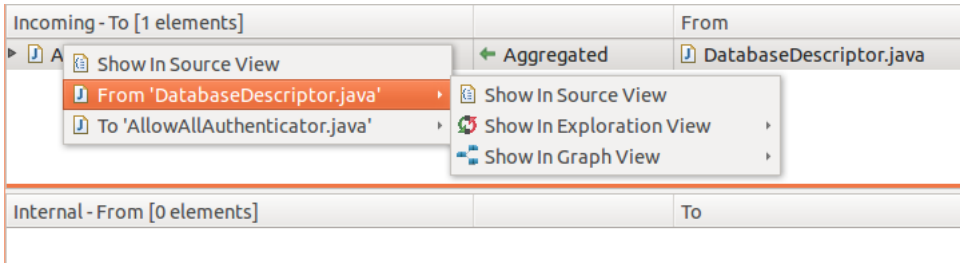


Figure 7.50. Context Menu Interactions

7.11. Searching Elements

For systems with a very large code base, finding *programming elements* can sometimes prove challenging. *Sonargraph* offers a search dialog to quickly locate *programming elements* in the currently open *software system*.

To bring it up select "Edit" → "Search..." .

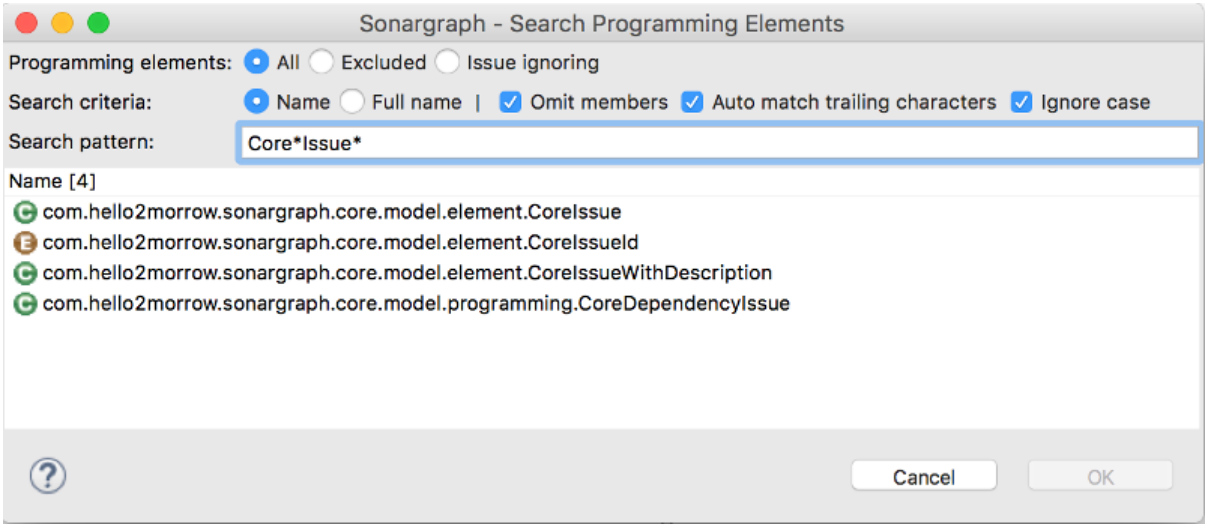


Figure 7.51. Standard Search Dialog

The dialog will start revealing potential matches as soon as you start typing the element you are looking for. You can search for simple or complete name of a *programming elements* and choose to omit members, search for excluded elements only, auto match trailing characters and search ignoring case.

After selecting the correct element, the Navigation view highlights the found element.

If you want to extend the search to also find methods or member variables, deselect the option "Omit members". If also "Full name" is activated, filtering by packages and types is possible as shown in the following screenshot.

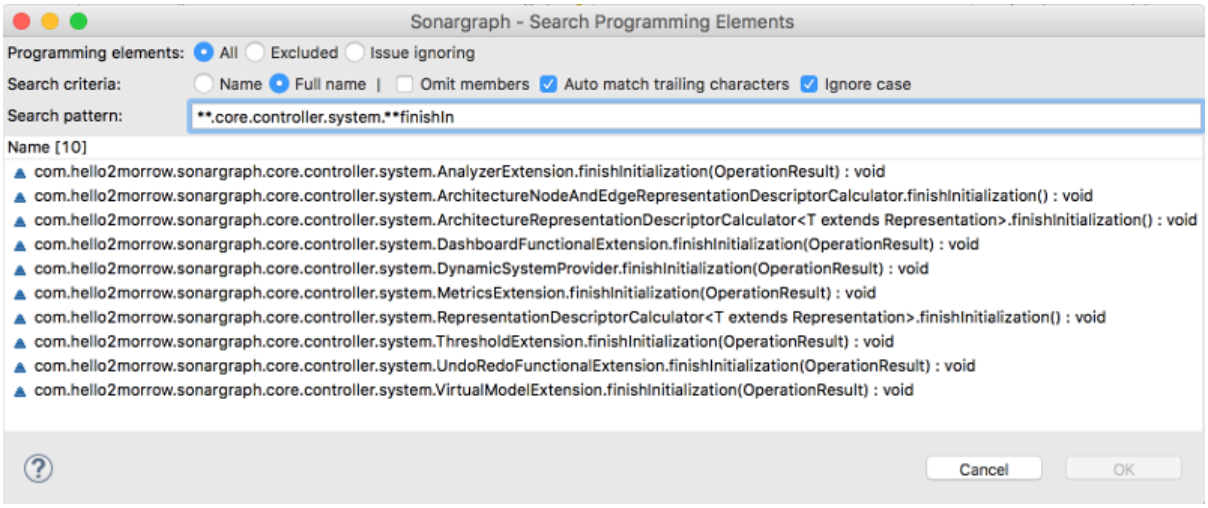


Figure 7.52. Search Dialog to Locate Members

NOTE that you can either search in all programming elements or restrict the search to 'Excluded' or 'Issue ignoring'. This might be used to check if the workspace filters (Production Code filter and Issue filter) have been configured correctly.

7.11.1. Searching Elements in Views

Text search functionality is supported by Graph and Exploration views and most table based views, like the Issues view, Refactorings view, Metrics view, etc. This functionality makes it easy to navigate a view that displays a high number of elements. Matches are highlighted as shown in the following screenshot.

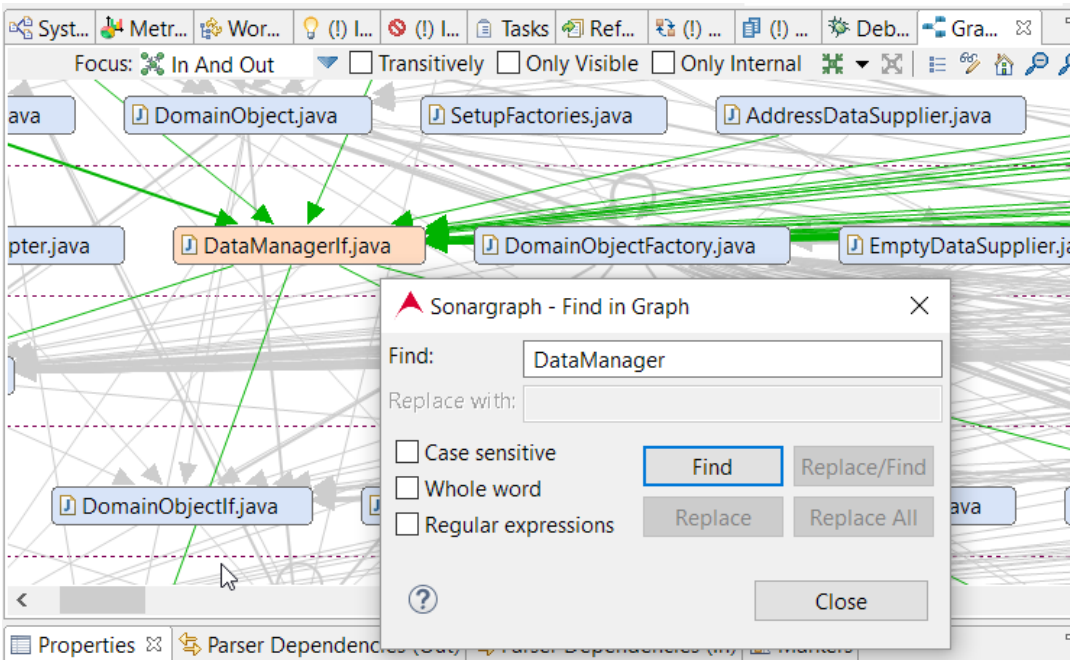


Figure 7.53. Text Search in Views

7.12. Detecting Duplicate Code

Duplicate code analysis in *Sonargraph* is achieved through the Duplicate Blocks view and the Duplicates Source View. The Duplicate Blocks view lists duplicate code blocks that have been found in source files of the system that have not been excluded from analysis via a filter. For each duplicate block, all the occurrences are listed, with source file, length of the block in lines, start line of the block, and the tolerance, i.e., a number of lines that need to be changed in the block so that it is (more or less) equal to another text block.

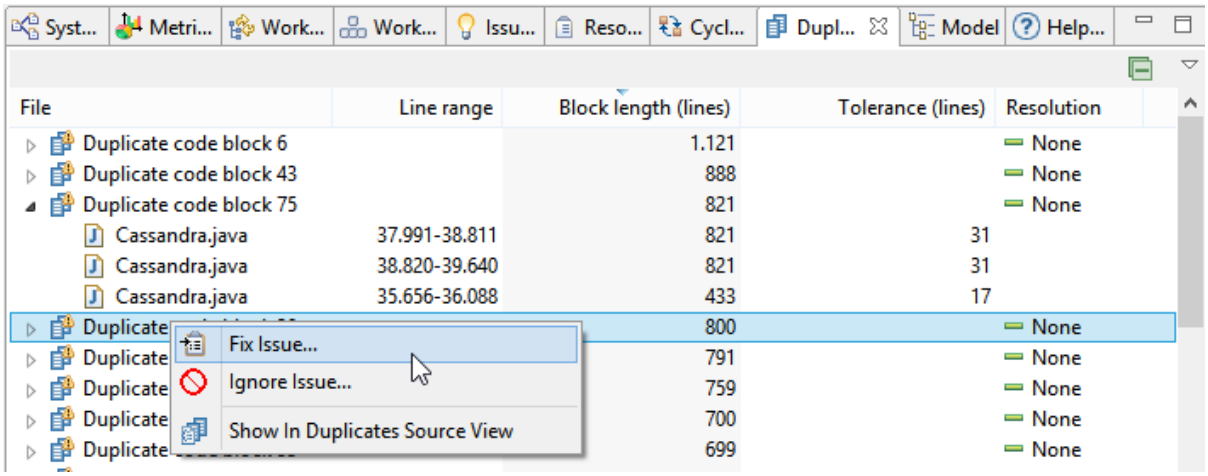


Figure 7.54. Duplicate Blocks View

Duplicate code blocks are considered as issues in *Sonargraph* as they make more difficult the maintenance of the code base and undermines the implementation of new features. Thus, duplicate code blocks can also be found in the form of Issues in the Issues view of *Sonargraph* (See Section 8.2, “ Examining Issues ”). The context menu for a duplicate block (both in the Duplicate Blocks view and the Duplicates Source view) allows to take care of it as an issue, by either ignoring it or creating a fix resolution for it.

By double-clicking (or selecting "Show In Duplicates Source View" in the context menu) on a line that represents a duplicate code block, one jumps to the Duplicates Source View where the selected occurrence is presented side by side along with the next occurrence in the block so that the similarities and differences can be appreciated:

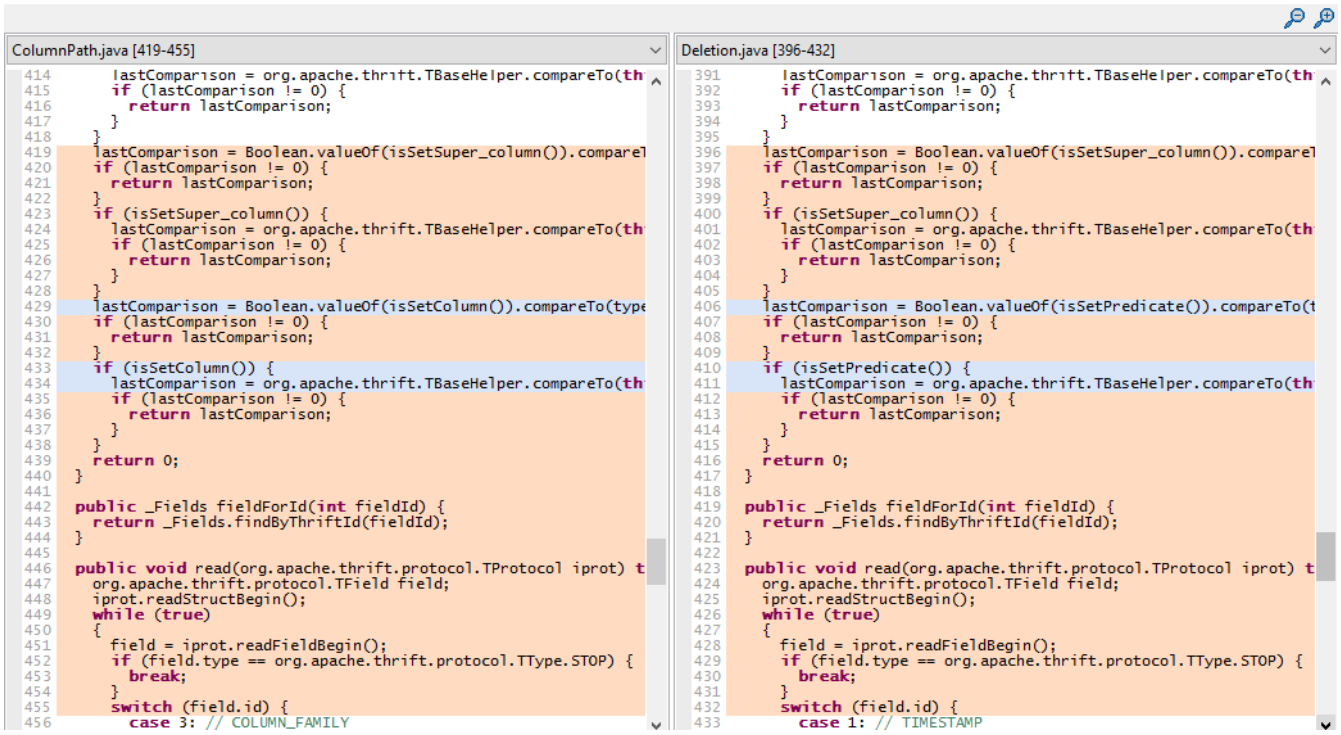


Figure 7.55. Duplicates Source View

Normally, duplicate code blocks are computed automatically on every *software system* open or refresh via the duplicate code analyzer.

7.12.1. Configuration of Duplicate Code Blocks Computation

The settings for how duplicates are located can be adjusted at "System" → "Configure..." → "Duplicate Code" . Normally, the default settings are acceptable. In order to understand how the configuration parameters work, it is helpful to know how the algorithm works. The main process is as follows:

- First, candidates for start lines of duplicate code blocks are determined. For this, all lines of all source files are read.
- If a line is too short (shorter than the number given in the configuration parameter "Minimal Line Length"), it is discarded. This allows to save memory, since all other lines might have to be stored if there occur copies of them.
- Each non-discarded line is space-normalized (i.e., sequences of white space characters are replaced by a single space character; and words that are not separated by whitespace characters are separated by a single space character). This normalization allows to detect almost-copied blocks that only differ from each other by the whitespace in them.
- Lines that occur too often (more often than the number given in the configuration parameter "Maximal Number of Copies") are discarded. This feature is used for excluding e.g. preambles that start every file from duplicate analysis.
- For any pair of identical lines that result from the steps above, it is checked if they are the start of a duplicate code block. Only blocks that have a certain minimum length are reported (configuration parameter "Minimal Block Length").
- Two other parameters allow for a certain "slack" in the comparison so that not only completely identical blocks are found, but also blocks that differ a bit.

  1. The configuration parameter "Maximal Tolerance per Edit" works like this: When two text blocks are compared, the comparison algorithm allows some differences, or "edits". Each single edit may only add, remove or change a number of lines (the one given by this parameter) in order to make the blocks identical. Note that behind the edited region, the two blocks must continue identically for at least one line.

2. The configuration parameter "Maximal Relative Tolerance Percentage" works like this: When comparing two blocks, the number of edited lines in relation to the number of matched lines may never be larger than this percentage.

The total number of lines in all the edits that occur in a block comparison is the "tolerance" of the comparison. The larger it is, the more lines need to be changed to consider the two blocks to be copies from one another.

- The algorithm up to this point only identifies pairs of start lines of duplicated blocks. The last step in the identification of duplicated blocks is the aggregation: Not only are code blocks considered to be duplicates of one another when they form result pairs in the algorithm above, but also when they are indirectly copies of one another. E.g., consider two already identified pairs of duplicated blocks A,B on the one hand and C,D on the other hand, where the start of B equals the start of C; then A, B, C and D are all considered to be duplicates of the same code block. This aggregation is done until no more blocks can be aggregated. The tolerance specified for a code block in the view is the minimal tolerance that occurred during the comparison of the block with other code.

7.13. Examining the Source Code

Anywhere in the *Sonargraph* workbench you have the option of double clicking (or right clicking + "Show In Source View") on an element to show the source code of the clicked element if that is available.

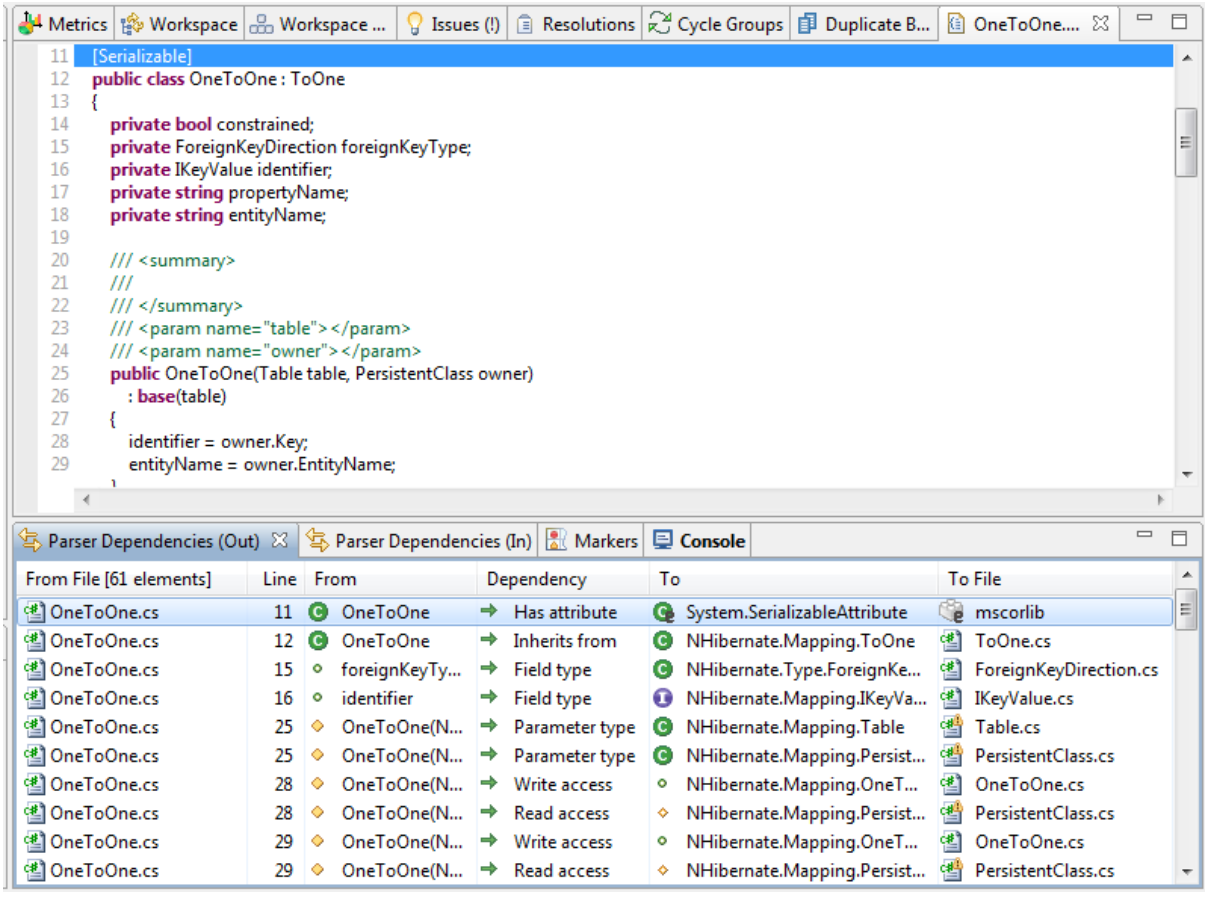


Figure 7.56. Source View

"Find Text" feature can be invoked with Ctrl-F (Command + F on Mac). If more than one occurrence of the search string is found, press F3 to jump to the next search result. In the Script view (see Chapter 10, *Extending the Static Analysis*) and Architecture File view the search feature offers also "replace" and "replace all" to ease content edition.

Regular expressions can be used for advanced match and replace use cases. Line-breaks in the replacement text can be specified with \R. The implementation uses standard Java regular expression API and also allows using capturing groups. More details can be found at the *JavaDoc of java.util.regex.Pattern* and *JavaDoc of Capturing Groups* .

As you move around the mouse cursor through the source code, you can see that some elements (names of fields, methods, types and so forth) are being underlined. By pressing Ctrl (Command on Mac) and clicking on this 'hyper linked' elements you navigate to the definition of the element which might be defined in the same source file or another.

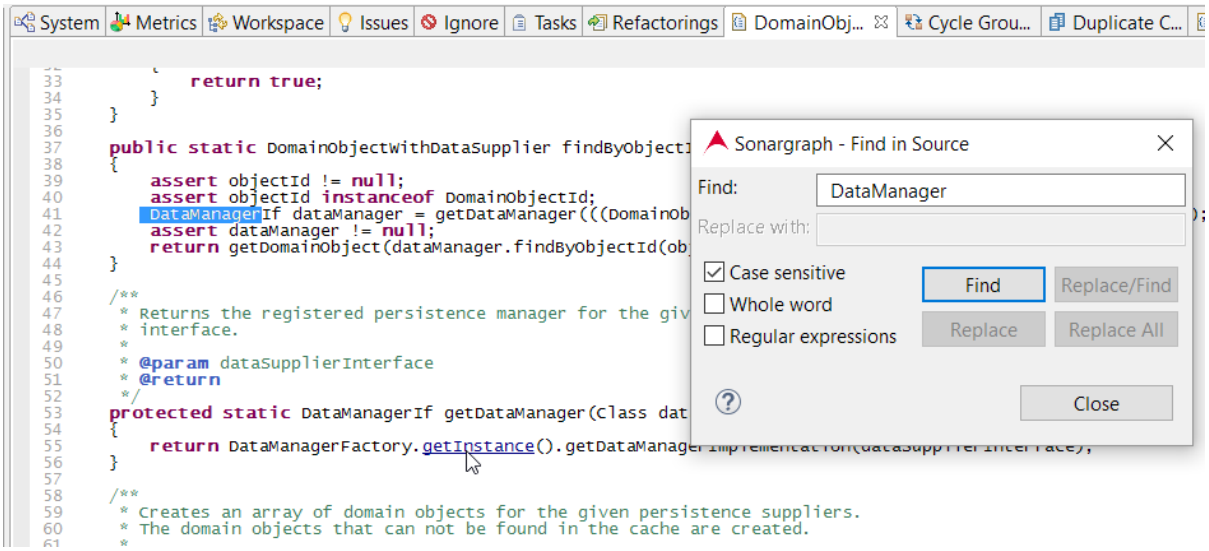


Figure 7.57. Hyperlinking and Find Text Features in Source View

7.13.1. Interaction with Auxiliary Views

The Source view offers interaction with the Auxiliary views: Parser Dependencies (Out), Parser Dependencies (In) and Markers: Below the main source viewer, three tabs provide further information about the currently loaded source file:

- The Parser Dependencies (Out) tab lists all dependencies that depart from the source file. Clicking on a dependency jumps to the respective line in the upper pane of the source view.
- The Parser Dependencies (In) tab lists all dependencies that arrive into the source file. Clicking on a dependency opens up another instance of the Source view showing the file where the selected incoming dependency belongs to.
- In both Parser Dependencies views in and out, you can select the "Show Only Violations" and focus only on violating parser dependencies.

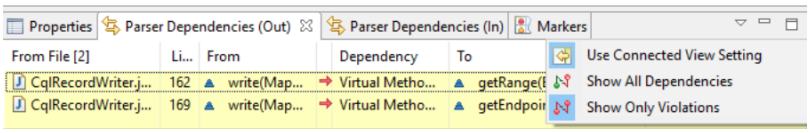


Figure 7.58. Show Only Violations

To enable this feature, select "Show Only Violations" in the Parser Dependencies views (in and out) view options menu.

- The Markers tab lists all the markers of the source file. Markers are graphic indicators of issues in the source file under inspection. It also shows user defined tasks (See Section 8.4, “ Defining Fix And TODO Tasks ”) and refactorings that pertain to the file or elements in the file. Clicking on a marker jumps to the corresponding line in the upper pane of the source view.

7.14. Examining Metrics Results

Sonargraph calculates metrics on different abstraction levels and displays them in the Metrics view. Metrics are calculated on different levels. Select the level in the combo box at the top left of the view and select the metric in the shown table. The metric values are then displayed in the table on the right.

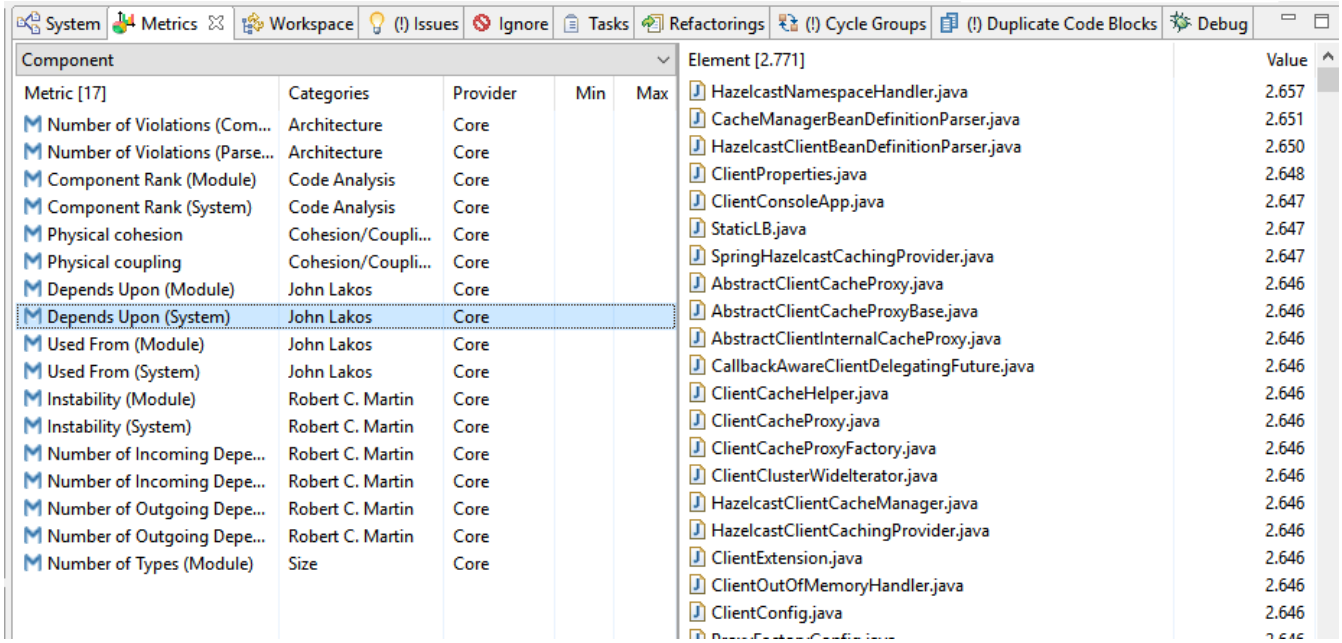


Figure 7.59. Metrics View

If you are interested in all metrics of a specific element, the Element Metrics view can be opened via the main menu "Window" → "Show View" → Element Metrics.

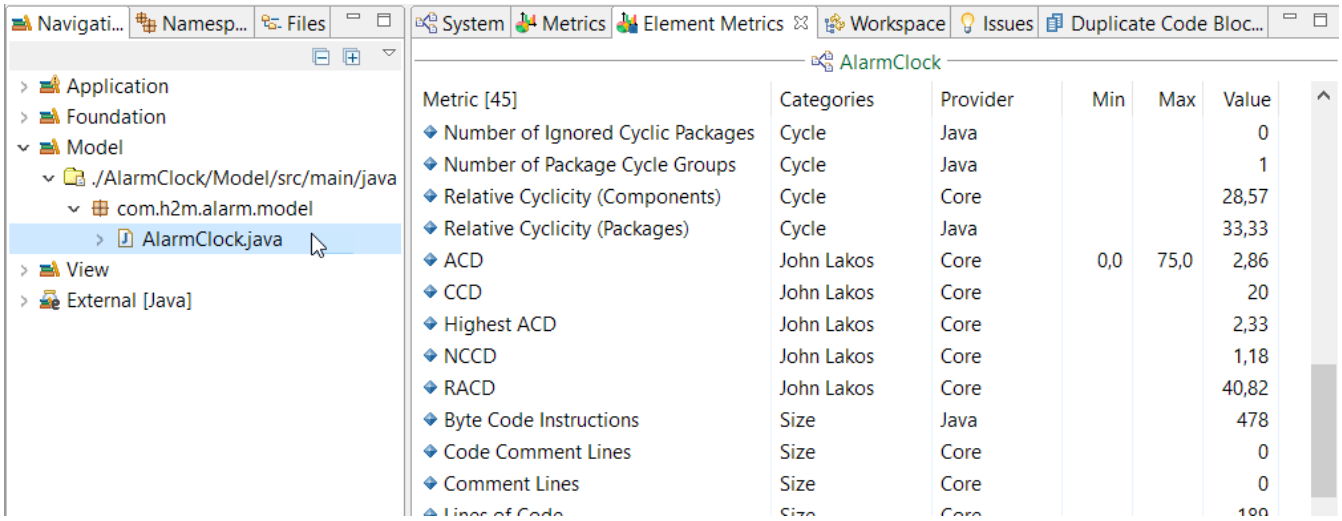


Figure 7.60. Element Metrics View

The metric thresholds configuration allows to define threshold values for those predefined metrics in order to have an accurate control of the behavior of your code base as it evolves.

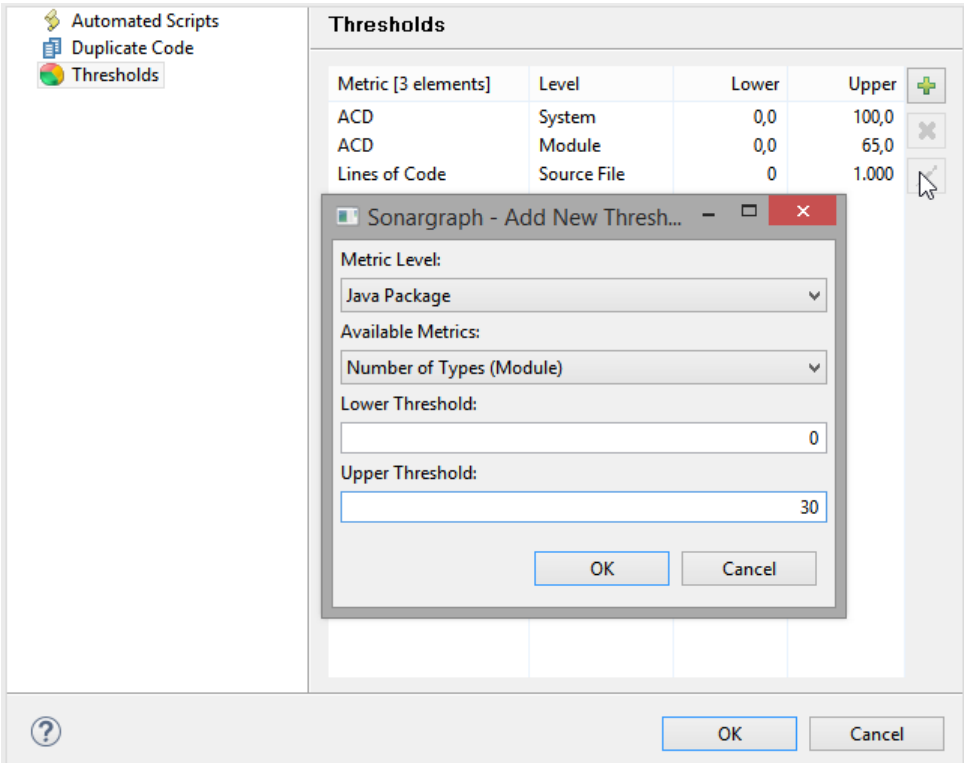


Figure 7.61. Metric Thresholds Configuration

Thresholds can also be defined, edited or deleted via context menu by right clicking on a metric in the Metrics or Element Metrics view.

Related topics:

- More information about the built-in metrics can be found in Chapter 16, *Metric Definitions* .
- Custom metrics can be defined using Groovy Scripts. More information is contained in Chapter 10, *Extending the Static Analysis* .

7.15. Analyzing C++ Include Dependencies

The Include Dependency view is available via the context menu of a C++ source file, as shown in the following screenshot. It allows analyzing the dependencies to header files.

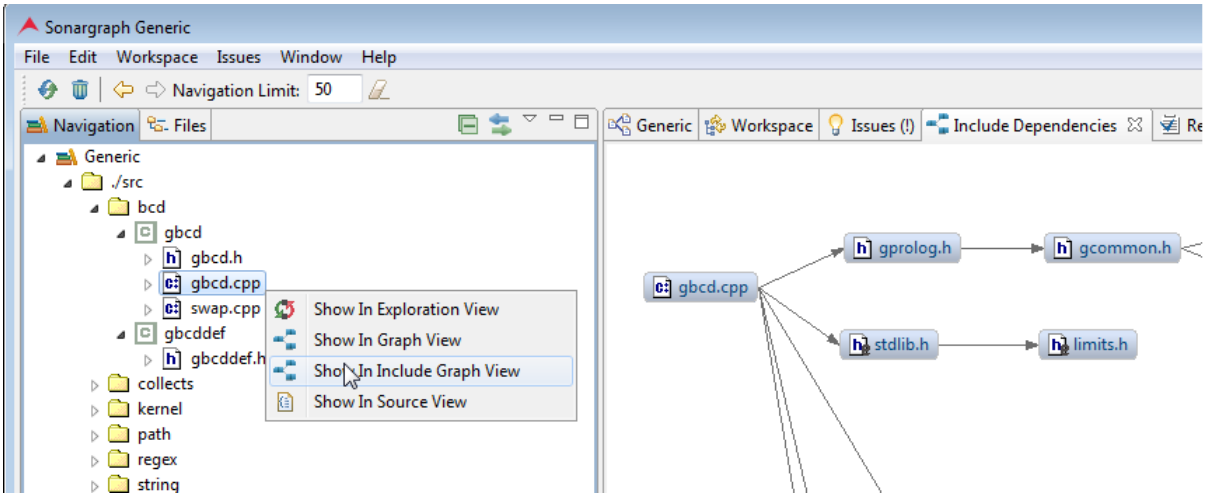


Figure 7.62. C++ Include Dependency View

7.16. Creating a Report

Select "File" → "Export to HTML/XML Report..." to generate an HTML or XML report containing all metric values, issues and resolutions (TODO, Ignore, Fix). You can select the element level for which the metric values are exported.

The corresponding XML schema can be found in <sonargraph-inst>/report.

TIP

The XML output is normalized to minimize the size of the file. To get a more expressive report, set the log level for the ReportExtension to "debug" in <sonargraph-inst>/logback.xml.

NOTE

The report files can easily get several MBs big and take a few seconds to generate. Start with the default configuration first to check the size and then increase the number of levels and the number of values per metric.

The HTML report contains tables that can be filtered, e.g. the table of "Unresolved Issues". The tables provide the following functionality:

- The table header allows to filter for rows containing the specified text as shown in the screenshot. Paging will be enabled for tables containing more than 25 rows. You can select to show 25, 50 rows per page or all on one page by using the combo box on the right.
- The table header provides info about the number of items shown and the current page.
- The matching terms are highlighted as shown in the screenshot.
- Several filter conditions can be connected via logical OR (||) and logical AND (&&).
- Table cells containing numeric values can also be filtered for value ranges as shown in the screenshot.
- Rows can be sorted by clicking on the table column header.
- All filters can be cleared by clicking on the right-most icon.
- A short help function is available by clicking on the question mark on the right.

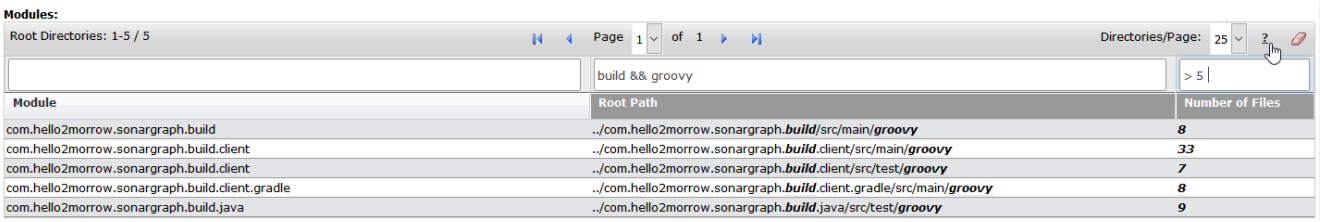


Figure 7.63. Table Filter Options in HTML Report

7.17. Restructure and Organize Code

Sonargraph offers the session model concept to be able to:

- Restructure a *software system* applying refactorings.
- Organize a *software system* defining architectural artifacts.

A session model is created using a specific structure aspect and applying operations on this structure. The structure is created based on the currently loaded (parsed) system after having applied the selected virtual model. The session model is persisted in a file. The user can define multiple session models. The session model is manipulated using the Session and Operations view.

NOTE: We are currently working on that feature and included a first version of it. Things that already work:

- Create a Session model which is persisted in a file. Use File->New->Session->New Session... or right click in the Files view on the Sessions node. Choose between 2 the physical model structures (with or without root directories) when creating a session. Open an existing session from the files view via the context menu. Both create and open will only be possible with a loaded parser model.
- The Session view shows a tree-like structure down to component level.
- Selection support by pressing SHIFT in combination with the arrow keys (up and down) or left mouse click for bulk selection. Use the modifier key (CMD, CTRL) of the platform with left mouse click to add or remove elements to/from the current selection.
- Create and edit artifacts with their properties either based on a selection or empty. Try the context menu on selections (right mouse click) to see what is possible.
- Assignment of elements to existing artifacts or removal from existing artifacts.
- Assignment and parent structure changes for artifacts are possible via drag and drop.
- The operations you apply (e.g. create/edit artifacts, assign elements, ...) may be seen in the Operations view. The operations may also be deleted from that list. Operations that have no effect (e.g. a previous element is no longer their because the code changed) are marked with a warning marker.
- Architecture check in real time meaning that you see the dependencies changing their colors according to their violation state.
- Undo/redo.
- The views Properties, Parser Dependencies (Out) and Parser Dependencies (In) react to the selection in the Session view and show the corresponding additional information of the selected element.

Things to come:

- More architecture check related features.
- Possibility to apply refactorings.
- Focus operations.
- Search support.

- Support for logical model based structure.
- Drill down to programming element level.
- Forward/backward navigation.
- ...

7.17.1. Session View

The session view offers 3 presentation modes that affect recursive elements (e.g. package,namespace,directory):

- Mixed: empty elements without siblings are compacted.
- Hierarchical: all elements are shown.
- Flat: only the elements containing elements of other types are shown in parallel.

The session view shows some horizontal grey lines. These are the level lines. Elements between 2 lines are not depending on each other.

If an element has children, it will show a collapse/expand figure (+/-). If the background of this figure is darker it has more children.

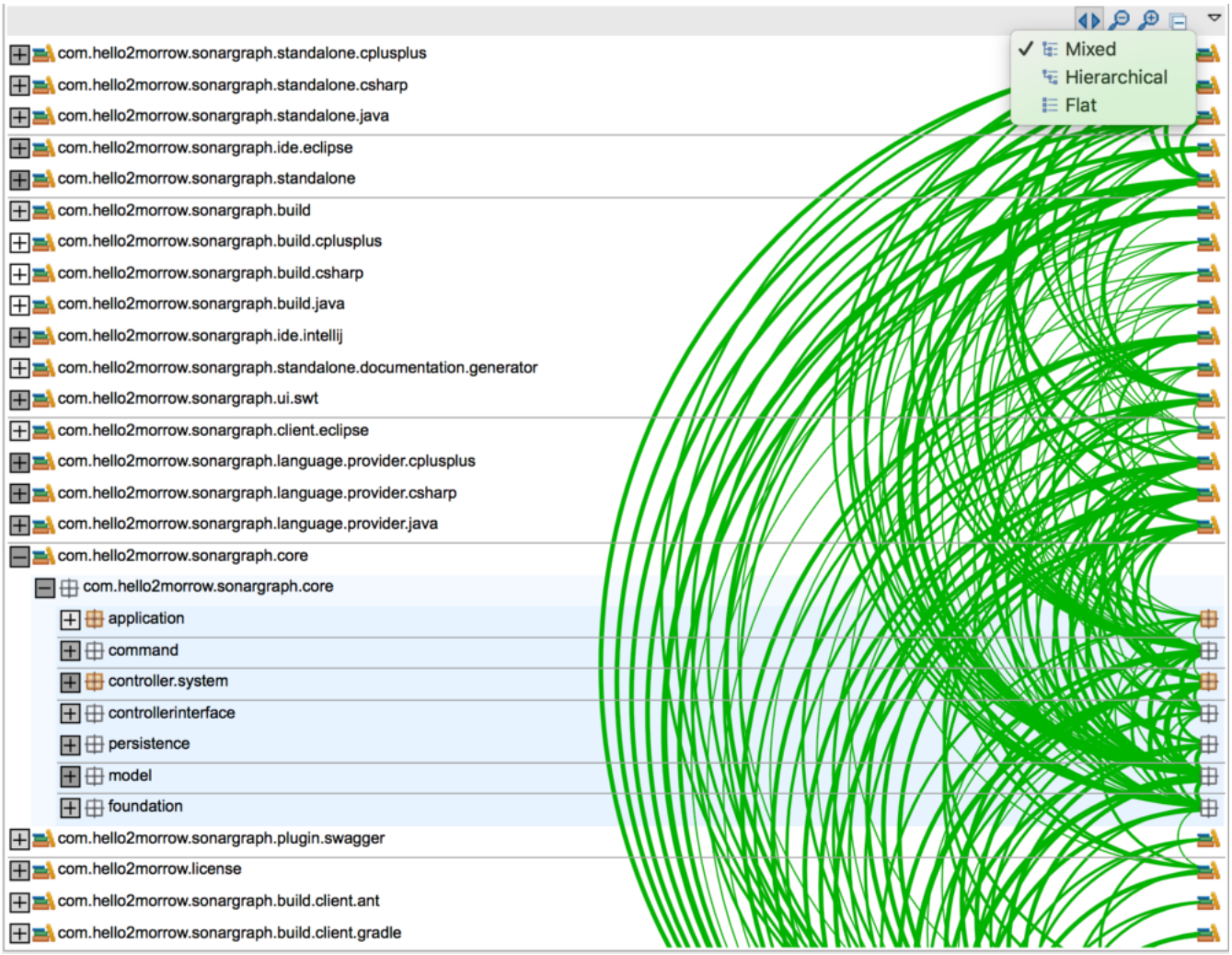


Figure 7.64. Session view

When no element is selected all dependencies are shown.

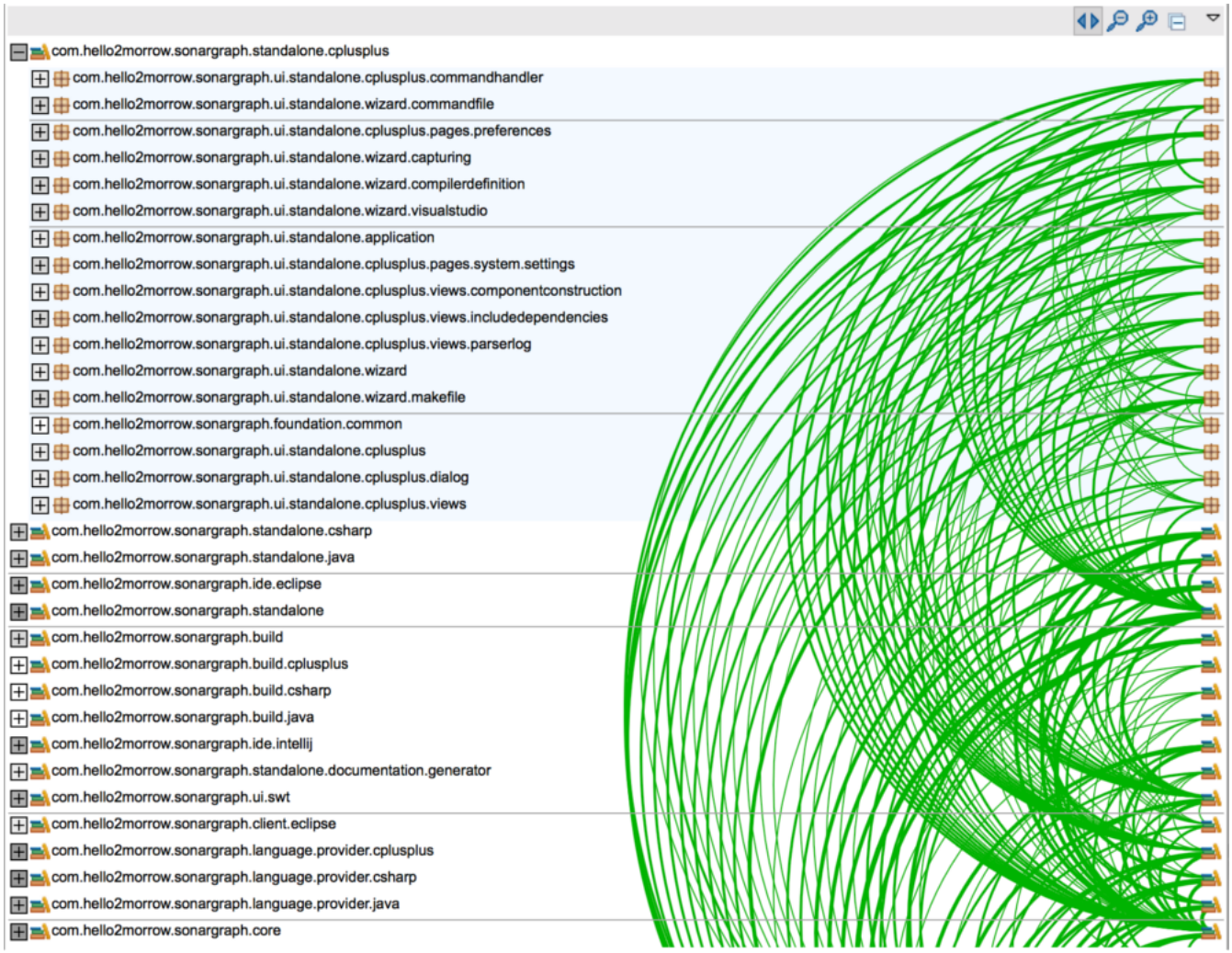


Figure 7.65. Session view without selection

When an element is selected only the incoming and outgoing dependencies are shown. More than one element can be selected. A selected element has a yellow background. Other elements used from or using the selected element have a lighter yellow background.

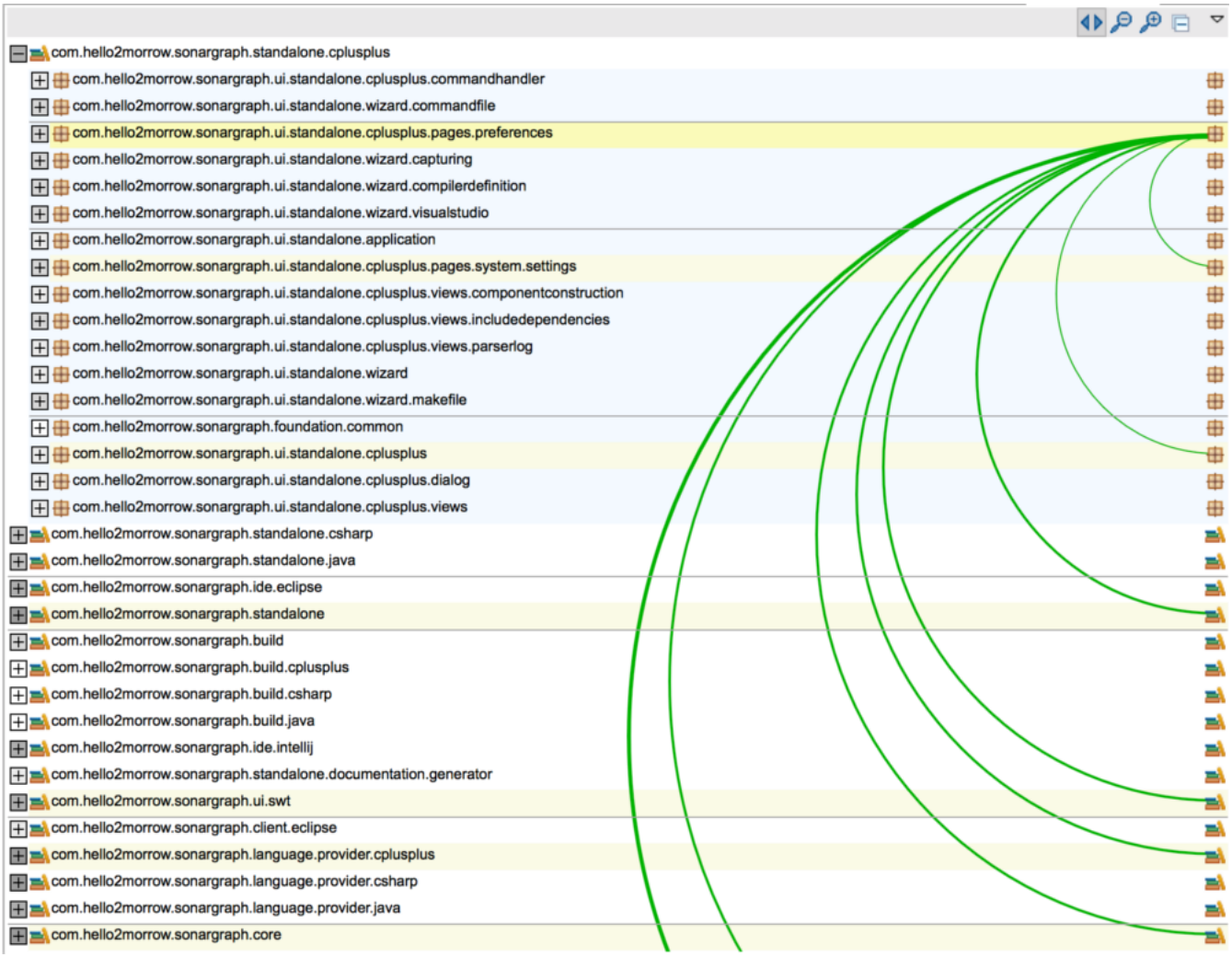


Figure 7.66. Session view with selection

Chapter 8. Handling Detected Issues

This chapter explains the purpose of virtual models and how they can be used to define standard resolutions (Ignore, Fix) for detected issues.

The following views provide relevant information: Issues, Ignore and Tasks view.

8.1. Using Virtual Models for Resolutions

Virtual models in *Sonargraph* are resolutions containers used to try different solutions for issues in the system without distorting its original status. *Sonargraph* ships with two *virtual models* already created: "Parser" and "Modifiable".

Virtual models management section is located on the right-hand side of the main toolbar.

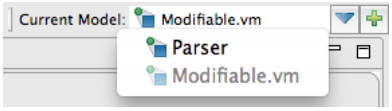


Figure 8.1. Virtual Models

The "Modifiable" model is selected by default so you can start creating resolutions (fixes, ignores or TODO's) right away. On the contrary, the "Parser" model, represents the "facts" model, determined by the parser, which means it can not be modified as it represents the actual state of things on your *software system*.

Using the green plus symbol you can create as many different *virtual models* as you need to try out different resolutions with your *software system* and you will always have your original model available in the "Parser" model.

8.2. Examining Issues

The Issues view displays information about the found issues such as their severity, category, affected elements and the associated provider.

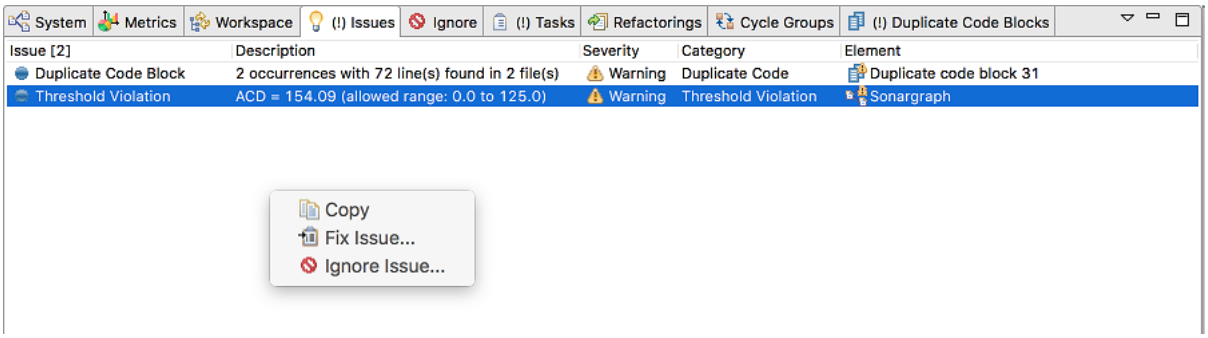


Figure 8.2. Issues View

Context menu and double click interactions give you options to examine the issue in a more suitable view. They also allow to "ignore" or "fix" the issue by either ignoring it or creating a fix request for someone in the development team. These requests are called "Resolutions" in *Sonargraph* and are covered in depth in the following sections.

In case of having too many issues, you can apply filters using the “Filter...” view option on the upper-right corner where several criteria are offered to reduce the amount of visible issues:

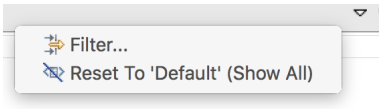


Figure 8.3. Filter Issues

You can also reduce the number of issues by defining an *Issue Filter* as described in Section 7.7.1, “ Definition of Component Filters, Modules and Root Directories ”.

8.3. Ignoring Issues

The upper section of the Ignore view provides information about the type of issue the resolution resolves, the assigned priority for it, the assignee and an optional comment put in by the creator of the resolution among other data. The lower section displays the affected elements of the issues that match the selected "Ignore" resolution.

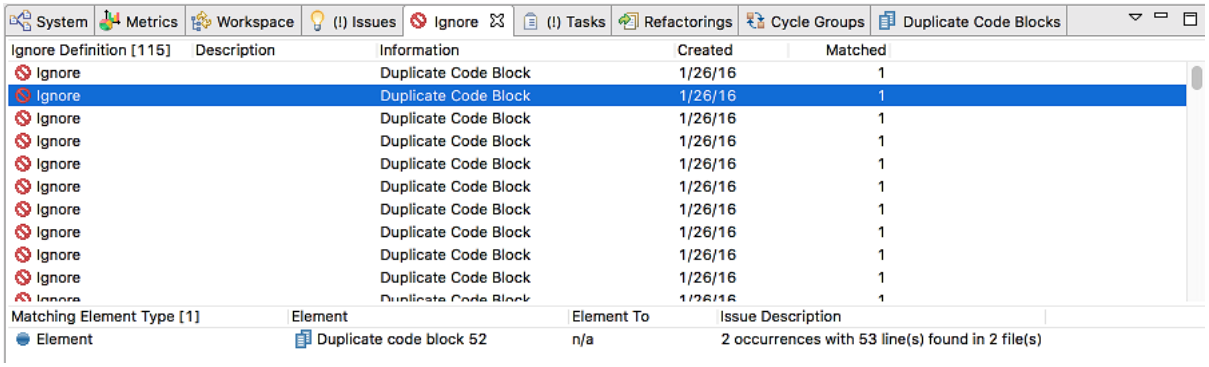


Figure 8.4. Ignore View

As mentioned previously, you can also reduce the number of issues by defining an *Issue Filter* as described in Section 7.7.1, “ Definition of Component Filters, Modules and Root Directories ”.

8.4. Defining Fix And TODO Tasks

"Fix" resolutions represent a proposed solution to one or many issues in the application. They are usually created to make sure that the related issues get eventually dealt with by someone in the development team.

Sonargraph allows to define specific "TODO" tasks for the different system elements. Those tasks can be assigned to a member of the development team to take care of. To define a TODO task, right click on the element and select "New TODO" in the context menu.

The "Fix" and "TODO" tasks are listed in the Tasks view.

8.5. Editing Resolutions

Using the context menu, you can modify the assignee, priority or comment of a resolution and even delete it if you deem it does not represent an appropriate solution anymore.

For some resolutions, right-clicking also offers the option of editing the element pattern of the resolution. The element pattern is an identifier of the element(s) a resolution is applied to:

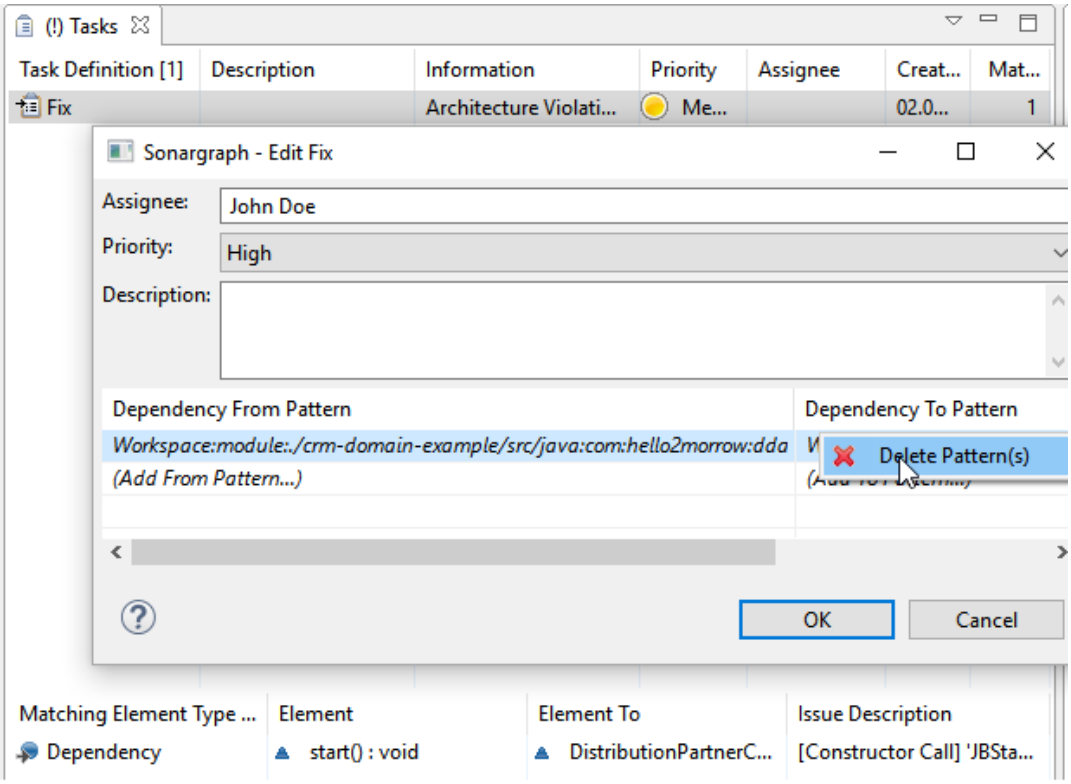


Figure 8.5. Resolution Dialog

The image above shows the element pattern matching mechanism between issues and resolutions. One resolution can be used to match several different elements via a wildcard pattern. This mechanism allows to group together in the same resolution (ignore or fix) current and new related issues as they are generated so to avoid the need to manually resolving each of them as they come about. It also helps when dealing with issues that should likely be taken care of together or by the same person.

You can have an idea of what the pattern for a specific element looks like by creating a resolution for the related issue and then looking at the element pattern section in the edit resolution dialog. You can create as many patterns for a resolution as you deem convenient.

Chapter 9. Simulating Refactorings

Sonargraph allows the simulation of refactorings to quickly analyze different approaches to fix structural problems. Refactorings represent a proposed improvement to your code base. They are usually created to make sure that the related improvement is dealt with by someone in the development team, thus striving towards a healthy code base which is the ultimate goal of *Sonargraph*.

9.1. Creating Delete Refactorings

The *Delete* refactoring is available via "System" → "New Delete Refactoring..." or in the context menu when selecting an appropriate element.

A delete refactoring may be applied to the following (physical) elements (i.e. elements that come from the parsing process and are displayed in the Navigation view):

- Non-external programming elements (e.g. types, methods, fields)
- Non-external Directories (but not root directories)
- Non-external Namespaces
- Dependencies (parser level or aggregated)

When deleting parser level or aggregated dependencies there are up to 3 options. Their appearance, order and selected default option depend on the current context:

- Delete Parser Dependencies: Delete the currently contained parser dependencies of a given edge based on parser dependency patterns.
- Delete Parser Dependencies Based on Endpoints: Delete the parser dependencies of a given edge based on end point patterns, after the next 'refresh' there could be more or less matches.
- Delete Violating Parser Dependencies: Only delete the violating parser dependencies of a given edge based on parser dependency patterns.

Directories are always deleted recursively. Namespaces can be deleted flat or recursively. When deleting a type all its methods and fields or nested types are deleted.

Delete refactorings on (physical) namespaces may also be applied in the (logical) Namespaces view. Since a logical namespace (either in system or module scope) may be based on more than one physical namespace, the deletion of a logical namespace might delete several physical namespaces.

Delete refactorings may also be applied in the Architecture view.

Delete refactorings may also be applied in the Exploration, Graph and Dependencies View which are opened based on arbitrary Navigation, Namespace and Architecture view selections.

Delete refactorings can be managed in the Refactorings view as described in Section 9.3, “ Managing Refactorings ”.

9.2. Creating Move/Rename Refactorings

The *Move/Rename* refactoring is available via "System" → "New Move/Rename Refactoring..." or in the context menu when selecting an appropriate element.

A Move/Rename refactoring may be applied to the following (physical) elements (i.e. elements that come from the parsing process and are displayed in the Navigation view):

- Directories (but not root directories) for C# and C/C++

- Namespaces for Java
- Components for Java, C# and C/C++

Move/Rename refactorings may also be applied in the Architecture view.

Move/Rename refactorings may also be applied in the Exploration, Graph and Dependencies View when they are opened based on arbitrary Navigation and Architecture view selections.

9.3. Managing Refactorings

The upper section of the Refactorings view provides information about the type of refactoring, the provider, the applicability, the assigned priority for it, the assignee and an optional description.

The lower section displays the affected elements of the refactoring.

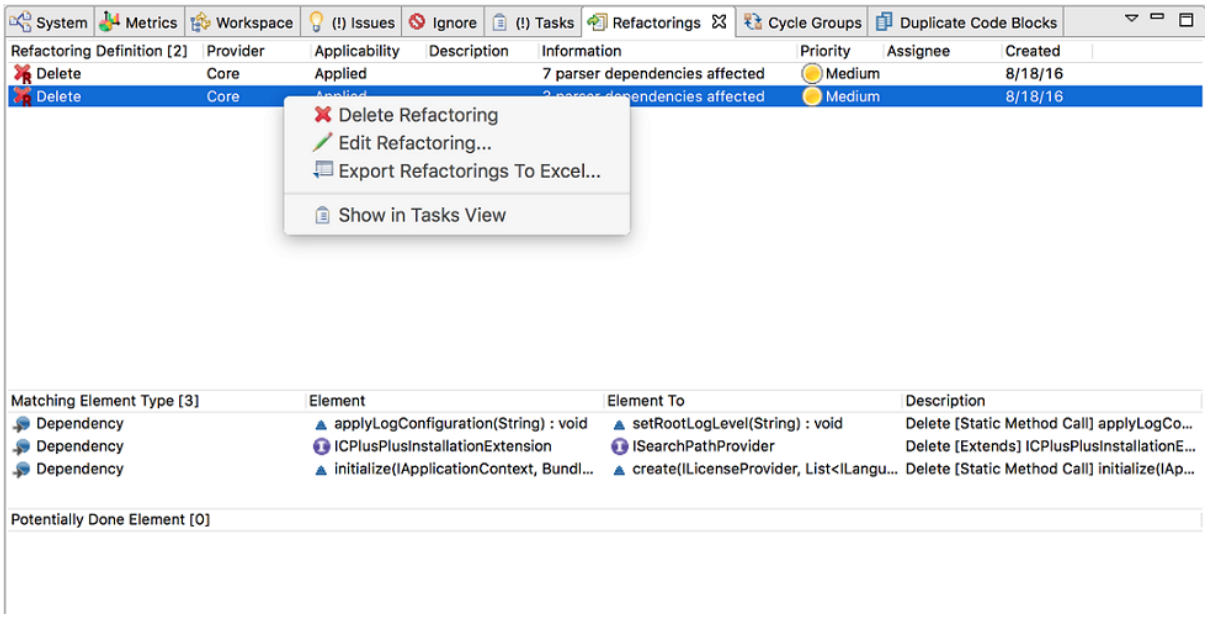


Figure 9.1. Refactorings View

The "Sonargraph Refactorings" view offers filter options in the top right corner. Refactorings can be filtered by status, priority, assignee and description.

9.4. Best Practices

The code base of a living software project changes fast, therefore we recommend the following approach to work with refactorings:

- **Do not get carried away and create hundreds of refactorings! It is better to "simulate a little, refactor a little".**

  Try to limit the impact of individual refactorings. Move and rename a package at the top of the hierarchy might have severe consequences on the code base and are most likely high-risk operations during implementation.

  If a package or class file gets renamed to a different name than specified in the refactorings, the refactorings are no longer applicable. There might be a chance in the future to semi-automatically update refactoring definitons based on the project's history, but we do not know when this will be implemented.

- **Work with only a few virtual models.**

  Note that in the IDE integrations, the standard "Modifiable.vm" is always applied and currently cannot be changed.

Virtual models are great for experimenting with refactorings in isolation. But, since refactorings are not synchronized between virtual models, it is recommended to have one "main" model that contains approved refactorings and integrate the experiments as frequently as possible. If the same compilation unit is affected by refactoring sequences in different virtual models, implementing the refactorings of the first model will make the refactorings of the second model "unapplicable". We plan to improve the exchange of refactorings between virtual models in future versions.

Related topics:

- Section 15.1.6, “ Execute Refactorings in Eclipse ”

Chapter 10. Extending the Static Analysis

Sonargraph presents the possibility to write Groovy scripts that will be run over the current *software system* in order to get specific results.

Scripts support the following use cases (among others): Create and calculate custom metrics, identify specific elements, list dependencies to methods, create issues for detected anti-patterns.

To get an idea of the Script API's power, it is recommended to examine the existing scripts contained in the provided quality models. For the core and each of the supported languages (Java, C#, C++) a script named VisitorExample.scr exists that illustrates the available Script API.

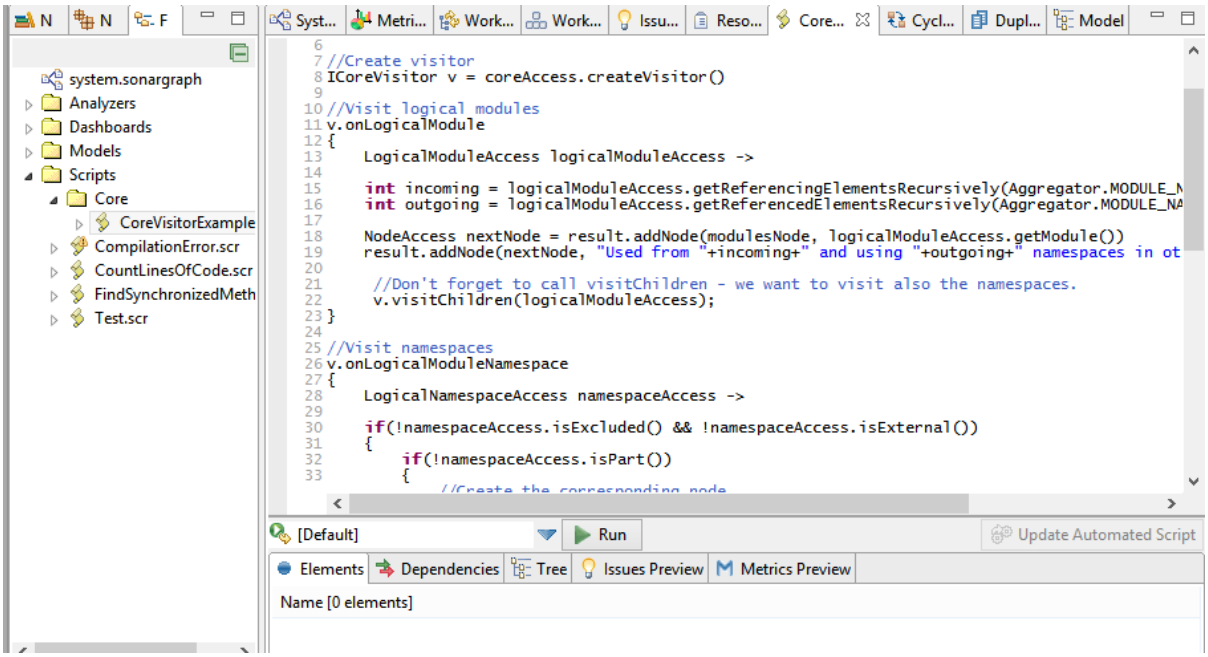


Figure 10.1. Script View

The Script view has two main sections:

- **Script editing area:** In this area you can write Groovy based scripts to retrieve information of your system in ways that would not be possible otherwise.
- **Results area:** Shows the results from the executed script which can be *software system* elements, dependencies between the different components of the system, a tree structure of elements, a list of issues, or metrics created by the script.

The execution of the current script can be triggered by clicking the button "Run" below the text edit area.

10.1. Interaction with Auxiliary Views

The Script view offers interaction with the Markers Auxiliary view which lists all markers of the script file. Typically those markers indicate compilation errors.

10.2. Groovy Scripts From Quality Model

When creating a new *system* , an existing quality model can be used, which usually contains some scripts. (See Section 5.1, “Quality Model”)

Figure 10.2. Quality Model

10.3. Creating a new Groovy Script

A new Groovy script can be created by "New" → "Other" → "Script" , or by selecting a Groovy script directory in the Files view (See Section 7.6, “ Managing the System Files ”) and choosing "New Script..." in the context menu. The "New Script Wizard" will open.

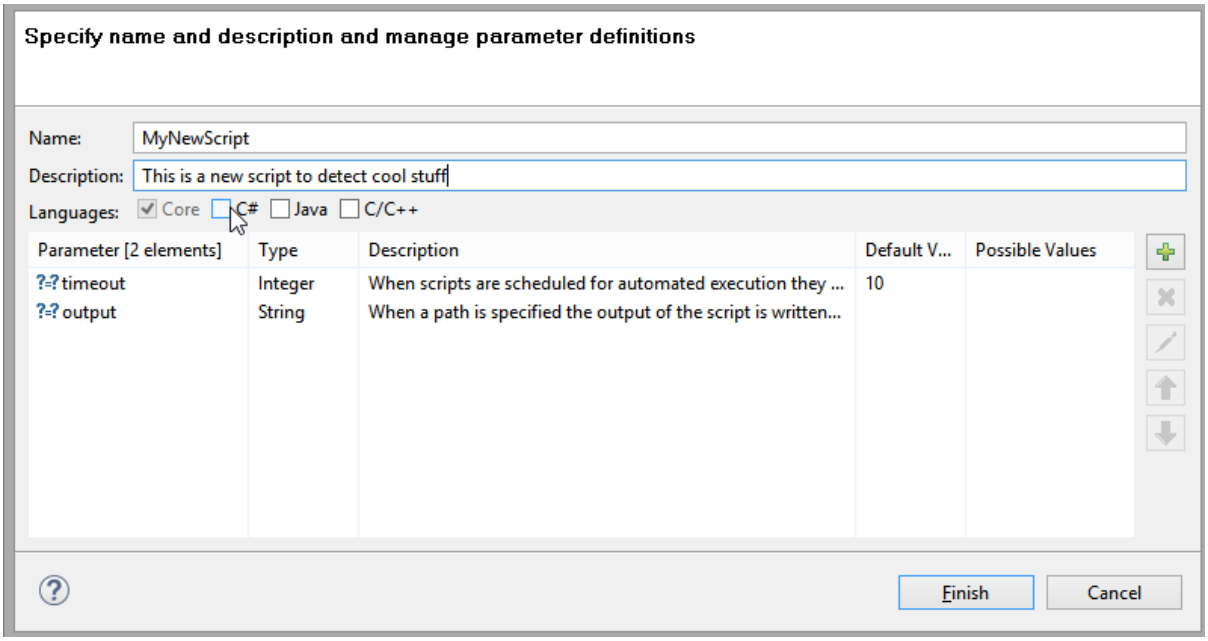


Figure 10.3. New Script

On the main page the following metadata of a Groovy script can be edited:

- the name of the Groovy script (must be unique in its directory)
- a description for the Groovy script
- a timeout value in seconds: whenever the Groovy script takes more time to run, it is stopped automatically
- the output filepath where the textual output produced by println-Statements within the script is written.
- a list of APIs the Groovy script can use: "Core" contains functionality available to all languages, selecting any of the other languages offers additional functionality. Obviously, relying on a language specific API makes the script language-dependent.

10.3.1. Default Parameters in a Script

Every Groovy scripts has a binding with some predefined parameters

- **out** the output stream of a Groovy script. Use `out.println "message"` or `println "message"` in the script. The output will appear in the Console view and in the output file (in case an output parameter has been specified).
- **result** of type Result Access (see JavaDoc) for adding the results of a Groovy script.

- **coreAccess** of type CoreAccess (see JavaDoc) for all Groovy scripts.
- **javaAccess** of type JavaAccess (see JavaDoc) for Groovy scripts using the Java API.
- **cppAccess** of type CppAccess (see JavaDoc) for Groovy scripts using the C++ API.
- **csharpAccess** of type CSharpAccess (see JavaDoc) for Groovy scripts using the CSharp API.

10.3.2. Adding Parameters

User defined parameters may be added to a Groovy script. In the Groovy script they can be referenced by their name, preceded by "parameter".

There are three different types of parameters:

- **String parameter** a default value can be given, a list of candidates (allowed values) can be given
- **Integer parameter** a default value can be given, a list of candidates (allowed values) can be given
- **Boolean parameter** allowed values are "true" or "false" (case insensitive)

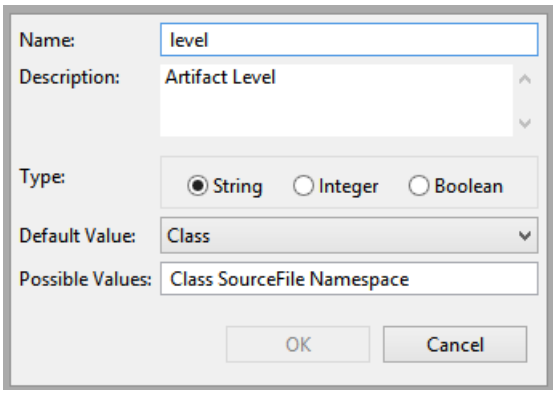


Figure 10.4. Parameter Definition

Now if you defined a parameter "level", it can be referenced in your script with name "parameterLevel":

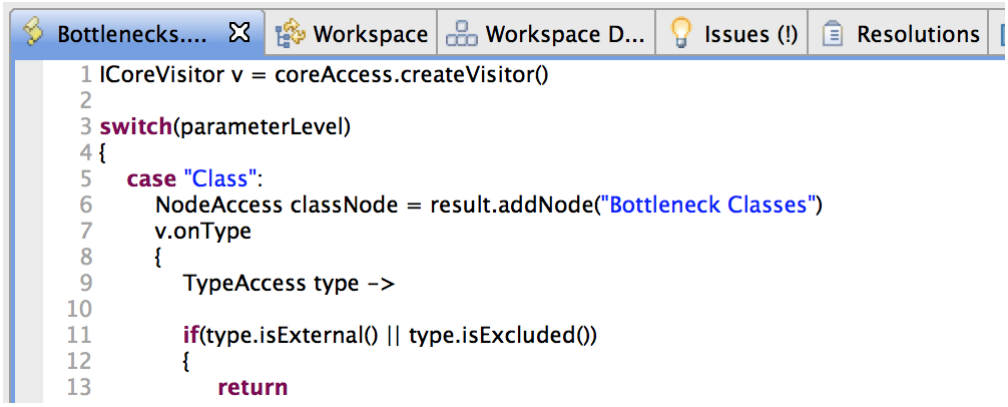


Figure 10.5. Parameter Usage in Script

10.3.3. Creating Run Configurations

Run Configurations allow a parameterized execution of a script. Right-click on a Groovy script in the Files view and select "New Run Configuration...".

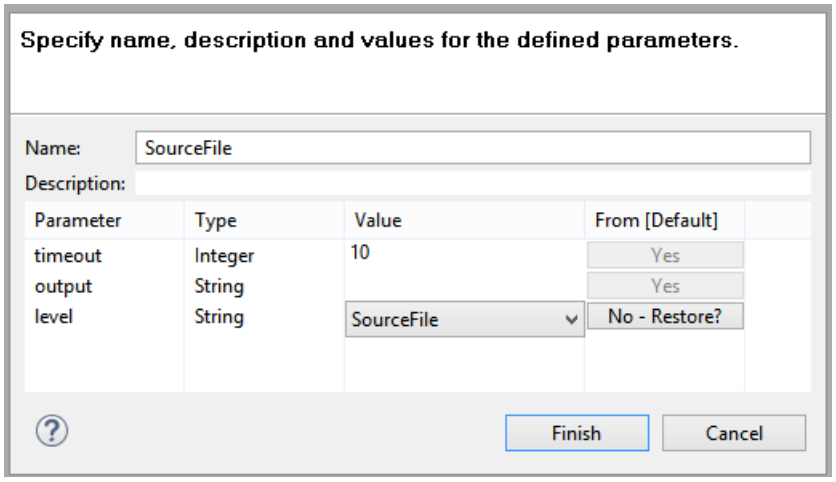


Figure 10.6. Create Run Configuration

A Run Configuration consists of

- a name
- a description
- a list of parameters and values that are inherited from the script's default Run Configuration.

Run configurations are used in two places: When a Groovy script is run manually, and when a Groovy script is run automatically. They are saved in the same directory as the script as <scriptname>#<runconfigname>.rcfg

10.4. Editing a Groovy Script

To edit the metadata (description, API use, parameters, run configuration) of a Groovy script, select the script and choose "Edit Script..." from the context menu, or press **F2** . To edit the Groovy script source code, open it in the Script view.

10.4.1. Auto Completion

To start auto completion in the Script view, place the cursor at the position you want autocompletion for and press CTRL+SPACE .

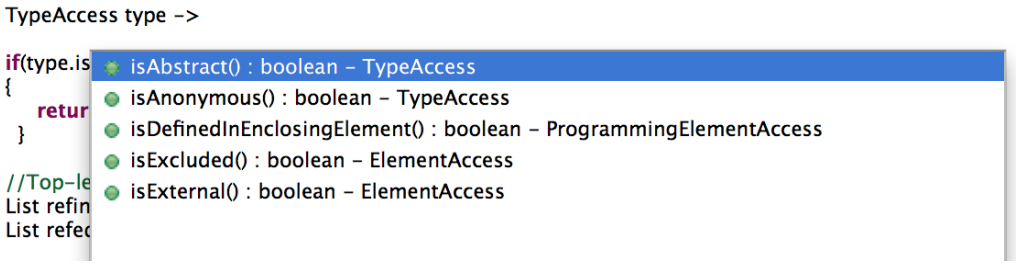


Figure 10.7. Auto Completion

Delayed Auto Completion

The first request for the auto completion might take several seconds to complete since some initialization needs to be done behind the scenes.

10.4.2. Compiling a Groovy Script

After editing a script the "Run" button changes to "Compile". Press "Compile" first, and after successful compilation the button will changed its caption to "Run". If the Groovy script wasn't compiled successfully, there will be some Markers applied to the Groovy Script.

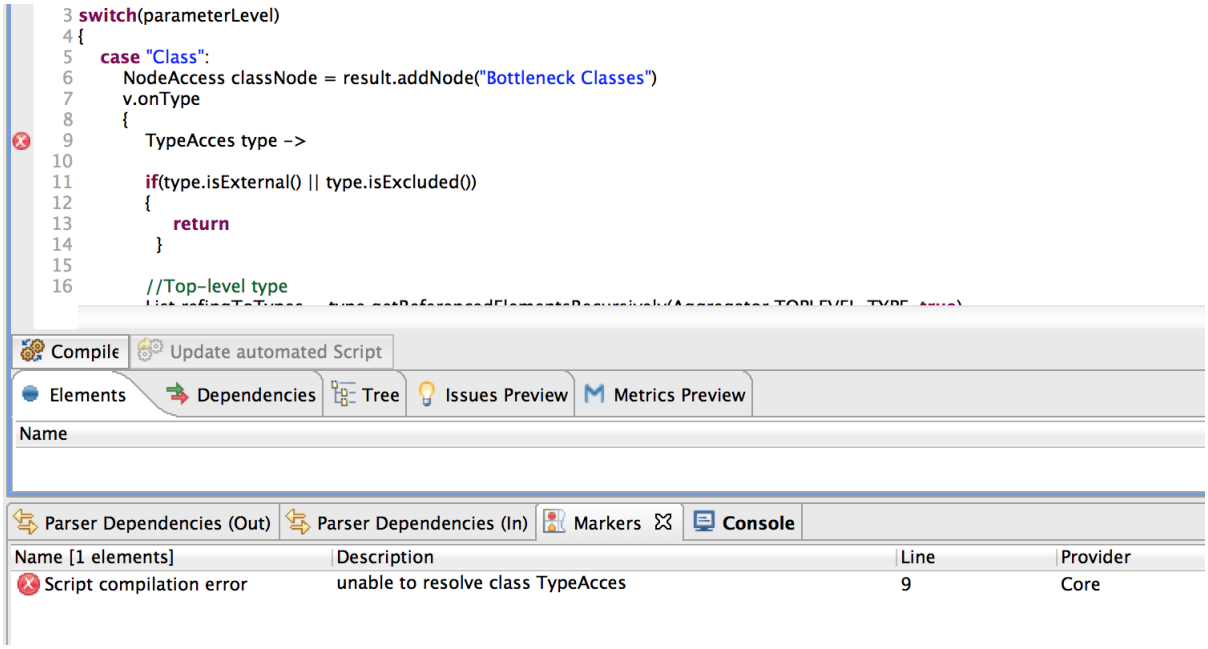


Figure 10.8. Script View Marker

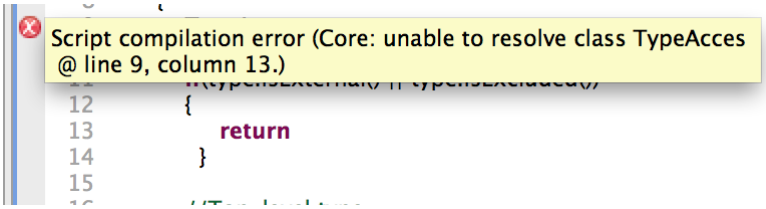


Figure 10.9. Script View Marker Tooltip

Update Automated Script

If this Groovy script is configured to be run automatically, the button "Update automated Script" will be active after a change, successful compilation and saving the script.

10.5. Producing Results with Groovy Scripts

Press the "Run" button to run a Groovy script manually. The combo box allows to change the Run Configuration to be used.

After a script was executed, the results of the scripts appear in five different tabs. The tabs that really hold results are marked with an exclamation mark. The class ResultAccess (see JavaDoc) provides methods to add different types of results.

The "Elements" and "Dependencies" tab hold a list of elements/dependencies, which were added by the script with

```
result.addElement()
```

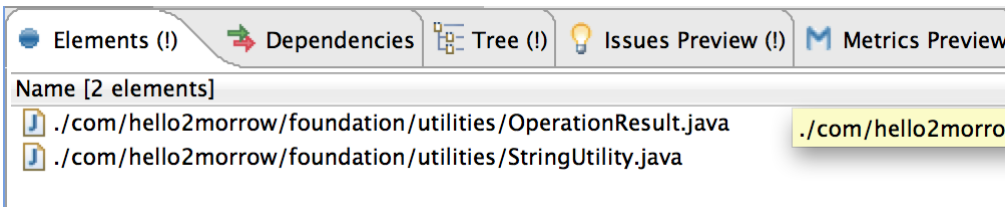


Figure 10.10. Script View Elements Tab

The "Tree" tab holds structure of nodes, which were added by the script with

`result.addNode()`

A node can have child nodes, or child elements.

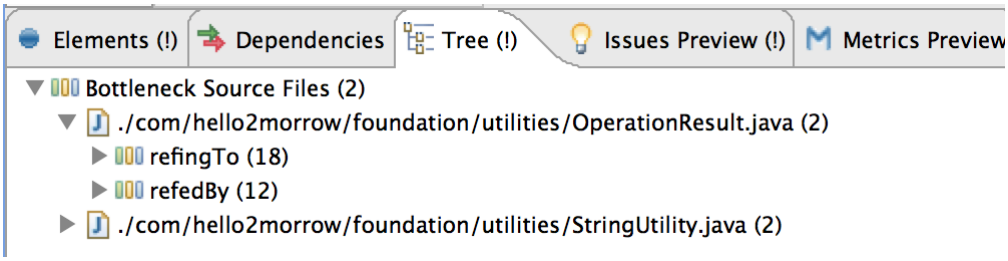


Figure 10.11. Script View Tree Tab

The "Issues Preview" tab shows a list of issues, which were added by the script with one of

`result.addInfoIssue()`

`result.addWarningIssue()`

`result.addErrorIssue()`

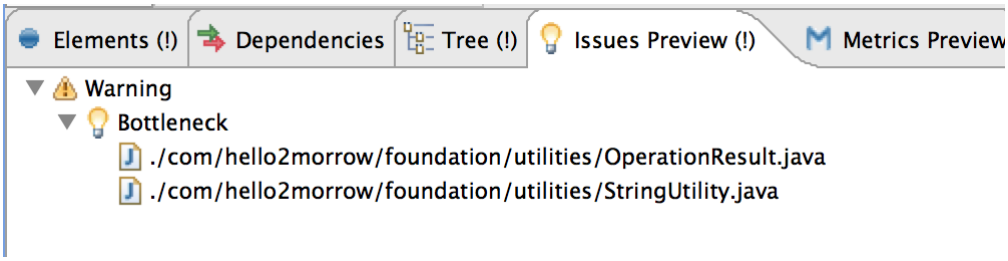


Figure 10.12. Script View Issues Preview

The "Metrics Preview" tab shows a list of metrics, which were added by the script with

```
MetricIdAccess id = coreAccess.getOrCreateMetricId(
    "SupertypeUsesSubtype",
    "Supertype uses subtype",
    "A super type must not know its subtypes",
    false /*non-float*/);
result.addMetricValue(id, coreAccess, warnings)
```

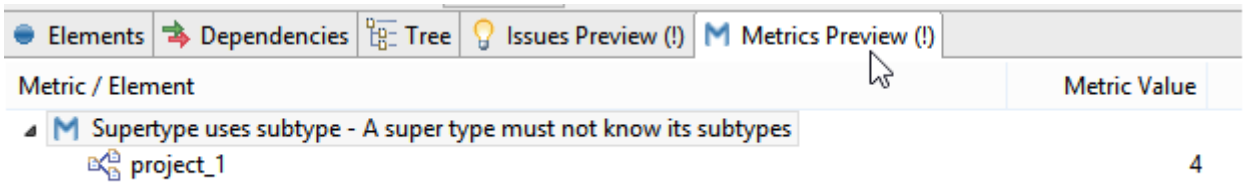


Figure 10.13. Script View Metrics Preview

10.6. Running a Groovy Script Automatically

It is possible to run Groovy scripts automatically whenever the workspace is refreshed. Go to "System" → "Configure..." → "Automated Scripts" and add the Groovy script + Run Configuration.

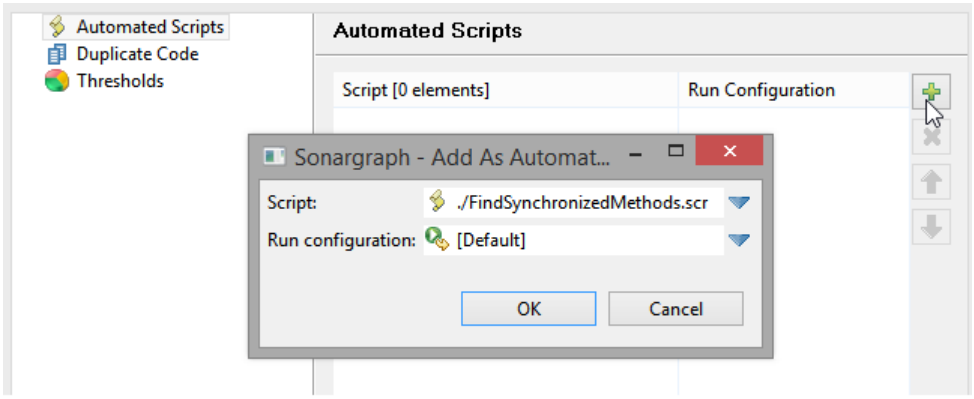


Figure 10.14. Script Runner

Run a Script With Different Run Configurations

It is possible to add the same Groovy script multiple times with different run configurations to the list of automated scripts.

Metrics and Issues

When a script running automatically creates a metric, this metric is displayed in the Metrics view. Executing the same script manually lets the metric show up in the "Metrics" tab of the Script view, but not in the Metrics view.

The same applies for any issues created during the script execution.

10.7. Managing Groovy Scripts

The Files view shows the organization of Groovy scripts. To add a new Groovy script directory, select an existing one (or the root directory "Scripts") in Files view, and choose "New Script Directory..." from the context menu.

To delete a script directory, select it in Files view, and press **DEL** , or select "Delete Script Directory" from the context menu. All contained Groovy scripts and Groovy script directories will be deleted recursively.

Single or multiple selected Groovy scripts can be deleted via **DEL** , or via the context menu.

Automated Scripts

If any of the deleted Groovy scripts was configured to be run automatically, it will be automatically removed from the list of automated scripts.

10.8. Groovy Script Best Practices

This chapter provides hints for improving the performance of Groovy scripts. This becomes more important the more scripts are configured to be executed automatically and thus run on every "refresh".

10.8.1. Only Visit What is Needed

The Script API uses the "Visitor" pattern to traverse the information of a software system. The pattern is very popular and explanations are easy to find.

Use the Right "visit" Method

Choosing the "visit" method that matches the script's purpose leads to fewer methods being called by the visitor and faster execution:

1. CoreAccess.visitLogicalModuleNamespaces() : Visits logical module namespaces an contained elements. See Section 4.4, “Logical Models” for details.

2. CoreAccess.visitLogicalSystemNamespaces() : Visits logical system namespaces and contained elements. See Section 4.4, “Logical Models” for details.

3. CoreAccess.visitParserModel() : Visits all elements of the parser model, i.e. no logical system or module namespaces.

4. CoreAccess.visitModel() : Visits all elements of the model. Most powerful, but obviously the most detailed and slow execution.

Only Visit Interesting Parts of the Model

If you are not interested in visiting externals or certain root directories, stop the visitor traversing that part of the model. The easiest way to exclude external elements from the analysis:

```
visitor.onExternal
{
    //We are not interested in external
    return;
}
```

Similarly, if you only want to investigate dependencies to external elements, you can stop the visitor from traversing the internal model:

```
visitor.onModule
{
    //We are not interested in internal
    return;
}
```

If you want to check only a specific module named "Test", you can do the following:

```
v.onExternal
{
    return;
}

visitor.onModule
{
    ModuleAccess module ->
    if (module.getName().equals("Test"))
    {
        //only visit children of this module
        visitor.visitChildren(module);
    }
}

visitor.onType
{
    TypeAccess type ->

    //Prints out only types of module "Test"
    println "Type $type";
}
```

The same approach should be used to limit the visiting of other model elements (e.g. namespace, component, type, method, field).

10.8.2. Find Text in Code

If you want to create metrics or issues based on text contained in source files, the visitor offers the method onSourceFile() and the class SourceFileAccess that provides access to individual lines.

Combined with regular expressions this is a very powerful method to identify anything in the code that is not contained in the model, e.g. FIXME or TODO in comments.

The following is an excerpt from the script FindFixmeAndTodoInComments.scr contained in the "Core" quality model:

```
def todoPattern = ~/\/\/\s?TODO\b/;
ICoreVisitor visitor = coreAccess.createVisitor();

visitor.onSourceFile
{
    SourceFileAccess source ->
        if(source.isExcluded())
        {
            return;
        }

        List<String> lines = source.getSourceLines(false);
        ...
}
```

TIP

The compilation of the regular expression pattern is an expensive operation and should be done in the "global" section of a script, not within a visit() method.

TIP

Limit the number of scripts using SourceFileAccess. Sonargraph does not keep file contents in memory, thus visiting source files and traversing individual lines causes the actual files being opened. This is a costly operation and slows down the execution.

If you notice that various scripts contain source matching and this is time consuming, think about minimizing file operations by violating the "Single Responsibility Principle" and merge the functionality of several scripts into one.

Chapter 11. Defining an Architecture

Sonargraph 8 and higher allows the definition of an architecture as code via a Domain Specific Language (DSL) that is expressive and readable enough so that every developer is able to understand it. The graphical representation in *Sonargraph 7* allowed the creation of your architectural blueprint in one single diagram. This leads to potentially very big and complex diagrams that are difficult to understand.

The requirements for the new DSL approach were the following:

1. It should be possible to describe an architecture in a set of files. Some of them should be generic enough so that they could be reused by many projects, e.g. a generic template describing the layering of a system.
2. It should be possible to describe an architecture in form of several completely independent aspects. E.g. one aspect describes layering, another aspect describes components and a third aspect looks at separation of client and server logic.
3. On the other hand the language should also be powerful to describe the complete architecture in a single aspect.
4. The DSL must be easy to read and easy to learn.
5. The restrictions for dependencies should allow also the specification of dependency types (e.g. "new", "inheritance", etc.).

To create an architecture description you select "New Architecture File..." from the menu "File/New...". That will open an editor window where you can work on your architecture description. You can have as many architecture files as you like. To enable Sonargraph to use your description to check for architectural violations you also must add your architecture file to Sonargraph's architecture check. This is done in the "Files" tab of the navigation view by right-clicking on your architecture file and select "Add to Architecture Check..." from the context menu. If you later decide to remove the file from Sonargraph's architecture check you can also do this over the context menu.

It is also recommended to open the "Architecture View" while working on an architectural model. You can open that view from the "Window / Show View" menu. The view is split vertically into three main sections. In the top section you can see all architecture descriptions that are not actively checked at this time in a tree view. This might also include files that imported by currently checked architectural models.

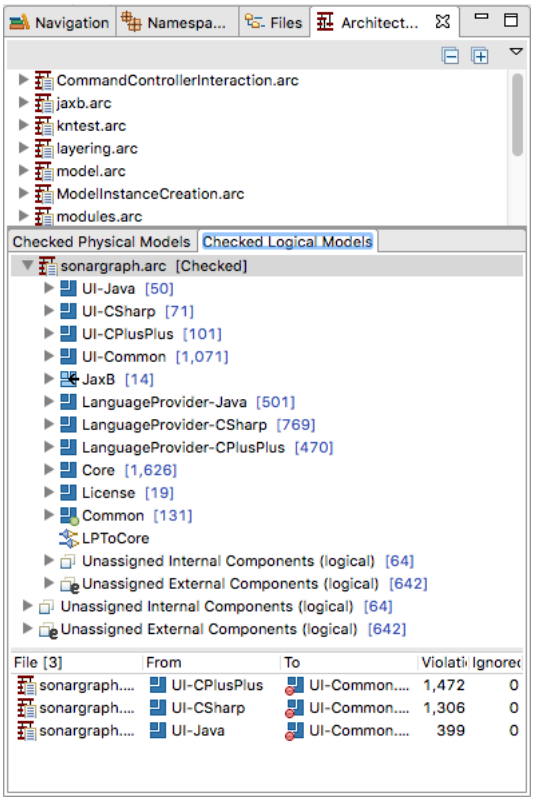


Figure 11.1. Architecture View

In the middle section you have two tabs, one for physical models and one for logical models. (Models are explained in the next section). They contain architectural models that are actively checked. That means you will be able to see which elements are assigned to which artifact by browsing through the tree. You can also easily see which elements have not been assigned to any architectural artifact by inspecting the nodes for "Unassigned internal/external components".

The bottom section lists all architecture violations of the element selected in he middle section. If no element is selected all architecture violations from all models are shown. If you click on a line in that table the associated violating dependencies are shown in the "Parser Dependencies Out" slave view.

11.1. Models, Components and Artifacts

To describe architecture in a formal way we first need to think about the basic building blocks that we could use to describe the architecture of a system. The smallest unit of design is what we call a component. What is represented by a component depends on the base model you choose for you architecture.

Since version 9.7 Sonargraph supports two different base models. The "physical" model - which is the default model and the only model that was supported prior to 9.7 - is based on the model in the "Navigation View". Components are based on the physical layout of your project. In Java a component is a single source files. In C# a component is a single C# source file or a top level type in an external assembly. In C/C++ components are created dynamically out of combining associated header and source files.

The "logical" model is based on the model in the module based namespace view. Here our components are top level programming elements, which for Java or C# is always some type, usually a class or an interface. The logical model organizes these types only by their namespaces/packages. The directory structure of the project is not reflected in the model. In C/C++ components can also be functions or other top level programming elements. For Java there is almost no difference between the physical and the logical model. Only in the rare case that a Java file has more than one top level type the logical model would create one component for each top level type, while the physical model only generates one component per source file.

So logical models are more interesting for languages like C++ and C# where the namespace structure is not related to the physical organization of your project. For these languages it makes sense to use the logical model if your namespaces are in some way reflecting your architectural design.

To define an architecture you would group associated components into architectural artifacts. Then you could group several of those artifacts together into higher level artifacts and so on. For each artifact you would also define which other artifacts can be used by them.

Each component has a name which we call the architecture filter name. In the physical model the filter name starts with the module name or "External [language]". Then follows the path of the component relative to a module specific root directory. The filter name ends with the name of the source file without an extension, All name parts are separated by slashes.

TIP

To determine the architecture filter name of a component just click on the component in the navigation or namespace view and check the "Properties View". There you should be able to see the architecture filter name and other properties of the selected item.

When using a logical model the filter name again starts with the module name followed by the namespace followed by the name of the programming element. Each name part is again separated by slashes.

In most cases assignment of components to artifacts is based on their architecture filter name. But it is also possible to assign components based on other attributes like annotations or implemented interfaces. This will be explained in more detail later in this chapter.

```
// Main.java in package com.hello2morrow:
"Core/com/hello2morrow/Main"

// The Method class from java.lang.reflection:
"External [Java]/[Unknown]/java/lang/reflect/Method"

// SimpleAction.cs in subfolder of NHibernate:
"NHibernate/Action/SimpleAction"

// An external class from System.dll:
"External [C#]/System/System/Uri"
```

For internal components (components that actually belong to your project) we use the following naming strategy:

module/rel-path-to-project-root-dir/source-name (physical)

module/namespace-or-package/element-name (logcal)

For external components (third party components used by your project) we use a slightly different strategy. Here we might not have access to any source files:

External [language]/jar-or-dll-if-present/rel-path-or-namespace/typename (physical)

External [language]/jar-or-dll-or-header/namespace-or-package/element-name (logical)

Now we can use patterns to describe groups of components:

```
// All components from the Core module with "business" in their name:
"Core/**/business/**"

// All components in java.lang.reflect:
"External*/*/java/lang/reflect/*"
```

As you can see a single '*' matches everything except a slash, '**' matches over slash boundaries. You can also use '?' as a wildcard for a single character.

Now we can build our first artifacts:

```
model "physical" // or "logical"

artifact Business
{
    include "Core/**/business/**"
}

artifact Reflection
{
    include "External*/*/java/lang/reflect/*"
}
```

In the first line you specify which model you would like to use. If you omit the model specification we assume "physical".

We grouped all components from module "Core" with "business" in their name into an artifact named "Business". The reflection classes from the Java runtime are now in their own artifact called "Reflection". Artifacts can also have "exclude" filters. They help you to describe the content of an artifact with an "everything except" strategy. Exclude filters will always be applied after all include filters.

TIP

More than one "include" statement can be used to assign components to an artifact.nIt is also possible to use "exclude" statements to specify exceptions from the elements included above.

11.1.1. Using other criteria to assign components to artifacts

Sometimes the information needed to properly assign a component to an artifact is not part of its architecture filter name. Imagine for example a code generator that generates classes for different functional modules. If all those classes end up in the same package it becomes very hard to assign the generated classes to the right functional modules unless the class name contains some clue. If those generated classes could be properly assigned based on an annotation that would be a far more effective method of assignment.

The following class shows a practical example:

```
package com.company.generated;

import com.company.FunctionalModule;

@FunctionalModule(name = "Customer")
class E5173
{
    // ....
}
```

Neither the class name nor the package name contain a clue that this class is associated with the functional module "Customer". Only the annotation gives that information away.

Since Sonargraph 9.7 it is possible to use what we call "attribute retrievers" in name patterns. In our example we would do the assignment as shown below:

```
artifact Customer
{
    include "JavaHasAnnotationValue: com.company.FunctionalModule: name: Customer"
}
```

If a search pattern contains colons it is split up into the parts separated by the colons. The first part must be the name of an existing attribute retriever, in our example "JavaHasAnnotationValue". The last part is always a pattern describing what we would like to match and can make use of the wildcards "**", "*" and "?". Everything in between the first part and the last part are parameters for the retriever. Here we tell the retriever that we want to match with the "name" attribute of the annotation "com.company.FunctionalModule". Most retrievers don't need parameters, the example above is therefore already a pretty sophisticated use of attribute retrievers.

11.1.2. List of predefined attribute retrievers

PhysicalFilterName

This retriever only works in the context of a logical model and will return the physical architecture filter name of a component. The component in this case would be a logical element, e.g. a class. The result is the architecture filter name of the physical component containing this element. Using this retriever allows you to mix physical and logical assignment strategies in a logical model.

WorkspaceFilterName

This retriever will return the workspace filter of any component. The workspace filter name is the relative path of the source file containing an element. This can be useful to separate assignment by root directory (e.g. test code versus generated code), since root directories are not part of any architecture filter name.

JavaHasAnnotation

This retriever only works for Java and will match if the pattern matches the fully qualified Java name of any annotation of a class. In a physical model if a Java file has more than one top level type we only consider the Java class that has the same name as the file. Please note that "*" will match anything except dots ('.') for this retriever.

```
artifact Controller
{
    include "JavaHasAnnotation: **Controller"
}
```

This example will match any class that has an annotation ending with "Controller".

JavaExtendsClass

This retriever only works for Java and will match if the pattern matches the fully qualified Java name of any direct or indirect base class of a class. In a physical model if a Java file has more than one top level type we only consider the Java class that has the same name as the file. Please note that "*" will match anything except dots ('.') for this retriever.

JavaImplementsInterface

This retriever only works for Java and will match if the pattern matches the fully qualified Java name of any interface implemented by the class. In a physical model if a Java file has more than one top level type we only consider the Java class that has the same name as the file. Please note that "*" will match anything except dots ('.') for this retriever.

JavaHasAnnotationValue

This retriever only works for Java and will match if the pattern matches value of a specific annotation of a class. It has two parameters: the fully qualified Java name of the annotation class and the name of the annotation property to extract. In a physical model if a Java file has more than one top level type we only consider the Java class that has the same name as the file. Please note that "*" will match anything except dots ('.') for this retriever.

CSharpExtendsClass

This retriever only works for C# and will match if the pattern matches the fully qualified C# name (namespace plus class name separated by '.') of any direct or indirect base class of a class. In a physical model a C# file will only be considered if it contains a type that has the same name as the file. Please note that "*" will match anything except dots ('.') for this retriever.

CSharpImplementsInterface

This retriever only works for C# and will match if the pattern matches the fully qualified C# name (namespace plus class name separated by '.') of any interface implemented by the class. In a physical model a C# file will only be considered if it contains a type that has the same name as the file. Please note that "*" will match anything except dots ('.') for this retriever.

CppExtendsClass

This retriever only works for C++ and will match if the pattern matches the fully qualified C++ name (namespace plus class name with '.' as separator) of any direct or indirect base class of a class. In a physical model a C++ component will only be considered if it contains a type that has the same name as the component. Please note that "*" will match anything except dots ('.') for this retriever.

11.2. Interfaces and Connectors

To define allowed relationships between artifacts it helps to use some simple and effective abstractions. Lets assume every artifact has at least one incoming and one outgoing named port. Artifacts can connect to other artifacts by connecting an outgoing port with an incoming port of another artifact. We will call outgoing ports "Connectors" and incoming ports "Interfaces". By default each artifact always has an implicit connector called "default" and an implicit interface also called "default". Those implicit ports always contain all the elements contained in an artifact, unless redefined by the architect.

Let us now connect our artifacts:

```
artifact Business
{
    include "Core/**/business/**"
    connect default to Reflection.default
}

artifact Reflection
{
    include "External*/*/java/lang/reflect/*"
}
```

This will allow all elements contained in "Business" use all elements contained in "Reflection" by connecting the default connector of "Business" with the default interface of "Reflection". In our architecture DSL you can also write this shorter:

```
artifact Business
{
    // ...
    connect to Reflection
}

// ...
```

If we reference an artifact without explicitly naming a connector or an interface the language will assume that you mean the default connector or interface. Connections can only be established between connectors and interfaces. The syntax of the connect feature is as follows:

connect [connectorName] to interfaceList

The interface list is a comma separated list of interfaces to connect to. The connector can be omitted, in that case the default connector will be used.

A dependency from a component A to another component B is not an architecture violation if any of the following conditions is true:

- Either A and/or B do not belong to any artifact.
- A and B belong to the same artifact.
- The artifact of B is nested in the artifact of A.
- There is an explicit connection from a connector that contains A to an interface that contains B.
- B belongs to the default interface of a "public" artifact that is a sibling of a artifact that has a default connector containing A. The artifact of A must be defined before the artifact of B. In other words, "public" artifacts are accessible by sibling artifacts defined above them. ("public" will be introduced later)
- The artifact of A or one of its parent artifacts is "unrestricted" and B is assigned directly or indirectly to a sibling of the unrestricted artifact. In other words, unrestricted artifacts have access to all of their siblings. ("unrestricted" will also be introduced later)
- The artifact of A or one of its parent artifacts is "strict" (i.e. is a strict layer) and B is assigned directly or indirectly to the next following sibling of the strict artifact. More precisely: A must be part of the default connector of the strict artifact, while B must be part of the default interface of its next sibling. Strict layers are allowed to access the layer (artifact) directly below them.
- The artifact of A or one of its parent artifacts is "relaxed" (i.e. is a relaxed layer) and B is assigned directly or indirectly to the any of the siblings of the relaxed artifact that are defined after it. More precisely: A must be part of the default connector of the relaxed artifact, while B must be part of the default interface of any of its siblings that are defined after it. Relaxed layers are allowed to access all the layers (artifacts) defined below them.

Any dependency that does not meet any of the above conditions is considered to be an architecture violation.

"strict", "relaxed" and "unrestricted" are mutually exclusive, i.e. an artifact can have at most one of those three stereotypes.

Now let us assume that we would not want anybody to use the class "Method" of the reflection artifact. This can be achieved by redefining the default interface of "Reflection":

```
artifact Reflection
{
    include "**/java/lang/reflect/*"

    interface default
    {
        include all
        exclude "**/Method"
    }
}
```

Doing that makes it impossible to access the *Method* class from outside the "Reflection" artifact because it is not part of any interface. Here we used an include all filter to add all elements in "Reflection" to the interface. Then by using an exclude filter we took out *Method* from the set of accessible elements in the interface.

Most of the time you will not need to define your own connectors. This is only necessary if you want to exclude certain elements of the using artifact from accessing the used artifact. Using more than one interface on the other hand can be quite useful. But for the sake of completeness let us also define a connector in "Business":

```
artifact Business
{
    include "Core/**/business/**"

    connector CanUseReflection
    {
        // Only include the controller classes in Business
        include "**/controller/**"
    }

    connect CanUseReflection to Reflection
}

// ...
```

Now only classes having "business" and "controller" in their name will be able to access "Reflection".

Let us do something more advanced and assume that the architect wants to make sure that "Reflection" can only be used from elements in the "Business" layer. To achieve that we can simply nest "Reflection" within the "Business" artifact and hide it from the outside world:

```
artifact Business
{
    include "Core/**/business/**"

    hidden artifact Reflection
    {
        // Need a strong pattern to bypass patterns defined by parent artifact
        strong include "**/java/lang/reflect/*"
    }
}
```

By declaring a nested artifact as "hidden" it will be excluded from the default interface of the surrounding artifact. We also don't need to connect anything because parent artifacts always have full access to the artifacts nested within them. In general an artifact can access anything that belongs to itself including nested artifacts and all components that are not part of any artifact. Access to other artifacts requires an explicit connection.

Notice the strong include pattern. Without using a strong pattern the elements belonging to reflection would not make it past the pattern filters defined by "Business".

You can also use the "local" modifier for artifacts. A local artifact will not be part of the default connector of the surrounding artifact.

If you later find out that another part of your software needs access to "Reflection" too you have several options. You could add an interface to "Business" exposing "Reflection" or you could again make a top level artifact out of it. Here is how you'd expose it:

```
artifact Business
{
    include "Core/**/business/**"

    hidden artifact Reflection
    {
        // Need a strong pattern to bypass patterns defined by parent artifact
        strong include "External*/*/java/lang/reflect/*"
    }

    interface Refl
    {
        export Reflection
    }
}
```

With *export* you can include nested artifacts or interfaces of nested artifacts in an interface. Now clients can connect to the "Business.Refl". The counterpart of *export* for connectors is the keyword *include*. It will include nested artifacts or connectors from nested artifacts in a connector.

In that particular example we can expose "Reflection" even more easily:

```
artifact Business
{
    include "Core/**/business/**"

    exposed hidden artifact Reflection
    {
        // Need a strong pattern to bypass patterns defined by parent artifact
        strong include "External*/*/java/lang/reflect/*"
    }
}
```

Now that looks a little strange on first sight, doesn't it - "exposed" and "hidden" at the same time? Well, "hidden" will exclude "Reflection" from the default interface of "Business", while "exposed" makes it visible to clients of "Business". Now clients can connect to "Business.Reflection" which is a shortcut for "Business.Reflection.default". If "Reflection" had more interfaces they could also connect to those other interfaces.

That brings us to another important aspect of our architecture DSL - encapsulation. An artifact only exposes its interfaces or the interfaces of exposed artifacts to its clients. It is not possible for a client to connect to a nested artifact until it is explicitly exposed by its surrounding artifact.

export and *include* can be used together with the keyword *any*. The following example shows how you could explicitly define the default interface and the default connector of any artifact:

```
artifact SomeArtifact
{
    include "**/something/**"

    hidden artifact Hidden
    {
        // ...
    }

    local artifact Local
    {
        // ...
    }

    artifact Nested
    {
        // ...
    }

    interface default
    {
        include "**"
        export any    // will export 'Local.default' and 'Nested.default'
    }

    connector default
    {
        include "**"
        include any   // will include 'Hidden.default' and 'Nested.default'
    }
}
```

If you use *any* by itself it will include all nested artifacts except hidden artifacts for *export* and local artifacts for *include*. You can also explicitly name an interface or a connector of a nested artifact after *any*. In that case the interface or connector is included if it exists, even if its artifact is marked as hidden or local (see next example).

```
artifact SomeArtifact
{
    include "**/something/**"

    hidden artifact Hidden
    {
        // ...
        interface UI { /* ... */ }
    }

    artifact Nested
    {
        // ...
        interface UI { /* ... */ }
    }

    interface default
    {
        export any.UI    // will export 'Hidden.UI' and 'Nested.UI'
    }
}
```

This feature can become quite useful if there are many nested artifacts with a similar structure.

We mentioned before that an artifact can have the modifier *unrestricted*. This means that dependencies coming out of such an artifact to any of its siblings will not be checked. That can be useful if you are creating an architecture description for an existing system with many violations. By declaring some artifacts as *unrestricted* you are not being overwhelmed by violations and can

focus on the most important violations first. It is also useful for grouping legacy code that you want to exclude form architecture checks.

```
strict artifact SomeArtifact
{
    include "**/something/**"
}
strict artifact OtherArtifact
{
    include "**/other/**"
}
unrestricted artifact Legacy
{
    // All remaining internal components
    include "**"
    exclude "External*/**"
}
```

In the example above the two artifacts above "Legacy" have clear architecture rules. They are both defined as strict layers, i.e. they have access to the artifact defined directly beow them. All remaining internal components are assigned to "Legacy". Since "Legacy" is unrestricted, its dependencies towards its siblings are not checked. That can be quite useful when you start defining an architecture for an existing system and only want to focus on certain parts of the system. Just keeping components unassigned would have a slightly different effect. I our example we do not allow dependencies from "SomeArtifact" to "Legacy" because we have defined "SomeArtifact" as a strict layer. That restriction could not be checked if we had kept the components in "Legacy" unassigned.

Here is a summary of the different stereotypes that can be used on artifacts:

Stereotype	Description
hidden	The artifact will not be included in its parents default interface.
local	The artifact will not be included in its parents default connector.
public	All sibling artifacts defined above this artifact can implicitly access the default interface from this artifact using their default connector.
unrestricted	All elements of this artifact can freely access the default interfaces of all the siblings of this artifact.
strict	Creates an implicit connection from the default connector of this artifact to the default interface of its next sibling. (strict layering)
relaxed	Creates implicit connections from the default connector of this artifact to the default interfaces of all sibling artifacts defined after this artifact. (relaxed layering)
exposed	Makes this artifact visible to clients of its parent.
optional	Don't warn if this artifact has no components assigned to it.
deprecated	Do create a warning if any components are assigned to this artifact.

Table 11.1. Artifact stereotype summary

Additionally, in order to ease the visualization of the different stereotypes that can modify the behavior of an artifact, *Sonargraph* uses the following icons and/or decorators:

		via "apply"	via "require"	public	local	hidden
artifact						
unrestricted artifact						
strict artifact						
relaxed artifact						

Table 11.2. Icons/Decorators for Artifacts

Note that artifacts via "apply" or "require" can also have decorators for public, local and hidden stereotypes.

At the end of this section let us have a look at the general syntactic structure of artifacts, interfaces and connectors:

```
artifact name
{
    // include and exclude filters
    // nested artifacts
    // interfaces and connectors
    // connections
}

interface iname
{
    // include and exclude filter
    // exported nested interfaces
}

connector cname
{
    // include and exclude filters
    // included nested connectors
}
```

The order of the different sections is important. Not following this particular order will lead to syntax errors.

Now that we have covered the basic building blocks we can progress to more advanced aspects. In the next section I will focus on how to factor out reusable parts of an architecture into separate files that can best be described as architectural aspects. We will also cover the restriction of dependencies by dependency types.

11.3. Creating Architectural Aspects

Let us assume we want to use a predefined layering for several modules of our software system. Without a mechanism to factor our architectural aspects we would have to write something like that:

```
artifact Module1
{
    include "Module1/**"

    artifact UI
    {
        include "**/ui/**"
        connect to Business
    }
    artifact Business
    {
        include "**/business/**"
        connect to Persistence
    }
    artifact Persistence
    {
        include "**/persistence/**"
    }
    public artifact Model
    {
        include "**/model/**"
    }
    interface Service
    {
        export Business, Model
    }
}

artifact Module2
{
    include "Module2/**"

    artifact UI
    {
        include "**/ui/**"
        connect to Business
    }
    artifact Business
    {
        include "**/business/**"
        connect to Persistence
    }
    artifact Persistence
    {
        include "**/persistence/**"
    }
    public artifact Model
    {
        include "**/model/**"
    }
    interface Service
    {
        export Business, Model
    }
}
```

As you can see the inner structure of both modules is completely identical. Now imagine having dozens of modules. We clearly need a better way to model that. That is where architectural aspects come into the game. They are separate architecture DSL files that are instantiated with an apply directive (see below).

We also introduced a new artifact modifier on the fly: *public*. All artifacts marked as public can be used by all non-public artifacts on the same level (siblings in the artifact tree). "UI", "Business" and "Persistence" therefore have an implicit connection to "Model" (from default connector to default interface).

```
// File layering.arc
artifact UI
{
    include "**/ui/**"
    connect to Business
}
artifact Business
{
    include "**/business/**"
    connect to Persistence
}
artifact Persistence
{
    include "**/persistence/**"
}
public artifact Model
{
    include "**/model/**"
}
// Top level interfaces only make sense, when used together with "apply" (see below)
interface Service
{
    export Business, Model
}

// New file modules.arc
artifact Module1
{
    include "Module1/**"

    apply "layering"
}

artifact Module2
{
    include "Module2/**"

    apply "layering"
}
```

Now we only have to describe the inner structure of modules in one separate file and apply this structure to the them using the apply directive. That is a very powerful construct that will enable you to define reusable architectural patterns.

Let us introduce two additional artifact modifiers that can be useful in certain situations: "optional" is used for artifacts defined within an aspect that could potentially be empty. Using "optional" will suppress the warning marker that is attached to artifacts that have no components assigned to them.

"deprecated" works the other way around. Artifacts declared as "deprecated" will get a warning marker if they have components assigned. That features is very useful to catch components that are not named correctly. The next example will show both modifiers in action:

```
// File layering.arc
artifact UI
{
    include "**/ui/**"
    connect to Business
}
artifact Business
{
    include "**/business/**"
    connect to Persistence
}
artifact Persistence
{
    include "**/persistence/**"
}
public artifact Model
{
    include "**/model/**"
    connect to Util // since Model is public this is required
}
optional public artifact Util
{
     include "**/util/**"
}
deprecated artifact Deplorables
{
    include "**"
}
// Top level interfaces only make sense, when used together with "apply" (see below)
interface Service
{
    export Business, Model
}
```

We added two more artifacts. "Util" is for utility classes that might or might not be present. That is why we added the "optional" modifier. "Util" is also "public"" so that all non-public sibling artifact can use the utility classes implicitly. Since "Model" is also declared to be "public" we need to make an explicit connection to "Util" if we want "Model" to have access to "Util".

The artifact "Deplorables" catches all remaining components that are assigned to the surrounding artifact. Note that the order of artifacts is critical in this case. "**" matches everything, so if we would move "Deplorables" to the top of the artifact list it would get all available components assigned. At the end of the list it will only get those components that have not been assigned to the artifacts above. If we did not have the "Deplorables" artifact those would usually stay assigned to the parent artifact or stay unassigned if there is no parent artifact.

So having an unconnected deprecated artifact like "Deplorabes" is useful for several reasons:

- It catches all components that are not properly named.
- Usually it is desirable that parent artifacts distribute all their components among their children and do not keep components to themselves. This is achieved by using the "**" pattern in "Deplorables".
- If there are components that are not properly named the artifact will get a warning marker and all dependencies to those components are marked as architecture violations.

11.4. Extending Aspect Based Artifacts

Now let us assume we want to refactor one of our modules to have an extra layer. We cannot do this change in the aspect file because this would apply to all modules. If we still want to be able to use the aspect for this module we need some way to extend or modify the elements in the aspect file:

```
artifact Module2
{
    include "Module2/**"

    apply "layering"

    // New layer
    artifact BusinessInterface
    {
        include "**/businessinterface/**"
    }

    // Now Business and UI need access to BusinessInterface
    extend Business
    {
        connect to BusinessInterface
    }
    extend UI
    {
        connect to BusinessInterface
        // UI should not use Business directly
        disconnect from Business
    }
}
```

Extending an artifact only makes sense in the context of apply directives. It allows us to add nested elements to an artifact and/or modify its connections to other artifacts. Within an extended artifact you can also use the keyword override to override the definitions of interfaces or connectors defined in the the original version of the artifact:

```
artifact Module2
{
    // ...
    extend Business
    {
        // This assumes that the imported version of Business has an interface named "X"
        override interface X
        {
            // Use other patterns or other exports
            include "**/x/*"
        }
        connect to BusinessInterface
    }
    // ...
}
```

This allows you to adapt the architecture elements derived from an aspect file when needed.

11.5. Extending Interfaces or Connectors

It is also possible to extend interfaces or connectors defined via apply. That is sometimes quite useful as shown in the following example:

```
artifact Module2
{
    include "Module2/**"

    apply "layering"

    // New artifact that should also be part of the service interface
    artifact ServiceInterface
    {
        include "**/serviceinterface/**"
    }

    // Make the ServiceInterface artifact part of the interface Service
    extend interface Service
    {
        // add an extra export
        export ServiceInterface
    }
}
```

Without the possibility to extend interfaces or connectors we would be forced to create a completely new interface with a different name.

11.6. Adding Transitive Connections

Transitive dependencies are a useful addition to formal architecture descriptions. The following example shows a typical use case:

```
artifact Controller
{
    include "**/controller/**"
    connect to Foundation
}

artifact Foundation
{
    include "**/foundation/**"
}
```

Here *Controller* depends on *Foundation*. We also assume that classes from *Foundation* are used in the public interface of the controller classes. That means that each client of *Controller* must also be able to access *Foundation*.

```
artifact ControllerClient
{
    include "**/client/**"
    connect to Controller, Foundation
}
```

This is certainly not ideal because it requires the knowledge that everything that uses the *Controller* artifact must also connect to *Foundation*. It would be better if that could be automized, i.e. if anything connects to *Controller* it will automatically be connected to *Foundation* too.

Using transitive connections this is easy to implement:

```
artifact ControllerClient
{
    include "**/client/**"
    connect to Controller // No need to connect to Foundation explicitly
}

artifact Controller
{
    include "**/controller/**"
    connect to Foundation transitively
}
// ...
```

Using the new keyword *transitively* in the connect statement will add *Foundation* to the default interface of *Controller*. That means that anybody connecting to the default interface of *Controller* will also have access to *Foundation* without needing an explicit dependency.

The new keyword only influences the default interface. For explicitly defined interfaces the transitive export also has to be made explicit:

```
artifact ControllerClient
{
    include "**/client/**"
    connect to Controller.Service // Will also have access to Foundation
}

artifact Controller
{
    include "**/controller/**"

    interface Service
    {
       include "**/service/**"
       export Foundation // Transitive connection must be explicit here
    }

    connect to Foundation transitively // only affects default interface
}
// ...
```

Before we had transitive connections an interface could only export nested artifacts. Now interfaces can also export connected interfaces. In the example above we add the default interface of *Foundation* to the *Service* interface of *Controller*. Exporting interfaces that are not a connection of he parent artifact will cause an error message.

11.7. Restricting Dependency Types

Sometimes you are in a situation, where you allow one artifact to use another one, but would like to restrict the usage to dependencies of a certain type. For example let us assume you do not want the UI layer to create new instances of classes defined i the "Model" layer. Only "Business" and "Persistence" would be allowed to create "Model" instances. You can solve this by creating a new interface that restricts the usage of certain dependency types:

```
artifact UI
{
    include "**/ui/**"
    connect to Business, Model.UI
}
artifact Business
{
    include "**/business/**"
    connect to Persistence, Model
}
artifact Persistence
{
    include "**/persistence/**"
    connect to Model
}
artifact Model
{
    include "**/model/**"
    interface UI
    {
        include all // everything in "Model"
        exclude dependency-types NEW
    }
}
```

Now it would be marked as an architecture violation if a class from the UI layer would create a new instance of an object from the model layer. Please note that we had to remove the public modifier from "Model". If we had kept it there would have been an implicit connection from UI to the default interface of Model bypassing our special restriction.

Currently the language supports the following list of language agnostic abstract dependency types:

```
        // instance creation
        NEW

        // inheritance
        EXTENDS

        // interface implementation
        IMPLEMENTS

        // all non-virtual function or method calls
        CALL

        // reading a field or variable
        READ

        // writing to a field or variable
        WRITE

        // all other uses
        USES
```

In the next section we will look at another advanced concept called "connection schemes".

11.8. Connecting Complex Artifacts

In this section we will examine the different possibilities to define connections between complex artifacts. Let us assume we use the following aspect file to describe the inner structure of a business module:

```
// File layering.arc
exposed artifact UI
{
    include "**/ui/**"
    connect to Business
}
exposed artifact Business
{
    include "**/business/**"

    interface default
    {
        // Only classes in the "iface" package can be used from outside
        include "**/iface/*"
    }

    connect to Persistence
}
artifact Persistence
{
    include "**/persistence/**"
}
exposed public artifact Model
{
    include "**/model/**"
}
```

This example also show a special feature of our DSL. You can redefine the *default* interface if you want to restrict incoming dependencies to a subset of the elements assigned to an artifact. Our layer "Business" is now only accessible over the classes in the "iface" package.

Now lets bring in some business modules:

```
// File modules.arc
artifact Customer
{
    include "Customer/**" // All in module "Customer"
    apply "layering"
    connect to Core
}
artifact Product
{
    include "Product/**" // All in module "Product"
    apply "layering"
    connect to Core
}
artifact Core
{
    include "Core/**" // All in module "Core"
    apply "layering"
}
```

Here "Customer" and "Product" are connected to "Core". We used the most simple way to connect those artifacts which means that all elements in "Customer" or "Product" can use everything in the default interface of "Core". Since we redefined the default interface of "Business" this is not everything in "Core". The default interface of "Core" exports all default interfaces of non-hidden nested artifacts which means that the restrictions defined in "Business" are respected by surrounding artifacts.

Nevertheless this way of connecting artifacts does not give us enough control. For example "Product.Model" could now access "Core.UI" - not pretty. That means we need to put a bit more effort into the connection:

```
// File modules.arc
artifact Customer
{
    include "Customer/**" // All in module "Customer"
    apply "layering"

    connect UI to Core.UI, Core.Controller, Core.Model
    connect Controller to Core.Controller, Core.Model
    connect Model to Core.Model
}
artifact Product
{
    include "Product/**" // All in module "Product"
    apply "layering"

    connect UI to Core.UI, Core.Controller, Core.Model
    connect Controller to Core.Controller, Core.Model
    connect Model to Core.Model
}
artifact Core
{
    include "Core/**" // All in module "Core"
    apply "layering"
}
```

Now we are more specific about the details of our connection. Please note that we can only connect to "UI", "Controller" and "Model" of "Core" because we have marked those artifacts as exposed. Otherwise they would be encapsulated and not directly accessible. The "Persistence" layer is not exposed and can therefore only be used from inside its enclosing artifact.

11.9. Introducing Connection Schemes

If you look closely you will find that both connection blocks in "Customer" and "Product" are absolutely identical. Now image you had to connect dozens of artifacts in this way. That would be quite annoying and error prone. To avoid this kind of duplication we added the concept of connections schemes:

```
// File modules.arc
connection-scheme C2C
{
    connect UI to target.UI, target.Controller, target.Model
    connect Controller to target.Controller, target.Model
    connect Model to target.Model
}

artifact Customer
{
    include "Customer/**" // All in module "Customer"
    apply "layering"

    connect to Core using C2C // connection scheme C2C
}
artifact Product
{
    include "Product/**" // All in module "Product"
    apply "layering"

    connect to Core using C2C
}
artifact Core
{
    include "Core/**" // All in module "Core"
    apply "layering"
}
```

Now I hope you agree that this is cool. Using connection schemes it becomes possible to describe the wiring between artifacts in an abstract way. That makes it easy to change the wiring if the architect comes up with a new idea or wants to add or remove restrictions.

In big systems you may need some additional nesting to avoid having too many toplevel artifacts:

```
artifact SystemPartA
{
    //...
    artifact A
    {
        //...
        apply "layering"
    }

    artifact B
    {
        //...
        apply "layering"
    }

    connect to SystemPartB using Part2Part
}

arifact SystemPartB
{
    //...
    artifact C
    {
        //...
        apply "layering"
    }

    artifact D
    {
        //...
        apply "layering"
    }
}

connection-scheme Part2Part
{
    // Please note the use of "any"
    connect any.UI to target.any.UI, target.any.Controller, target.any.Model
    connect any.Controller to target.any.Controller, target.any.Model
    connect any.Model to target.any.Model
}
```

Here parts contain nested parts which share a common layering. The use of the keyword *any* allows to insert a wildcard for those nested parts into the scheme. In our example each wildcard connection defined in the scheme would result in 4 real connections since each part has 2 nested parts here (A.x to C.x, A.x to D.x, B.x to C.x and B.x tp D.x). To keep the number of connections under control only one *any* is allowed on each side of a wildcard connection.

11.10. Artifact Classes

Artifact classes have been added as an optional and advanced feature that can be really useful in larger projects or in conjunction with connection schemes. An artifact class basically names the connectors and interfaces an artifact is supposed to have. If an artifact is declared to have a specific class Sonargraph will verify that it defines all the interfaces and connectors required by the class. Moreover connection schemes can now also define source and target classes which allows immediate checking of correctness.

Another benefit is that artifact classes make it a lot easier to organize artifacts into a tree so that the number of top-level artifacts stays manageable.

Let us introduce a real example:

```
// File "layering.arc"
artifact Service
{
    // ...
    connect to Controller
}
artifact Controller
{
    // ...
    connect to DataAccess
}
artifact DataAccess
{
    // ...
}
public exposed artifact Model
{
    // ...
}
interface IService
{
    export Service, Model
}

// Main file "business.arc"
class BusinessComponent
{
    interface IService, Model
    connector Controller, Model
}

connection-scheme BC2BC : BusinessComponent to BusinessComponent
{
    connect Controller to target.IService
    connect Model to target.Model
}

artifact Customer : BusinessComponent
{
    apply "layering"
}

artifact Order : BusinessComponent
{
    apply "layering"

    connect to Customer using BC2BC
}
```

The artifacts "Customer" and "Product" are specifying "BusinessComponent" as their artifact class. Therefore they must have "IService" and "Model" either as an interface or as an exposed artifact. They also must have connectors or artifacts named "Controller" and "Model". In our example the artifacts conform to the class. Otherwise Sonargraph would report an error.

The advantage of using artifact classes together with connection schemes: Now we can check the connection scheme for correctness at the point of definition. Without the use of classes we can only do checks at the point of use.

Another aspect of artifact classes is that they help grouping components together in an elegant way. Let's look at another example:

```
artifact OrderProcessing : BusinessComponent
{
    local artifact Customer : BusinessComponent
    {
        apply "layering" // see above
    }
    artifact Order : BusinessComponent
    {
        apply "layering"
        connect to Customer using BC2BC // defined above
    }
    connect to ProductManagement using BC2BC
}

artifact ProductManagement : BusinessComponent
{
    artifact Product
    {
        apply "layering"
        connect to Part using BC2BC
    }
    hidden artifact Part
    {
        apply "layering"
    }
}
```

The first thing you should notice is that neither "OrderProcessing" nor "ProductManagement" define the interfaces and connectors required by "BusinessComponent". They don't have to, because their nested artifacts do provide those connectors and interfaces. If an artifact belongs to a class and does not explicitly define a required interface or connector Sonargraph will check if it has nested artifacts that do.

In the case of interfaces Sonargraph will implicitly create a missing interface by exporting the matching interfaces of nested artifacts that are not hidden. In the case of connectors Sonargraph will implicitly create a missing connector by including the matching connectors of nested artifacts that are not local.

Here is the same example with all those implicitly defined interfaces and connectors explicitly defined:

```
artifact OrderProcessing : BusinessComponent
{
    local artifact Customer : BusinessComponent
    {
        apply "layering" // see above
    }
    artifact Order : BusinessComponent
    {
        apply "layering"
        connect to Customer using BC2BC // defined above
    }
    // Implicitly defined
    connector Controller
    {
        include any.Controller  // will not include Customer.Controller because Customer is local
    }
    connector Model
    {
        include any.Model       // will not include Customer.Model because Customer is local
    }
    interface IService
    {
        export any.IService
    }
    interface Model
    {
        export any.Model
    }
    // end of implicit definitions
    connect to ProductManagement using BC2BC
}

artifact ProductManagement : BusinessComponent
{
    artifact Product
    {
        apply "layering"
        connect to Part using BC2BC
    }
    hidden artifact Part
    {
        apply "layering"
    }
    // Implicitly defined
    connector Controller
    {
        include any.Controller
    }
    connector Model
    {
        include any.Model
    }
    interface IService
    {
        export any.IService // will not include Part.IService because Part is hidden
    }
    interface Model
    {
        export any.Model    // will not include Part.Model because Part is hidden
    }
    // end of implicit definitions
}
```

The implicit definitions only occur when you do not make an explicit definition. So you can always override those definitions although this should hardly ever be necessary.

Using artifact classes can become a very powerful pattern especially for the design of larger systems with many components that have a similar internal structure.

11.11. How to Organize your Code

In this article I am going to present a realistic example that will show you how to organize your code and how to describe this organization using our architecture DSL. Let us assume we are building a micro-service that manages customers, products and orders. A high level architecture diagram would look like this:

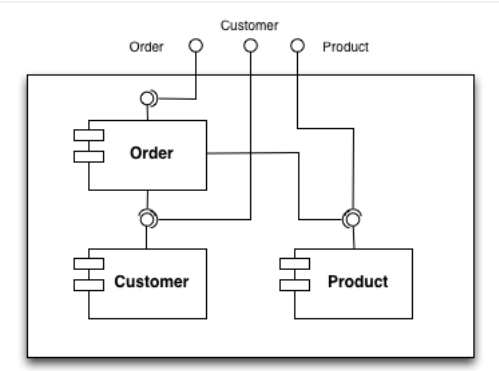


Figure 11.2. Architecture of the order management micro service

It is always a good idea to cut your system along functionality, and here we can easily see three subsystems. In Java you would map those subsystems to packages, in other languages you might organize your subsystem into separate folders on your file system and use namespaces if they are available.

Let us assume the system is written in Java and its name is “Order Management”. In that case we would organize the code into those 3 packages:

```
com.hello2morrow.ordermanagement.order
com.hello2morrow.ordermanagement.customer
com.hello2morrow.ordermanagement.product
```

This can easily be mapped to our DSL:

```
artifact Order
{
    include "**/order/**"
    connect to Customer, Product
}

artifact Customer
{
    include "**/customer/**"
}

artifact Product
{
    include "**/product/**"
}
```

Internally all three subsystem have a couple of layers and the layering is usually the same for all subsystems. In our example we have four layers:

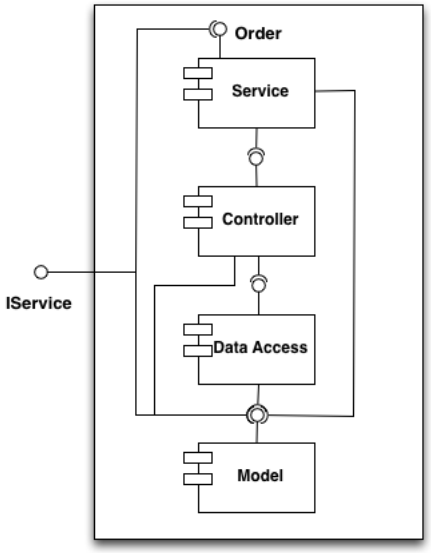


Figure 11.3. Layering of a subsystem

A service would only expose its service ad its model layer to the outside. The service layer contains all the service interfaces and talks to the controller and the model layer. The controller layer contains all the business logic and uses the data access layer to retrieve or persist data using JDBC. The model layer is defining the entities we are working with.

We will use a separate architecture file named “layering.arc” to describe our layering:

```
// layering.arc
artifact Service
{
    include "**/service/**"
    connect to Controller
}

artifact Controller
{
    include "**/controller/**"
    connect to DataAccess
}

require "JDBC"

artifact DataAccess
{
    include "**/data/**"
    connect to JDBC
}

public artifact Model
{
    include "**/model/**"
}

interface IService
{
    export Service, Model
}
```

Please note, that we declared “Model” as a public artifact. That saves us the need to explicitly connect all the other layers to “Model”. Also note the “require” statement. Here refer to a third architecture file, that contains the definition of the artifact JDBC. This way we can ensure that only the data access layer can make JDBC calls. using “require” will only declare the artifacts

contained in the required file, but not define them. This means that the artifacts in “JDBC” have to be defined on another level. The interface is used to define the exposed parts of a subsystem. When connecting to the “IService” interface you have only access to the “Service” and the “Model” layer.

Now we use apply statements to apply the layering to our three subsystems:

```
artifact Order
{
    include "**/order/**"
    apply "layering"
    // Connect to the IService interface of Customer and Product
    connect to Customer.IService, Product.IService
}

artifact Customer
{
    include "**/customer/**"
    apply "layering"
}

artifact Product
{
    include "**/product/**"
    apply "layering"
}

// By using apply we define the artifacts of "JDBC" in this scope
apply "JDBC"
```

We also apply “JDBC” in the outermost scope to ensure that the artifacts in there are defined exactly once.

For the sake of completeness, here is the definition of “JDBC.arc”:

```
// JDBC.arc
artifact JDBC
{
    include "**/javax/sql/**"
}
```

By using smart package naming it becomes easy to map your code to the architecture description. For example the order subsystem would have four packages:

```
com.hello2morrow.ordermanagement.order.service
com.hello2morrow.ordermanagement.order.controller
com.hello2morrow.ordermanagement.order.data
com.hello2morrow.ordermanagement.order.model
```

As you can see it required relatively little effort to create a formal and enforceable architecture description for our example.

11.12. Designing Generic Architectures Using Templates

Many companies already have some established architectural design patterns which are supposed to be used in most of their applications. For example it makes sense to standardize the layering of business components. It also makes sense to establish specific rules how one business component can access another one. The template feature in our architecture DSL makes it very easy to add generic architectural blueprints to a quality model which would allow automatic verification of those architectural design patterns on any business component without having to create a component specific architecture.

For generic architectures to work properly it is a good idea to think about code organization, in particular the efficient use of name spaces or packages to reflect architectural intent. That can be easily done by using naming conventions:

```
com.hello2morrow.{component-name}.{layer-name}
```

In this simple example we assume that the component name is always the thirst part of a package/namespace name. The fourth part represents the layer. Knowing that we can now create a generic architecture description for this example:

```
// aspect file layering.arc
strict exposed artifact Service
{
    include "**/service/**"
}

strict exposed artifact Controller
{
    include "**/controller/**"
}

require "JDBC"

exposed artifact DataAccess
{
    include "**/data/**"
    connect to JDBC
}

public exposed artifact Model
{
    include "**/model/**"
}

public exposed optional artifact Util
{
    include "**/util/**"
}

deprecated hidden artifact Leftovers
{
    include "**"
}

// main file components.arc
template Components
{
    include "**/com/hello2morrow/(*)/**"
    exclude "**/com/hello2morrow/framework/**"

    artifact capitalize($1)+"Component"
    {
        apply "layering"
    }
}

public artifact Framework
{
    include "**/com/hello2morrow/framework/**"
}
```

In the aspect file "layering.arc" we define our standardized layering. At this point the layer artifacts do not really need to be exposed. That will be needed later when we add connection schemes to our example.

In the main file we use the new template feature. An template is a special kind of artifact that can dynamically create children artifacts out of elements that are matched by the pattern. The pattern must include at least on pair of parentheses so that we can extract the component name and use it as part of the name of a generated artifact. Inside of a template there always is a prototype

artifact that uses a string typed expression as its name. '$1" represents the first extracted name part from the matched architecture filter name. We append "Component" to the capitalized extracted name part to form the name of a generated artifact. We explicitly exclude classes of a framework that is mapped to an extra artifact that has been declared to be public so that everything defined in "Components" can use it.

For our example we assume there are 3 components distributed over the following 3 packages:

```
com.hello2morrow.order
com.hello2morrow.customer
com.hello2morrow.product
```

Then the template artifact "Components" would generate 3 children artifacts named "OrderComponent", "CustomerComponent" and "ProductComponent". All of those would have access to "Framework" because it is a public artifact defined beneath "Components". But on the other hand the three generated components would not be allowed to access each other. Using templates there are currently three ways to regulate dependencies between generated artifacts:

- No dependency allowed (like in the above example)
- By marking the prototype artifact as "unrestricted" the generated artifacts could use each other (from default connector to default interface). It is always possible to restrict the default interface and/or the default connector by defining them explicitly.
- By using connection schemes in combination with artifact classes. That approach will be explained further down.

11.12.1. Using unrestricted generated artifacts

In the next example we use "unrestricted" in combination with a redefined default interface:

```
// main file components.arc
template Components
{
    include "**/com/hello2morrow/(*)/**"
    exclude "**/com/hello2morrow/framework/**"

    unrestricted artifact capitalize($1)+"Component"
    {
        apply "layering"

        interface default
        {
            export Service, Model, Util
        }
    }
}

public artifact Framework
{
    include "**/com/hello2morrow/framework/**"
}
```

Now the 3 generated artifacts can call each other, but only the "Service", "Model" and "Util" layers are exposed. If one of those generated artifacts were to access the "DataAccess" layer of another one this would be marked as an architecture violation.

11.12.2. Using connection schemes to regulate accessibility

If you need more control about the way generated artifacts can interact with other generated artifacts we need to use connection schemes in combination with artifact classes.

```
// main file components.arc
class Layered
{
    interface Service, Controller, DataAccess, Model, Util
    connector Service, Controller, DataAccess, Model, Util
}

connection-scheme C2C : Layered to Layered
{
    connect Service to target.Service, target.Controller, target.Model, target.Util
    connect Controller to target.Controller, target.Model, target.Util
    connect DataAccess to target.DataAccess, target.Model, target.Util
    connect Model to target.Model, target.Util
    connect Util to target.Util
}

template Components : Layered
{
    include "**/com/hello2morrow/(*)/**"
    exclude "**/com/hello2morrow/framework/**"

    artifact capitalize($1)+"Component"
    {
        apply "layering"
    }
    connect all using C2C
}
// ...
```

Now you have total control about the way components access each other. The connection scheme determines for each of the layers which layers can be used in the target artifact. The "connect all" statement declares the connection scheme to be used. The scheme has to connect an artifact class to itself ("Layered" to "Layered" in this example) and prototype artifact must be of the matching class. In our example that happens implicitly by using the class on the template.

11.13. Best Practices

This section explains how the views of Sonargraph can be used efficiently while working with the architecture definition and investigating reported architecture violations.

Investigate Violations

Architecture violations listed in the Issues view can have different root causes: a) There is a violating dependency, b) the architecture definition needs to be updated.

For further investigation, you can do the following:

- **Check the source code:** Simply double-click on the violation.
- **Investigate the dependency with more context:** Right-click on the violation and select "Show in Exploration View" → "Out".
- **Check the architecture definition:** Right-click on the violation and select "Show in Architecture View". The Architecture view is opened with the artifact selected that contains the element causing the violation. Double-click on the artifact and the Architecture File view is opened, highlighting the line of the artifact's definition.
- **Check the artifact dependencies:** The description of the architecture violation contains more details, e.g. "[Static Method Call] 'X' cannot access 'TypeA.java' from 'Y' ...". If you are interested in the architectural context of the involved artifacts 'X' and 'Y', open the Architecture view via right-click "Show in Architecture View". Open the context menu for the selected artifact and open the architecture-based Exploration view via "Show in Exploration View" → "In And Out".

NOTE

The architecture-based Exploration view offers dependency information down to the *component* level, since that is the smallest unit of assignment to an artifact.

Related topics:

- Section 7.10.1, “ Concepts for System Exploration ”
- Section 7.10.2, “ Tree Based System Exploration ”

11.14. Architecture DSL Language Specification

For the sake of completeness please find a formal grammar of our architecture DSL in EBNF form. The semantics of the language have been described in the preceding sections.

```
Body            = Declaration* Connection*
                ;

Declaration     = ArtifactDecl
                | ExtendDecl
                | ApplyDecl
                | RequireDecl
                | IncludeDecl
                | ExcludeDecl
                | InterfaceExt
                | ConnectorExt
                | InterfaceDecl
                | ConnectorDecl
                | Scheme
                | ClassDecl
                | TemplateDecl
                ;

ClassDecl       = "class" IDENT "{" ClassMember* "}"
                ;
ClassMember     = "interface" List
                | "connector" List
                ;

List            = IDENT ("," IDENT)*
                ;
ArtifactDecl    = StereoTypes "artifact" IDENT (":" IDENT)? "{" Body "}"
                ;

ExtendDecl      = "extend" IDENT "{" ExtendBody "}"
                | StereoType+ "extend" IDENT "{" ExtendBody "}"
                ;

ExtendBody      = Declaration* DisconnectDecl* Connection*
                ;
```

```
DisconnectDecl  = "disconnect" IDENT? "from" IdentList
                ;

StereoTypes     = StereoType*
                ;

StereoType      = "public"
                | "hidden"
                | "local"
                | "exposed"
                | "unrestricted"
                | "relaxed"
                | "strict"
                | "optional"
                | "deprecated"
                ;

ApplyDecl       = "apply" STRING
                ;

RequireDecl     = "require" STRING
                ;

IncludeDecl     = "strong"? "include" STRING
                | "include" "all"
                | "include" "dependency-types" DependencyTypes
                ;

ExcludeDecl     = "exclude" STRING
                | "exclude" "dependency-types" DependencyTypes
                ;

DependencyTypes = DependencyType ("," DependencyType)*
                ;

DependencyType  = IDENT
                ;

InterfaceDecl   = ("override"|"optional")? "interface" IDENT "{" InterfaceBody "}"
                ;

InterfaceExt    = "extend" "interface" IDENT "{" InterfaceBody "}"
                ;

InterfaceBody   = IDeclaration*
                ;

IDeclaration    = IncludeDecl
                | ExcludeDecl
                | Export
                ;

ConnectorDecl   = "override"? "connector" IDENT "{" ConnectorBody "}"
                ;

ConnectorExt    = "extend" "connector" IDENT "{" ConnectorBody "}"
                ;

ConnectorBody   = CDeclaration*
                ;

CDeclaration    = IncludeDecl
                | ExcludeDecl
                | Include
                ;

Export          = "export" SpecIdentList
                ;
```

```
Include         = "include" SpecIdentList
                ;

SpecIdentList   = SpecIdent ("," SpecIdent)*
                ;

SpecIdent       = "any" ("." IDENT)*
                | IDENT ("." IDENT)*
                ;

IdentList       = Identifier ("," Identifier)*
                ;

Identifier      = IDENT ("." IDENT)*
                ;

Connection      = "connect" "to" IdentList "transitively"?
                | "connect" Identifier "to" IdentList "transitively"?
                | "connect" "to" IdentList "using" IDENT
                ;

Scheme          = "connection-scheme" IDENT (":" IDENT "to" IDENT)? "{" TargetUse* "}"
                ;

TargetUse       = "connect" Identifier "to" TargetIdentList
                | "connect" "any" "." Identifier "to" TargetIdentList
                ;

TargetIdentList = TargetIdent ("," TargetIdent)*
                ;

TargetIdent     = "target" ("." IDENT)+
                | "target" "." "any" ("." IDENT)+
                ;

IDENT           = ("A" .. "Z" | "a" .. "z")("A" .. "Z" | "a" .. "z" | "0" .. "9" | "_" | "-")*
                ;

TemplateDecl    = StereoTypes "template" IDENT (":" IDENT)? "{" TemplateBody "}"
                ;

TemplateBody    = TemplateInclude+ TemplateExclude* TemplArtifact TemplateConnect*
                ;

TemplateInclude = "include" STRING
                ;

TemplateExclude = "exclude" STRING
                ;

TemplateConnect = "connect" "to" IdentList "transitively"?
                | "connect" Identifier "to" IdentList "transitively"?
                | "connect" "to" IdentList "using" IDENT
                | "connect" "all" "using" IDENT
                ;
```

```
TemplArtifact   = StereoTypes "artifact" NameExpr (":" IDENT)? "{" Body "}"
                ;

NameExpr        = NameItem
                | NameItem "+" NameExpr
                ;

NameItem        = STRING
                | "$" ["1"-"9"]
                | IDENT "(" NameExpr ")"
                ;

                // '@' stands for any character except the context specific terminator
STRING          = '"' (@ | '\\' @)* '"' | "'" (@ | '\\' @)* "'"
                ;
```

Chapter 12. Reporting Changes

Reports for large systems provide an overwhelming amount of information. Most of the times a report containing the changes compared to a baseline is enough - similar to a newspaper versus a whole encyclopedia. This delta feature is currently implemented in our Open Source project "Sonargraph Integration Access" that is hosted on GitHub at https://github.com/sonargraph/sonargraph-integration-access.

This functionality is available in Integration Access 3.0.0 and newer. It can be called with the following command-line and two mandatory arguments: The first being the baseline report and the second the XML report that is compared against the baseline. If no output file is specified as the third parameter, the info is printed to the console.

```
java -cp ../../target/sonargraph-integration-access-3.0.0.jar
    com.hello2morrow.sonargraph.integration.access.ReportDiff
        <path-to-baseline-report-xml> <path-to-report-xml> <optional: output-file-path>
```

If reports are generated at the beginning and end of a feature implementation, this delta log provides a quick overview about changes related to Sonargraph issues and how the overall state of the system has been improved.

The delta report can be generated by specifying a previously generated XML report file as a baseline. The delta report is a plain text file. An example report is shown below (lines have been truncated) that shows differences in issues:

```
Delta of System Reports:
   Report1 (baseline): D:\00_repos\sonargraph-integration-access\src\test\diff\AlarmClockMain_01.xml
   Report2           : D:\00_repos\sonargraph-integration-access\src\test\diff\AlarmClockMain_02.xml

System Info:
   Name: AlarmClockMain
   ID: 6db0a52dfa66892be8a4bc2bb7cf1720
   Path: D:\00_repos\sonar-sonargraph-integration\src\test\AlarmClockMain\AlarmClockMain.sonargraph

Delta of Systems
   System 1 (Baseline): AlarmClockMain from Nov 30, 2016 5:01:13 PM
   System 2           : AlarmClockMain from Dec 30, 2016 5:01:13 PM

- Issue delta:
    Removed (13):
        EmptyArchitectureElement, generated by Core: Artifact 'Foundation', line 1, resolved 'false'
        Potentially dead method, generated by ./Java/BadSmells/FindDeadCode.scr: Method has ...
        Potentially dead type, generated by ./Java/BadSmells/FindDeadCode.scr: Type has no ...
        Duplicate Code Block with 2 occurrences, block size '52', resolved 'false'
         Occurrence in ./com/h2m/alarm/model/AlarmClock.java, start '52', block size '52', ...
         Occurrence in ./com/h2m/alarm/presentation/Main.java, start '34', block size '52', ...
        JavaFileClassFileMissing, generated by JavaLanguageProvider: Missing class file for ...
    Improved (1):
        Previous: ThresholdViolation, generated by ./Java/BadSmells/FindDeadCode.scr: Potentially ...
    Worsened (1):
        Previous: ThresholdViolation, generated by Core: Total Lines = 106 (allowed range: 0 to ...
    Added (6):
        Supertype uses subtype, generated by ./Core/SuperTypeUsesSubType.scr: Reference to ...
        ArchitectureViolation, generated by ./Layers.arc: [Local Variable] 'Model' cannot access ...
```

If present, the report also shows differences in the core system configuration (i.e. licensed features, active analyzers, metric provider, metric ids, etc.), workspace configuration and resolutions.

Current Limitations

The following changes only indirectly affect the Sonargraph issues, but will be treated as changes by the delta detector. The issues in the baseline report will be reported as removed and the issues from the new report as added, despite the fact that the issues are logically the same:

1. Cycle groups issues and duplicate code block issues consist of several parts that contribute to their unique IDs. If one of these parts changes (for example a source file has been renamed) then the issue's ID is changed.

2. If a script or an architecture file is renamed, the origin of the issues generated by those resources is changed.

3. For some issues the originating line within a source file is stored and used for comparison. Changing unrelated lines in the source file before the issue's origin therefore will cause the issue to be treated as changed.

NOTE

As with every modification: Frequent and small changes are easier to review than big-bang refactorings.

Ideas for feature improvements are to include the baseline report as filter in Sonargraph Architect/Explorer to let the user focus on changed issues.

Chapter 13. Plugin Infrastructure

Sonargraph offers a plugin infrastructure to let plugins enhance *Sonargraph's* internal model, and create issues. Plugins can be installed by *Sonargraph's* Plugin Manager Preference Page.

On *Sonargraph's* Plugin Manager Preference Page you can install plugins from disk, configure and delete them, or install them from *Sonargraph* plugin repository.

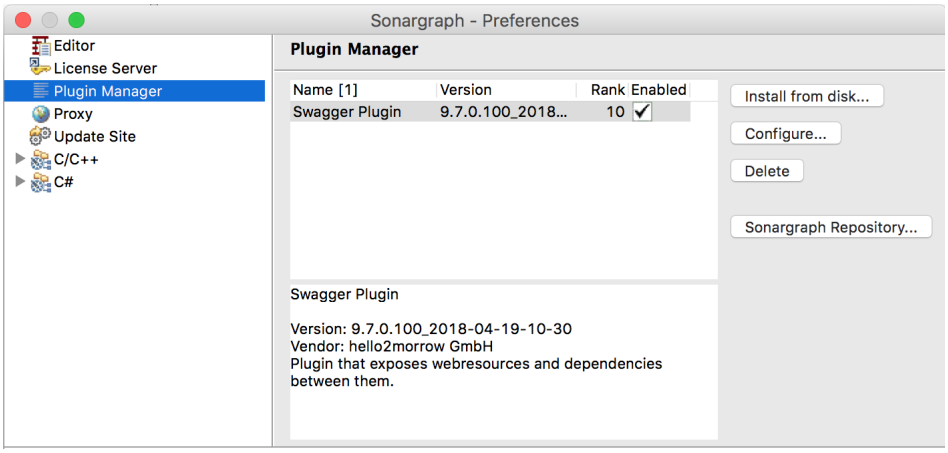


Figure 13.1. Plugin Manager Preference Page

If you choose to install a plugin from *Sonargraph* Plugin Repository, the following dialog is shown. It is possible to install new plugins, or update existing ones.

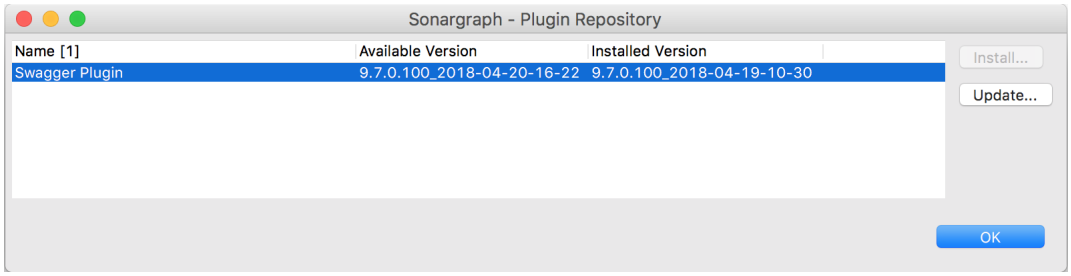


Figure 13.2. Sonargraph Plugin Repository

13.1. Swagger Plugin

The first plugin implemented for *Sonargraph's* plugin infrastructure is a 'Swagger' plugin. It exposes webresources and dependencies between them.

The webservices found by 'Swagger' plugin are shown in Navigation View.

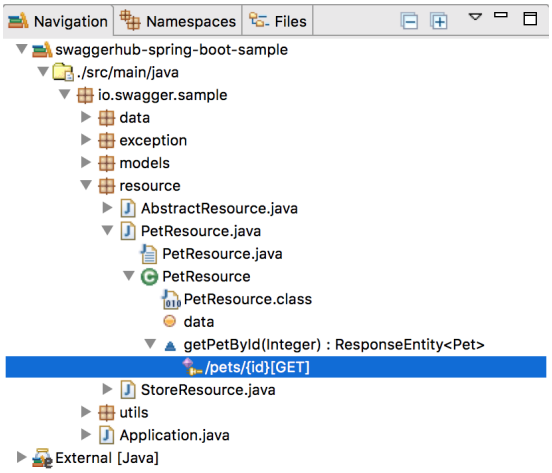


Figure 13.3. Swagger Plugin Webservices

The issues created because of calling webservices not allowed by your architecture are shown in Issues View.

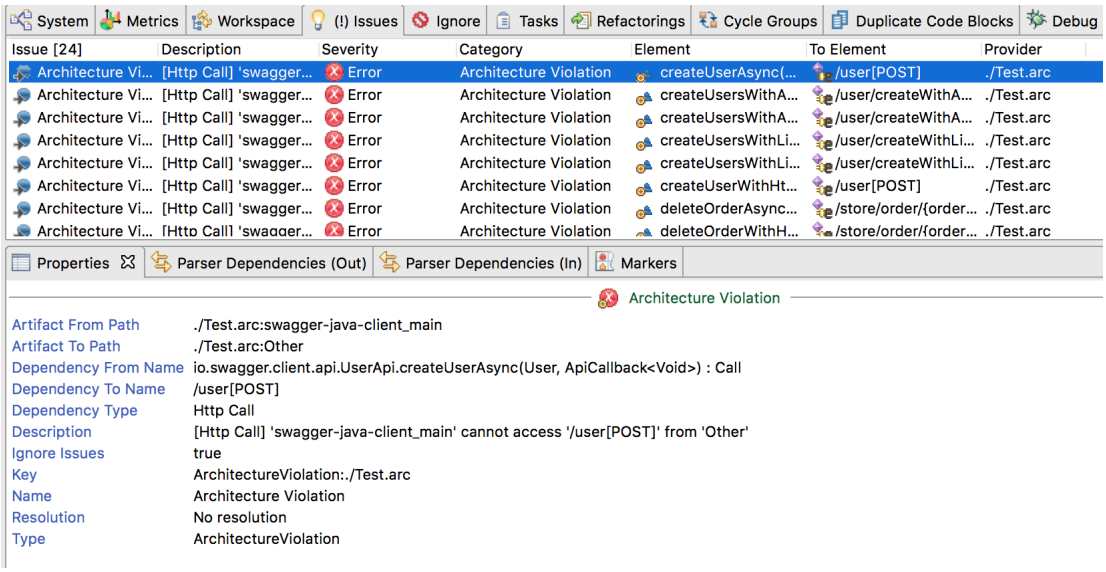


Figure 13.4. Swagger Plugin Issues

The calls to REST endpoints found by 'Swagger' plugin are presented in Navigation View below 'External [Web]'.

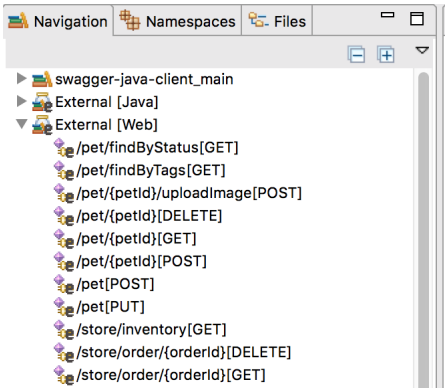


Figure 13.5. Swagger Plugin External

Chapter 14. Build Server Integration

Several integrations exist to run the same Sonargraph quality checks on your build server. SonargraphBuild can be downloaded from our web site: *https://www.hello2morrow.com/products/downloads* Integrations are available to start Sonargraph using Ant, Maven, Gradle or Shell scripts. Plugins are available to visualize the results in *SonarQube* and *Jenkins* . More details about configuration options can be found in the user manual of SonargraphBuild.

If you want to analyze a Java system with Ant on the build server, chances are high that the workspace definition contains class root directories of the development environment and that those directories are not available on the build server. The following section describes how workspace profiles can be used to solve this problem: Section 7.7.3, “ Creating Workspace Profiles for Build Environments ”

Related topics:

- Section 7.7.3, “ Creating Workspace Profiles for Build Environments ”

Chapter 15. IDE Integration

The purpose of the IDE integrations of *Sonargraph* is to run the quality checks continuously during development. This helps to prevent new problems being introduced into the shared code base: It is not needed to wait for the build server to report any problems, but instead the IDE integrations of Sonargraph run quality checks in the background, whenever the IDE compiles Java code. Problem and task markers are created for issues and resolutions and support the developer to fix the problems.

NOTE

The IDE must be started with a Java 8 runtime for the integration to work.

Currently, the IDE integrations only support Java systems.

15.1. Eclipse Plugin

To install the Sonargraph Eclipse plugin, run Eclipse and open menu "Help" → "Install New Software...". Add this update site as a new location: *http://eclipse.hello2morrow.com/sonargraphEclipse*

After successful installation and a restart of Eclipse the additional menu entry "Sonargraph" should be visible. If not, check the Eclipse "Error View" for any errors related to the plugin and get in contact with support@hello2morrow.com.

Note

Installing Sonargraph Eclipse plugin on Eclipse Oxygen with an already installed Groovy plugin may lead to some Eclipse editors or views showing errors after a restart of Eclipse, due to Groovy plugin's compiler resolver being broken when there are multiple Groovy compiler bundles for the same Groovy compiler version. In this case it may help to delete the Groovy compiler bundle introduced by Sonargraph Eclipse plugin from plugins folder of your Eclipse Oxygen installation. If you need further assistance please get in contact with support@hello2morrow.com.

Activation

You need to have a valid license or activation code in order to use the plugin. More details can be found in chapter Chapter 2, *Licensing* . Open the dialog via the menu "Sonargraph" → "Manage License..." and supply either the activation code or license file and hit "Request".

The following sections describe common interactions and usage of the plugin.

NOTE

The IDE must be started with a Java 8 runtime for the integration to work.

We tested the plugin successfully with Eclipse 4.3 and later versions. If you notice any compatibility problems during installation, please send us the Eclipse error log or a screenshot of the error and details about your Eclipse installation to support@hello2morrow.com .

15.1.1. Assigning a System

The next step after the successful installation and activation of the plugin is to open a Software System that has been previously created using *Sonargraph*. Open the menu "Sonargraph" → "Open System..." and select the Sonargraph system.

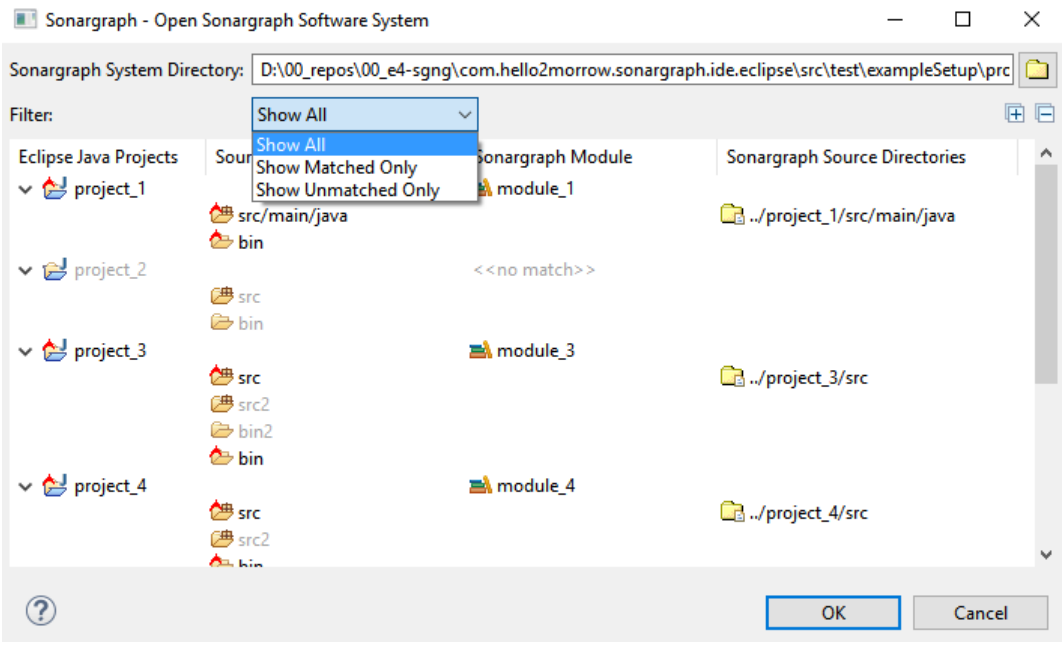


Figure 15.1. Open Sonargraph System

The red decorators and black font indicate, which Eclipse projects could be mapped to Sonargraph modules and which source and class directories are part of the Sonargraph workspace. The mapping is done based on matching source root directories. Projects and directories that are not part of the Sonargraph analysis are indicated by a gray font.

15.1.2. Displaying Issues and Tasks

NOTE

The plugin currently always applies the default virtual model "Modifiable.vm".

NOTE

The number of Sonargraph issues and resolution markers might differ from the number of issues and resolutions displayed in the Sonargraph application for the following reasons:

- Individual markers are created and attached to source files for each duplicate code block occurrence and each component involved in a component cycle group. This makes it easier for the developer to spot a problem while editing a source file, but results in a higher number of markers.
- No markers are created for ignored issues, because the developer cannot resolve them in the IDE.
- Markers are only generated for elements that are part of the currently monitored workspace. If a Sonargraph module cannot be mapped to an Eclipse project, no issues and resolutions for elements contained in that module are shown.

Detected issues are shown in the standard Eclipse Problems and Tasks views. The view options allow to group problems by "Type" as shown in the screenshot.

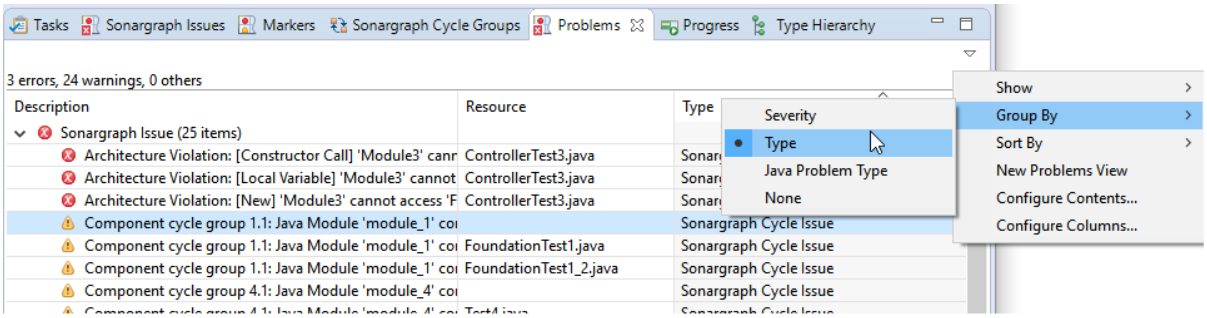


Figure 15.2. Show Issues in Problems View

It is also possible to configure a new Problems view via the Problems view's view menu and exclusively show the Sonargraph issues by selecting "Configure Contents..." and filtering for the Sonargraph issues as shown below in the screenshot. This configuration dialog can be opened via Problems view's view menu "Configure Contents...".

TIP

The same grouping and filtering options are applicable on the standard Eclipse Tasks and Markers views.

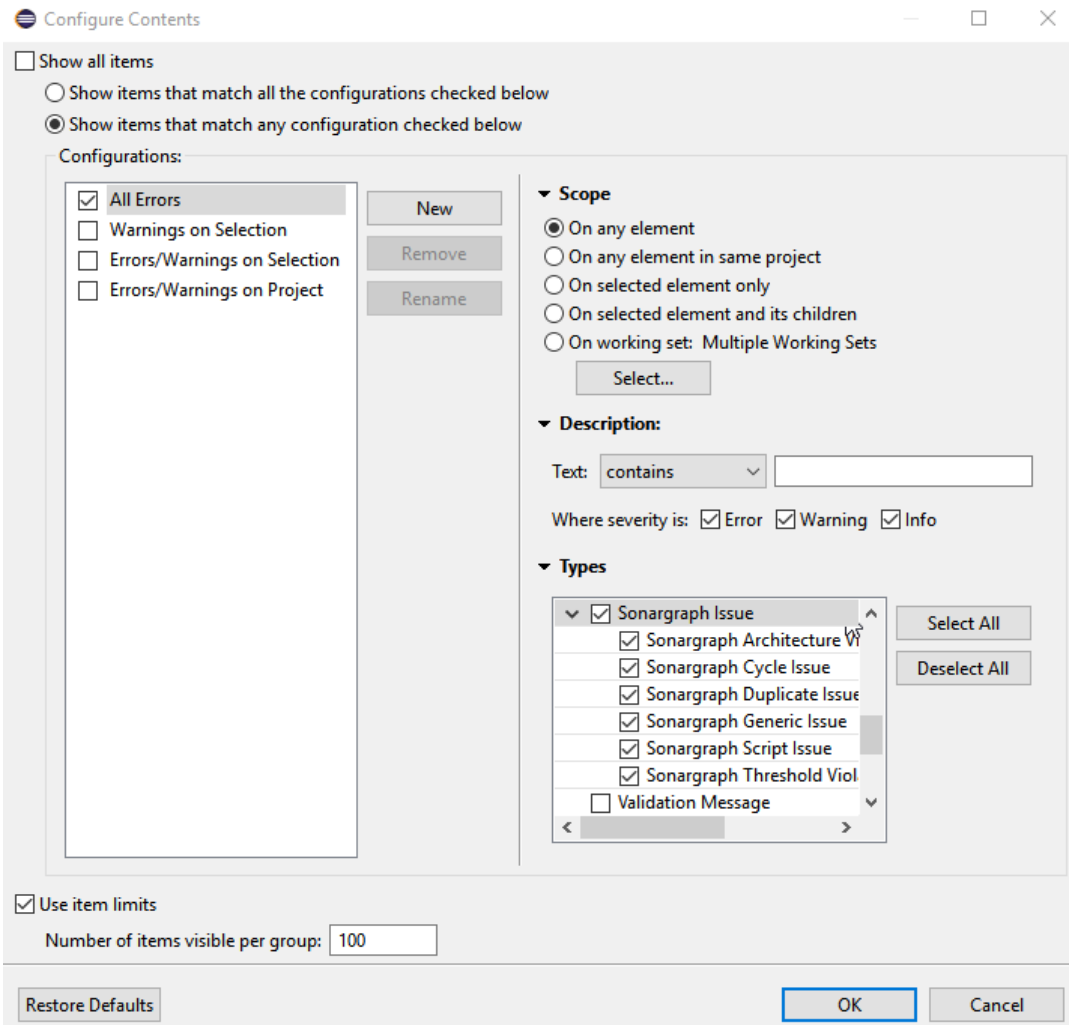


Figure 15.3. Problems View Configuration for Sonargraph Issues

Examining Cycle Group Issues

Sonargraph calculates logical namespace cycle groups, i.e. physical namespaces are merged on module or system level. The Sonargraph Cycle Groups view can be opened via the main Sonargraph menu or via the context menu of a Sonargraph Cycle Issue marker.

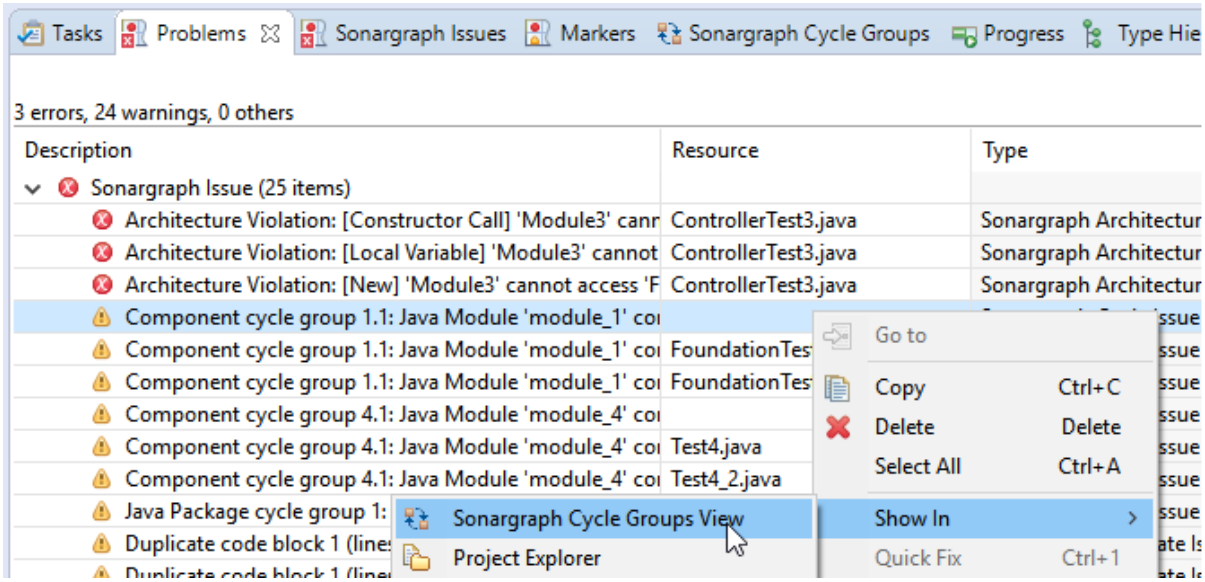


Figure 15.4. Context Menu To Open Sonargraph Cycle Groups View

More detailed cycle group analysis (including possibilities to break them up) should be done with the Sonargraph Architect application as described in Section 7.9, “ Analyzing Cycles ”.

15.1.3. Suspending / Resuming Quality Monitoring

The Sonargraph quality checks are executed as an additional "builder" in the background whenever the project is built. If this is too time consuming or you are currently not interested in the Sonargraph checks, the plugin can be disabled quickly via the menu "Sonargraph" → "Suspend Analysis". This is equivalent to closing the system. Once the checks should be resumed, simply select "Sonargraph" → "Resume Analysis". This is equivalent of openening the system from snapshot and doing a refresh.

NOTE

If the class path of a monitored Eclipse project is modified or a monitored project is closed, the monitoring is automatically suspended. Resume the monitoring, once your are finished with the workspace modifications.

15.1.4. Setting Analyzer Execution Level

The Sonargraph Analyzer Execution Level can be set via the menu "Sonargraph" → "Analyzer Execution Level".

15.1.5. Getting Back In Sync with Manual Refresh

If you updated Sonargraph system files in parallel using the Sonargraph Architect application, you can choose "Sonargraph" → "Refresh System Files" to just update those resources.

If you notice that some markers are not properly updated, or that the Sonargraph analysis has not picked up the latest changes, please use the menu "Sonargraph" → "Reparse System" to bring the Sonargraph model back in sync with the Eclipse workspace.

Since Eclipse caches resources sometimes, you might see Sonargraph "Class file out of date" issues on Eclipse startup. A "refresh" of the Eclipse workspace followed by a build should solve it. If the changes are not picked up by Sonargraph, trigger a manual "reparse" as described above.

TIP

If you notice any problem using the plugin, we a greateful to receive your feedback! The easiest way is to use the menu "Sonargraph" → "Send Feedback".

TIP

We think *assertions* are really helpful to ensure proper program execution and we are using them a lot in Sonargraph. You can enable assertions for Eclipse by adding the -ea VM argument at the end of your eclipse.ini configuration file.

An error dialog will show up if an assertion error happens. Please take the opportunity to let us know about the error! We will do our best to fix it as soon as possible.

15.1.6. Execute Refactorings in Eclipse

The list of Sonargraph refactorings definitions is shown in the Sonargraph Refactorings View. The view can be opened from the Eclipse main menu "Window" → "Show View" → "Other...". Select the folder "Sonargraph" and select "Sonargraph Refactorings".

The "Sonargraph Refactorings" view offers filter options in the top right corner. Refactorings can be filtered by status, priority, assignee and description.

NOTE

Refactorings defined in Sonargraph might affect a lot of resources. We recommend to commit all pending changes to your version control system before executing the refactorings, so you have a safe fallback.

NOTE

Execute the refactorings in the order of their definition. Otherwise subsequent refactorings might no longer be applicable.

The Sonargraph plugin delegates the refactorings to the refactoring mechanism of Eclipse. Some Sonargraph refactorings cannot be converted into a single Eclipse refactoring. The following refactorings need to be split:

1. Namespace refactorings that effectively merge two packages by moving or renaming a package into an existing target package.
2. Move refactorings that change the source root of a namespace or compilation unit.
3. Move refactorings of a package containing subpackages.
4. Move+Rename refactorings are not supported as an atomic operation in Eclipse and need to be split.

The following steps are executed for each refactoring:

1. If the Sonargraph refactoring needs to be split, a confirmation dialog will inform you about the necessary actions.
2. The standard Eclipse refactoring dialogs are shown that allow you to control the affected resources (e.g. change names in non Java files) and preview the changes.
3. If you chose to deviate from the planned refactoring, a dialog prompts you to add a comment.

NOTE

Subsequent Sonargraph refactorings might become obsolete if you deviate from the planned refactoring!

4. The refactoring log containing the list of changed resources is shown in the end. You can copy&paste these details as a protocol e.g. into your task management system.

Related topics:

- Chapter 9, *Simulating Refactorings*
- Section 9.4, “ Best Practices ”

15.2. IntelliJ Plugin

To install the *Sonargraph* Intellij plugin run Intellij, open the Intellij Settings dialog, go to "Plugins" → "Browse repositories..." → "Manage repositories..." and add a new repository supplying hello2morrow's intellij plugin repository URL: *http://intellij.hello2morrow.com/sonargraphIntelliJ/updatePlugins.xml*

Once the repository is configured, select *Sonargraph* from the plugin list and click on the green install button in the description area.

After successful installation and a restart of Intellij, the *Sonargraph* entry should appear under the "Other Settings" node in Intellij's setting dialog. If not, check the Event Log view and Intellij's notifications for any errors related to the plugin and get in contact with support@hello2morrow.com.

Activation

You need to have a valid license or activation code in order to use the plugin. More details can be found in chapter Chapter 2, *Licensing* . Open the dialog via Intellij's settings, then go to "Other Settings" → "Sonargraph" → "Manage License..." and supply either a license file or the activation code, hit "Request" and "Install License" before closing the dialog.

The following sections describe common interactions and usage of the plugin.

NOTE

The IDE must be started with a Java 8 runtime for the integrations to work.

15.2.1. Assigning a System

The next step after the successful installation and activation of the plugin is to open a Software System that has been previously created using *Sonargraph*. On the Intellij settings, go to "Other Settings" → "Sonargraph" and select the Sonargraph system.

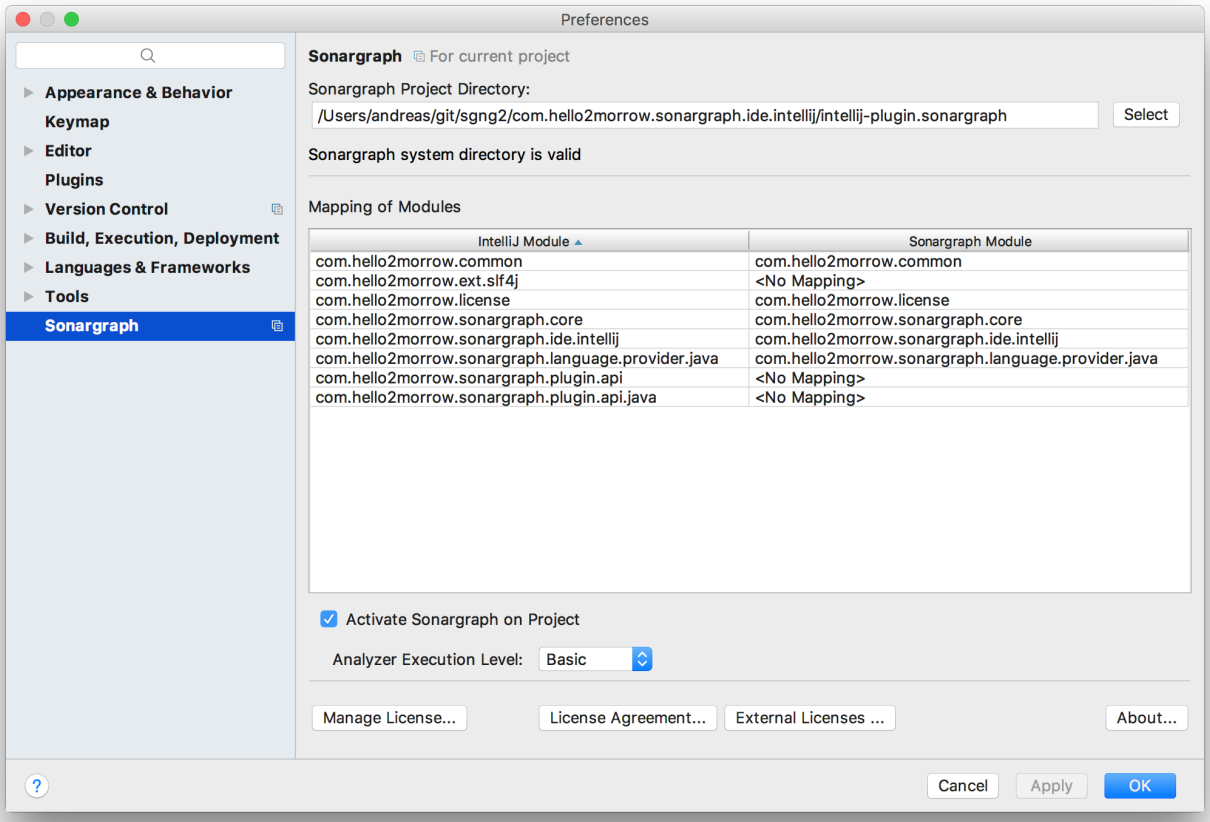


Figure 15.5. Open Sonargraph System

Sonargraph will match its own modules to Intellij's modules based on source root directories. The "Mapping of modules" table shown above indicates the result of the matching process.

Once the system is opened and the matching is completed, use the "Activate Sonargraph on Project" to enable *Sonargraph's* analysis and user interface components in your Intellij IDE.

The "Analyzer Execution Level" can be set to one of "Full", "Advanced", "Basic", or "Minimal". The tooltip shows which Analyzers will be run for each of the levels.

15.2.2. Displaying Issues and Tasks

NOTE

As of now, the plugin always applies the default virtual model "Modifiable.vm".

NOTE

The number of *Sonargraph* issues and resolution markers might differ from the number of issues and resolutions displayed in the *Sonargraph* application for the following reasons:

- Individual markers are created and attached to source files for each duplicate code block occurrence. This makes it easier for the developer to spot a problem while editing a source file, but results in a higher number of markers.
- No markers are created for ignored issues, because the developer cannot resolve them in the IDE.

- Markers are only generated for elements that are part of the currently monitored workspace. If a *Sonargraph* module cannot be mapped to an Intellij project, no issues and resolutions for elements contained in that module are shown.

Detected issues are shown in the standard *Sonargraph* tool window in the Intellij IDE. The tool window has the following tabs: Architecture Violations, Issues, Cycles, Tasks, and Refactorings.

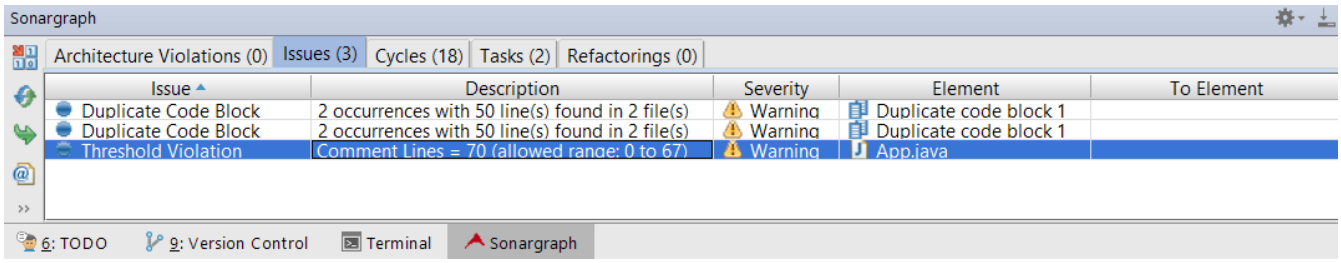


Figure 15.6. Sonargraph Tool Window

15.2.3. Toolbar

Sonargraph's tool window has a toolbar on the left hand side which has four buttons :

- Make Project : Triggers the source code compilation directly from *Sonargraph's* tool window.
- Synchronize : Reloads the information that is currently contained in *Sonargraph's* system files. If changes are detected, the user interface will be updated accordingly.
- Reset : Recreates graphical the components in *Sonargraph's* tool window and synchronizes the information contained in the system files.
- Send Feedback : This button will open *Sonargraph's* feedback dialog. Any information submitted from this dialog will be sent to support@hello2morrow.com
- Scroll to Source : When this toggle button is pushed, any click on an architecture violation, issue, task or compilation unit cycle group whose affected element is a source file will open the java source editor and go to the line containing the marker associated with the clicked issue.
- Toggle Markers : Shows/hides the different markers that the *Sonargraph* Intellij plugin will add for issues/tasks in the IDE source editor.

15.2.4. Getting Back In Sync with Manual Refresh

If you updated *Sonargraph* system files in parallel using the *Sonargraph* Architect application, you can use the "Synchronize" button in the toolbar to get these files in sync.

If you notice that some markers are not properly updated, or that the *Sonargraph* analysis has not picked up the latest changes, please compile your code to bring the *Sonargraph* model back in sync with the Intellij project. You can use the "Make Project" button in the toolbar.

TIP

If you notice any problem using the plugin, we are greateful to receive your feedback! The easiest way is to use the "Send Feedback" toolbar button.

TIP

If an exception happens in our plugin, you will get an error notification from Intellij and if you click on it, you will get the Intellij feedback dialog. Since this dialog only sends feedback to Intellij's bug tracking system, please click on the

"Add Details..." button to get the Sonargraph error feedback dialog, fill in the details and click on the "Ok" button. This way the information gets to us directly and we can address errors quickly.

15.2.5. Execute Refactorings in IntelliJ

The list of Sonargraph refactorings definitions is shown in the "Refactorings" tab of the *Sonargraph* tool window. A refactoring can be executed via right-click.

NOTE

Refactorings defined in Sonargraph might affect a lot of resources. We recommend to commit all pending changes to your version control system before executing the refactorings, so you have a safe fallback.

NOTE

Execute the refactorings in the order of their definition. Otherwise subsequent refactorings might no longer be applicable.

The Sonargraph plugin delegates the refactorings to the refactoring mechanism of IntelliJ. Sonargraph "Move+Rename" refactorings of compilation units cannot be converted into a single IntelliJ refactoring and therefore needs to be split.

The following steps are executed for each refactoring:

1. If the Sonargraph refactoring needs to be split, a confirmation dialog will inform you about the necessary actions.
2. The standard IntelliJ refactoring dialogs and views are shown that allow you to control the affected resources (e.g. change names in non Java files) and preview the changes.

Related topics:

- Chapter 9, *Simulating Refactorings*
- Section 9.4, “ Best Practices ”

Chapter 16. Metric Definitions

This chapter contains definitions for the built-in metrics provided by Sonargraph.

16.1. Language Independent Metrics

Number of Artifacts

Description: Number of active architecture artifacts

Categories: Architecture

Number of Components in Deprecated Artifacts

Description: Number of components that are assigned to deprecated artifact

Categories: Architecture

Number of Components with Violations

Description: Number of components that contain architecture violations

Categories: Architecture

Number of Empty Artifacts

Description: Number of active architecture artifacts that are empty

Categories: Architecture

Number of Ignored Violations (Parser Dependencies)

Description: Number of parser dependencies in ignored architecture violations

Categories: Architecture

Number of Logical Elements in Deprecated Artifacts

Description: Number of logical programming elements that are assigned to deprecated artifact

Categories: Architecture

Number of Unassigned Logical Elements

Description: Number of internal logical elements that are not assigned to any artifact

Categories: Architecture

Number of Unassigned Physical Components

Description: Number of internal physical components that are not assigned to any artifact

Categories: Architecture

Number of Violations (Component Dependencies)

Description: Number of architecture violating component dependencies

Categories: Architecture

Number of Violations (Parser Dependencies)

Description: Number of architecture violating parser dependencies

Categories: Architecture

Number of all Components with Violations

Description: Number of components that contain architecture violations (including ignored violations)

Categories: Architecture

Component Dependencies to Remove (Components)

Description: Number of component dependencies to remove to break up all non-ignored component cycles

Categories: Code Analysis, Cycle

Component Rank (Module)

Description: Component Rank is based on Google's page rank algorithm. The total componet rank over all components in the selected group adds up to 100. The higher the rank, the more 'important' a component is in a system. Having many incoming dependencies or being referenced by other important components increases rank.

Categories: Code Analysis

Component Rank (System)

Description: Component Rank is based on Google's page rank algorithm. The total componet rank over all components in the selected group adds up to 100. The higher the rank, the more 'important' a component is in a system. Having many incoming dependencies or being referenced by other important components increases rank.

Categories: Code Analysis

Number of Code Duplicates

Description: Number of duplicated code blocks.

Categories: Code Analysis

Number of Duplicated Code Lines

Description: Number of duplicated lines in non-ignored duplicated code blocks.

Categories: Code Analysis

Number of Ignored Code Duplicates

Description: Number of ignored duplicated code blocks.

Categories: Code Analysis

Number of Ignored Threshold Violations

Description: Number of ignored threshold violations.

Categories: Code Analysis

Number of Threshold Violations

Description: Number of non-ignored threshold violations.

Categories: Code Analysis

Parser Dependencies to Remove (Components)

Description: Number of code lines to change to break up all non-ignored component cycles.

Categories: Code Analysis, Cycle

Structural Debt Index (Components)

Description: Cummulative structural debt index of non-ignored component cycles.

Categories: Code Analysis

Biggest Component Cycle Group

Description: Number of components in biggest cycle.

Categories: Cycle

Cyclicity (Components)

Description: Cummulated cyclicity of component cycles.

Categories: Cycle

Number of Component Cycle Groups

Description: Number of component cycles.

Categories: Cycle

Number of Cyclic Components

Description: Number of components involved in cycles.

Categories: Cycle

Number of Cyclic Modules

Description: Number of modules involved in cycles.

Categories: Cycle

Number of Ignored Cyclic Components

Description: Number of components involved in ignored cycles.

Categories: Cycle

Relative Cyclicity (Components)

Description: Relative component cyclicity in percent.

Categories: Cycle

LCOM4

Description: Determines the number of components in a class. A component is composed of fields, methods and types defined top level including all their nested programming elements. Constructors, destructors, empty, abstract and overridden methods of classes are not included in the calculation. The metric represents the unrelated portions of code in a class. A value of 1 indicates the highest cohesion possible - which is normally desirable. High values might indicate that a class is a candidate for a refactoring. Consider that utility classes by nature have high LCOM4 values.

Categories: Cohesion/Coupling

Logical cohesion (Module)

Description: Number of dependencies 'to' and 'from' other top-level logical programming elements in the same namespace on module level.

Categories: Cohesion/Coupling

Logical cohesion (System)

Description: Number of dependencies 'to' and 'from' other top-level logical programming elements in the same namespace on system level.

Categories: Cohesion/Coupling

Logical coupling (Module)

Description: Number of dependencies 'to' and 'from' other top-level logical programming elements in other namespaces on module level.

Categories: Cohesion/Coupling

Logical coupling (System)

Description: Number of dependencies 'to' and 'from' other top-level logical programming elements in other namespaces on system level.

Categories: Cohesion/Coupling

Physical cohesion

Description: Number of dependencies 'to' and 'from' other components in the same module.

Categories: Cohesion/Coupling

Physical coupling

Description: Number of dependencies 'to' and 'from' other components in other modules.

Categories: Cohesion/Coupling

Code Comment Lines

Description: Counts all comment lines excluding header comments.

Categories: Size

Comment Lines

Description: Counts all comment lines.

Categories: Size

Lines of Code

Description: Lines of code excluding blank and comment lines.

Categories: Size

Number of Components

Description: Number of components.

Categories: Size

Number of Methods

Description: Number of member functions.

Categories: Size

Number of Modules

Description: Number of modules.

Categories: Size

Number of Parameters

Description: Number of parameters.

Categories: Size

Number of Statements

Description: Counts all statements.

Categories: Size

Number of Types (Module)

Description: Number of types (classes, enums or similar) in container on module level.

Categories: Size

Number of Types (System)

Description: Number of types (classes, enums or similar) in container on system level.

Categories: Size

Source Element Count

Description: Number of programming elements (i.e. types, fields, methods, functions, ...) plus number of statements.

Categories: Size

Total Lines

Description: Counts all lines including empty and comment lines.

Categories: Size

ACD

Description: Average component dependency according to John Lakos. Average number of components a component depends on directly and indirectly. This metric can be used to characterize the overall average coupling of internal components.

Categories: John Lakos

CCD

Description: Cumulative component dependency according to John Lakos. Cumulated depends upon values.

Categories: John Lakos

Depends Upon (Module)

Description: Depends upon module level according to DependsOn by John Lakos. Total number of components that a component directly and indirectly depends upon in containing module.

Categories: John Lakos

Depends Upon (System)

Description: Depends upon system level according to DependsOn by John Lakos. Total number of components that a component directly and indirectly depends upon in system.

Categories: John Lakos

Highest ACD

Description: Highest ACD value among child elements.

Categories: John Lakos

NCCD

Description: Normalized cumulative component dependency according to John Lakos. The ratio between the cumulative component dependency and the cumulative component dependency of a balanced binary tree of the same size. A value greater than 1 indicates a more vertical design. A value less than 1 indicates a more horizontal design.

Categories: John Lakos

RACD

Description: Relative average component dependency. Average component dependency divided by the number of internal components multiplied by 100 (in percent).

Categories: John Lakos

Used From (Module)

Description: Number of all depending elements (direct and indirect) + 1 (including self) in containing module.

Categories: John Lakos

Used From (System)

Description: Number of all depending elements (direct and indirect) + 1 (including self) in system.

Categories: John Lakos

Relational cohesion (Module)

Description: Relation cohesion according to Craig Larman (adapted). Number of internal namespace dependencies divided by the number of top-level logical programming elements in the same namespace on module level. Higher numbers suggest more cohesion.

Categories: Craig Larman, Cohesion/Coupling

Relational cohesion (System)

Description: Relation cohesion according to Craig Larman (adapted). Number of internal namespace dependencies divided by the number of top-level logical programming elements in the same namespace on system level. Higher numbers suggest more cohesion.

Categories: Craig Larman, Cohesion/Coupling

Abstractness (Module)

Description: Abstractness according to Robert C. Martin based on module level dependencies. Total number of abstract types divided by the total number of concrete types. The metric has a range of [0,1]. 0 means that the container contains no abstract types. 1 means that the container contains nothing but abstract types.

Categories: Robert C. Martin

Abstractness (System)

Description: Abstractness according to Robert C. Martin based on system level dependencies. Total number of abstract types divided by the total number of concrete types. The metric has a range of [0,1]. 0 means that the container contains no abstract types. 1 means that the container contains nothing but abstract types.

Categories: Robert C. Martin

Distance (Module)

Description: Distance according to Robert C. Martin based on module level dependencies. Abstractness + Instability - 1. The metric has a range of [-1,1]. This is a variation of the original metric definition. A negative sign means 'in the zone of pain' and a positive sign means 'in the zone of uselessness'. A 'good' value should be around 0.

Categories: Robert C. Martin

Distance (System)

Description: Distance according to Robert C. Martin based on system level dependencies. Abstractness + Instability - 1. The metric has a range of [-1,1]. This is a variation of the original metric definition. A negative sign means 'in the zone of pain' and a positive sign means 'in the zone of uselessness'. A 'good' value should be around 0.

Categories: Robert C. Martin

Instability (Module)

Description: Instability according to Robert C. Martin based on module level dependencies. The metric has a range of [0,1]. If there are no outgoing dependencies, then the Instability will be 0 and the measured element is stable. If there are no incoming dependencies, then the Instability will be 1 and the measured element is instable. Stable means that the element is not so easy to be changed. Instable means that it is easier to be changed.

Categories: Robert C. Martin

Instability (System)

Description: Instability according to Robert C. Martin based on system level dependencies. The metric has a range of [0,1]. If there are no outgoing dependencies, then I will be 0 and the measured element is stable. If there are no incoming

dependencies, then I will be 1 and the measured element is instable. Stable means that the element is not so easy to be changed. Instable means that it is easier to be changed.

Categories: Robert C. Martin

Number of Incoming Dependencies (Module)

Description: Number of incoming dependencies on module level.

Categories: Robert C. Martin

Number of Incoming Dependencies (System)

Description: Number of incoming dependencies on system level.

Categories: Robert C. Martin

Number of Outgoing Dependencies (Module)

Description: Number of outgoing dependencies on module level.

Categories: Robert C. Martin

Number of Outgoing Dependencies (System)

Description: Number of outgoing dependencies on system level.

Categories: Robert C. Martin

Cyclomatic Complexity

Description: Cyclomatic complexity according to Thomas J. McCabe. Number of decision points in a method plus one for the method entry.

Categories: Thomas J. McCabe

Extended Cyclomatic Complexity

Description: As cyclomatic complexity adding the number of logical '&&' and '||' operations.

Categories: Thomas J. McCabe

Modified Cyclomatic Complexity

Description: As cyclomatic complexity but switch statements only add 1 independent from the number of cases.

Categories: Thomas J. McCabe

Modified Extended Cyclomatic Complexity

Description: As cyclomatic complexity but switch statements only add 1 independent from the number of cases and adding the number of logical '&&' and '||' operations.

Categories: Thomas J. McCabe

16.2. Java Metrics

Component Dependencies to Remove (Packages)

Description: Number of component dependencies to remove to break up all non-ignored package cycles.

Categories: Code Analysis, Dependency

Parser Dependencies to Remove (Packages)

Description: Number of code lines to change to break up all non-ignored package cycles.

Categories: Code Analysis, Dependency

Structural Debt Index (Packages)

Description: Cummulative structural debt index of non-ignored package cycles.

Categories: Code Analysis

Biggest Package Cycle Group

Description: Biggest package cycle.

Categories: Cycle

Cyclicity (Packages)

Description: Cummulated cyclicity of package cycles.

Categories: Cycle

Number of Cyclic Packages

Description: Number of cyclic packages.

Categories: Cycle

Number of Ignored Cyclic Packages

Description: Number of ignored cyclic packages.

Categories: Cycle

Number of Package Cycle Groups

Description: Number of package cycle groups.

Categories: Cycle

Relative Cyclicity (Packages)

Description: Relative package cyclicity in percent.

Categories: Cycle

Byte Code Instructions

Description: Number of Java byte code instructions.

Categories: Size

Number of Packages

Description: Number of packages containing types.

Categories: Size

16.3. C# Metrics

Component Dependencies to Remove (Namespaces)

Description: Number of component dependencies to remove to break up all non-ignored namespace cycles.

Categories: Code Analysis, Dependency

Parser Dependencies to Remove (Namespaces)

Description: Number of code lines to change to break up all non-ignored namespace cycles.

Categories: Code Analysis, Dependency

Structural Debt Index (Namespaces)

Description: Cummulative structural debt index of non-ignored namespace cycles.

Categories: Code Analysis

Biggest Namespace Cycle Group

Description: Biggest C# namespace cycle.

Categories: Cycle

Cyclicity (Namespaces)

Description: Cummulated cyclicity of namespace cycles.

Categories: Cycle

Number of Cyclic Namespaces

Description: Number of cyclic C# namespaces.

Categories: Cycle

Number of Ignored Cyclic Namespaces

Description: Number of ignored cyclic C# namespaces.

Categories: Cycle

Number of Namespace Cycle Groups

Description: Number of C# namespace cycles.

Categories: Cycle

Relative Cyclicity (Namespaces)

Description: Relative namespace cyclicity in percent.

Categories: Cycle

Number of Namespaces

Description: Number of C# namespaces containing types.

Categories: Size

16.4. C/C++ Metrics

Component Dependencies to Remove (Directories)

Description: Number of component dependencies to remove to break up all non-ignored directory cycles.

Categories: Code Analysis, Cycle

Component Dependencies to Remove (Namespaces)

Description: Number of component dependencies to remove to break up all non-ignored namespace cycles.

Categories: Code Analysis, Cycle

Parser Dependencies to Remove (Directories)

Description: Number of code lines to change to break up all non-ignored directory cycles.

Categories: Code Analysis, Cycle

Parser Dependencies to Remove (Namespaces)

Description: Number of code lines to change to break up all non-ignored namespace cycles.

Categories: Code Analysis, Cycle

Structural Debt Index (Directories)

Description: Cummulative structural debt index of non-ignored directory cycles.

Categories: Code Analysis

Structural Debt Index (Namespaces)

Description: Cummulative structural debt index of non-ignored namespace cycles.

Categories: Code Analysis

Biggest Directory Cycle Group

Description: Number of directories in biggest cycle.

Categories: Cycle

Biggest Namespace Cycle Group

Description: Biggest C++ namespace cycle

Categories: Cycle

Cyclicity (Directories)

Description: Cummulated cyclicity of directory cycles.

Categories: Cycle

Cyclicity (Namespaces)

Description: Cummulated cyclicity of namespace cycles.

Categories: Cycle

Number of Cyclic Directories

Description: Number of directories involved in cycles.

Categories: Cycle

Number of Cyclic Namespaces

Description: Number of cyclic C++ namespaces.

Categories: Cycle

Number of Directory Cycle Groups

Description: Number of directory cycles.

Categories: Cycle

Number of Ignored Cyclic Directories

Description: Number of directories involved in ignored cycles.

Categories: Cycle

Number of Ignored Cyclic Namespaces

Description: Number of ignored cyclic C++ namespaces.

Categories: Cycle

Number of Namespace Cycle Groups

Description: Number of C++ namespace cycles.

Categories: Cycle

Relative Cyclicity (Directories)

Description: Relative directory cyclicity in percent.

Categories: Cycle

Relative Cyclicity (Namespaces)

Description: Relative namespace cyclicity in percent.

Categories: Cycle

Number of Directories

Description: Number of directories that contain components.

Categories: Size

Number of Namespaces

Description: Number of C++ namespaces containing types.

Categories: Size

Chapter 17. How to Resolve Issues

This section summarizes issues and how they can be resolved.

17.1. Language Independent Issues

Root path does not exist

Indicates that the path supplied for a Root Directory Path cannot be found on disk. A valid path on disk must be supplied.

Duplicate Code

See Section 7.12, “ Detecting Duplicate Code ” for more information about how to investigate code duplicates and the configuration of the analyzer.

17.2. Java Specific Issues

Class file is out-of-date

Indicates that the class file is older than the corresponding source file. Source needs to be re-compiled.

17.3. C# Specific Issues

C# Parsing Errors

Indicates that Sonargraph failed to parse a source file. Check that the correct assemblies are resolved. See Section 6.3.4, “C# Module Configuration” for details.

Report C# Parsing Problems

If you need further support, report the parsing problem to us via the menu "Help" → "Report C# Parsing Problem..." . All files relevant for the problem analysis will be zipped and sent to us for further inspection. Please consider adding some context info.

> **NOTE**
>
> The diagnostic files contain source code. If your company guidelines do not allow to share this information with us, deselect the corresponding checkboxes.

17.4. C/C++ Specific Issues

C/C++ Parsing Errors

Indicates that the EDG parser failed to process a source file. Check that the code compiles in your standard IDE or in your build environment.

Check that the compiler definitions are correct. See Section 3.7, “C/C++ Compiler Definitions” for details.

Report C/C++ Parsing Problems

If you need further support, report the parsing problem to us via the menu "Help" → "Report C/C++ Parsing Problem..." . All files relevant for the problem analysis will be zipped and sent to us for further inspection. Please consider adding some context info.

NOTE

The diagnostic files contain expanded source code. If your company guidelines do not allow to share this information with us, deselect the corresponding checkboxes.

Chapter 18. FAQ

This section summarizes common problems and their solutions.

18.1. Out Of Memory Exceptions

In case of OutOfMemoryExceptions increase the memory made available to *Sonargraph* by opening the file Sonargraph.ini and increase the value for the -Xmx parameter.

18.2. Groovy Template

The configuration of *Sonargraph* is very flexible due to usage of Groovy Templates. Per default, all environment variables are available. The following script illustrates the usage of the variable INCLUDE:

```
<%
def elements = INCLUDE.split(";");
for (element in elements)
{
   println "--sys_include=" + element;
}
%>
```

18.3. MSBuild Error (MSB4019) during Analysis of Visual Studio C# Project

Sonargraph uses MSBuild to retrieve configuration info for C# projects. This specific error can be resolved by removing the following lines from the .csproj file as described on *stackoverflow*:

```
<PropertyGroup>
   <VisualStudioVersion Condition="'$(VisualStudioVersion)' == ''">10.0</VisualStudioVersion>
   <VSToolsPath Condition="'$(VSToolsPath)' == ''">
      $(MSBuildExtensionsPath32)\Microsoft\VisualStudio\v$(VisualStudioVersion)</VSToolsPath>
 </PropertyGroup>
```

Chapter 19. References

Articles about various software quality topics can be found at http://blog.hello2morrow.com/

Our whitepapers and presentations are available at https://www.hello2morrow.com/products/whitepapers

The following list contains books that influenced us a lot prior and during the development of Sonargraph.

[ACM] McCabe, T. J. "A Complexity Measure." IEEE Trans. Software Eng. SE-2, 4, 308-320, Dec. 1976

[ASD] Agile Software Development, Robert C. Martin, Prentice Hall 2003

[AUP] Applying UML And Patterns, Craig Larman, Prentice Hall 2002

[EOT] Erfolgsschlüssel Objekttechnologie, Betrand Meyer, Hanser 1995

[JLS] James Gosling, Bill Joy, Guy Steele, Gilad Bracha, "The Java Language Specification", Addison-Wesley 2005

[LSD] Large-Scale C++ Software Design, John Lakos, Addison-Wesley 1996

[PAP] Robert C. Martin, "Design Principles and Patterns", Objectmentor 2000

[PPR] Jones T.C., "Programming Productivity", New York, McGraw-Hill 1986

[SEE] Boehm, B. W., "Software Engineering Economics", Englewood Cliffs, N. J.: Prentice-Hall 1981

[SOM] Everald E. Mills, "Software Metrics", SEI Curriculum Module SEI-CM-12-1.1 1988

[TOS] Testing Object-Oriented Systems, Beizer, Addison-Wesley 2000

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Chapter 21. Legal Notice

Glossary

C

Component — We follow the definition of John Lakos in "Large Scale C++ Software Design": “A component is the smallest unit of physical design.” This is a source file in Java and C# and a source file plus included header files in C/C++. For more details, see Chapter 4, *Getting Familiar with the Sonargraph System Model* .

L

Logical Namespace — Unifies physical namespaces contained in different root directories. More details are given in Section 4.4, “Logical Models” .

M

Module — Represents usually a deployable unit (e.g. an OSGi bundle, JAR file, C# assembly) containing components.

P

Programming Element — The abstract term that represents a type, method, routine, etc. within the different languages. More details are given in Chapter 4, *Getting Familiar with the Sonargraph System Model*

S

(Software) System — Represents the scope of analysis and contains all required resources, i.e. the workspace definition, virtual models, analyzer configurations and Groovy scripts and the analyzed source code.

W

Workspace Profile — Transforms the existing root directories. This is useful for the integration of *Sonargraph* in the build server. More details are given in Section 7.7.3, “ Creating Workspace Profiles for Build Environments ”.

V

Virtual Model — Represents a sandbox where virtual sets of resolutions (Fix, Ignore, TODO, Delete refactoring, Move/Rename refactoring) can be applied to the system.

Appendix A. Walk Through Tutorial (Java)

This tutorial provides a very concise introduction about the functionality of Sonargraph Architect. At least an evaluation license is required that can be requested via our web site *http://www.hello2morrow.com* to complete the tutorial.

A little example project is used for illustration - the code itself is by no means meant to be an example for good quality or design. The example project is available via our website *https://www.hello2morrow.com/products/downloads* .

You will learn how to create a system in Sonargraph, define a workspace, examine a system, customize the analysis via scripts, define an architecture and check for compliance in the user interface of the rich client application, use the build integration using Ant and Maven and the Eclipse IDE integration. At the end of a section (except the basic first setup) the current stage of the analysis is referenced, that allows to verify that you reached similar results.

This tutorial is intentionally kept as short as possible. For more detailed information about certain functionality, links are provided that will steer you to the corresponding chapters of the user manual.

A.1. Workspace Definition

The following steps describe the basic setup:

1. Unzip *Sonargraph Architect*.
2. On startup, specify a license file.
3. Create a new System using the menu "File" -> "New" -> "System" -> "New System...". Specify a name and location.
4. Create a new Java module using the menu: "File" -> "New" -> "Module" -> "New Java Module...". Specify a name.
5. Right-click on the created module in the Workspace view and select "Manage Java Root Directories...".
6. Specify the root folder of the crm-domain-example project.
7. Detect the root directories and drag&drop them to the module from right to left.
8. Parse / refresh the software system.
9. Check that there are no issues related to the workspace of the system in the Issues view.
10. Close and re-open the system using the menu "File" -> "Open Recently Used" -> "[System Name]" to see how fast the snapshot loading works.

Related topics:

- Chapter 3, *Getting Started*
- Chapter 2, *Licensing*
- Chapter 5, *Creating a System*
- Section 6.1.4, “ Creating a Java Module Manually”

A.2. Basic Analysis

The following steps describe the first analysis of a code base based on the existing dependencies, detected cyclic dependencies, detected duplicate blocks and further metrics:

1. Select packages in the Navigation View and open them via the context menu in the Graph view and Exploration view to see/ examine their existing dependencies. Experiment with the different options for creating the representations. Experiment also with the options provided on the opened views to focus on different dependency types, etc.

2. Examine the detected issues on the Issues view.

3. Customize the duplicate code analyzer via the menu "System" -> "Configure..." -> "Duplicate Code" and specify a smaller minimum block length (e.g. 20 lines), so that duplicates are detected. Use the Duplicate Blocks view to open a side-by-side diff for closer inspection.

4. Check the detected package cycles in the Cycle Groups view, open one of them in the Cycle view for closer inspection.

5. Right-click anywhere on the white area in the Cycle view to open the Cycle Breakup view. Compute a break-up set for the cycle.

6. Right-click on the proposed dependency to remove and create a new "Delete Refactoring" via the context menu. The created task is now visible in the Tasks and Refactorings views.

7. Create a resolution for another issue in the Issues view. Check the filter options of the view in the top right corner to show only issues of a certain category.

8. Switch the Virtual Model on the application's tool bar (top right of the application) and select the "Parser" model in the combo box. Since the resolutions are specific to the Virtual Model, they re-appear in the Issues view.

9. Select the Metrics view and examine the values for the system. Use the combo box at the top-left of the view to examine metric values on other levels (Java Package, Source File, Routine, etc.).

10. Check where JUnit is used: Open the Exploration view for the JUnit package that is contained in the "External [Java]" node in the Navigation view.

11. Specify an exclude filter on the Workspace view by right-clicking on the "Filter" node shown above the root directories. Experiment with the wildcards to exclude test related classes. Check that new issues appear in the Issues view.

12. Irrelevant issues can be either ignored or filtered. Click on the little downwards-pointing white triangle in the top-right corner of the Issues view and open the filter dialog. Deselect the issue type "Dependency To Excluded Internal Component".

13. **Ctrl+H** opens the search dialog. Enter **test* to identify test classes (they should all be marked as excluded).

    Note: If all internal types are filtered out with references to JUnit, there will be no dependencies being shown in the representation views (Exploration view, Graph view).

14. Create a new script by selecting the "Scripts" folder on the Files view and opening the context menu.

15. Modify the default content to check for all types being excluded.

End of Step 1 (step1_crm-domain-example.sonargraph).

Related topics:

- Section 7.4, “ Navigating through the System Components ”
- Section 7.10, “Exploring the System”
- Chapter 8, *Handling Detected Issues*
- Section 7.9, “ Analyzing Cycles ”
- Section 8.1, “Using Virtual Models for Resolutions ”
- Section 7.12, “ Detecting Duplicate Code ”
- Section 7.14, “ Examining Metrics Results ”
- Section 7.7.1, “ Definition of Component Filters, Modules and Root Directories ”
- Section 7.11, “ Searching Elements ”

A.3. Advanced Analysis

The following steps describe how the scripting functionality can be used for advanced analyis of a code base:

1. Select menu "File" -> "Import Quality Model" and choose some scripts from the Java quality model, e.g. "Java/DesignPatterns/Singleton.scr" and "Java/BadSmells/FindDeadCode.scr".
2. Open the Files view and open the scripts in the Script view. Run them and examine the results.
3. Check the script content and examine the usage of the visitor pattern.
4. Click **F1** to open the context help. Select the JavaDoc for the Script API. Detach the Help view for better usability and examine the available functionality.
5. Write a script that finds all "deprecated" methods and classes. Check "Java/BadSmells/FindDeadCode.scr" for the logic to examine dependencies to annotations.
6. Create issues for the found elements.
7. Use the Exploration view to verify your result.
8. Make the annotation class a script parameter.
9. Add the script to the automatically executed scripts via "System" -> "Configure..." -> "Script Runner".
10. Check that the created issues show up in the Issues view.
11. Modify the issue text in the script. Note that the button "Update Automated Script" is now enabled in the Script view. Transfer the modified content to the automated script and check in the Issues view that the description is changed.
12. Check the CoreAccess.find*() methods in the JavaDoc. Modify the script to search for the @Deprecated annotation and find all incoming dependencies. You can copy from the script UsageOfSystemOutPrintln, contained in the Java quality model.
13. Compare the execution times of the two different approaches (visitor vs. search). Think about the pros and cons of each.

End of Step 2 (step2_crm-domain-example.sonargraph).

Related topics:

- Chapter 10, *Extending the Static Analysis*

A.4. Architecture: Artifacts, Templates and Standard Connections

The following steps describe how a basic architecture check can be implemented using the Domain Specific Language (DSL):

1. Create a new architecture file "layers" by right-clicking on the folder "Architecture" in the Files view. Keep the default options and make this architecture file "checked".
2. Create artifacts "Business", "Integration", "Foundation" with the standard include patterns. Check the context help (**F1**) for more information.
3. Right-click on the file in the Architecture Files view and open the Exploration view for the architecture model. You should see red arcs representing violations.
4. Connect artifact "Business" with "Integration".
5. Make "Foundation" public, so that it is implicitly accessible by the other artifacts.

6. Save the changes and check in the Architecture view that the correct components are matched for the artifacts. Verify that the architecture-based Exploration view does not show any violations.

7. Create new checked architecture file "application". Create artifacts "Startup", "Application" (**/ddaexample/**), Framework (**/dda/**) with the standard include patterns. Connect the artifacts as indicated by the existing dependencies (use the Exploration view).

8. Use the "apply" statement for "Application" and "Framework" to create the layering.

9. Add the "optional" keyword to the "Foundation" artifact in layers.arc to get rid of the "Empty artifact" warning.

10. Create the checked architecture file "component". Create artifacts "Controller", "Data", "Domain", etc that correspond with the packages in the code.

11. Create the connections as the dependencies in the code indicate. Again, use the Exploration view to check for the existing dependencies.

12. Check for architecture violations in the Issues view. Drill-down to the code and examine the root cause for the violations.

13. Remove "layers.arc" from the list of checked architecture files. It is now implicitly used, since the layering is checked and applied in the file "application.arc".

End of Step 3 (step3_crm-domain-example.sonargraph).

Related topics:

- Chapter 11, *Defining an Architecture*
- Section 11.1, “ Models, Components and Artifacts ”
- Section 11.3, “ Creating Architectural Aspects ”

A.5. Architecture: Explicit Interfaces and Connectors

The following steps describe how the access between artifacts can be more sophisticated and restrictive:

1. Create checked architecture file "business".

2. Create artifacts for all domain aspects ("User", "Contact", etc), check the package structure and create the correct number of artifacts.

3. Create a dummy artifact that contains all code that is not matched by the other artifacts.

4. Connect the artifacts with simple "connect" statements.

5. Create default interface for the artifact "Service" in "components.arc" to restrict what is accessible from the outside. Include all, except "**/*DtoVal" types.

6. In "application.arc", create a default connector for "Startup" to restrict access to the outside. Only SetupFactories should be allowed to access types outside of its artifact.

7. Check for found architecture violations.

8. Introduce some dummy references in the code (use the Eclipse project) to produce more architecture violations.

9. "Refresh" in Sonargraph Architect and check that the new violations appear.

End of Step 4 (step4_crm-domain-example.sonargraph).

Related topics:

- Chapter 11, *Defining an Architecture*
- Section 11.2, “ Interfaces and Connectors ”

A.6. Architecture: Advanced Connections

The following steps describe how the access between nested artifacts can be more sophisticated and how duplication can be avoided with connection schemes:

1. Apply the component structure of "component.arc" to all artifacts contained in "business.arc".
2. Create more detailed connections between the different components using the nested artifacts explicitly. Check those dependencies in the Exploration view. Note that the artifacts in "component.arc" must be "exposed", so that they their default interfaces are visible.
3. Note that the components are always connected in the same way. Create a connection scheme in "component.arc". Check via the context help for more information about connection schemes.
4. Remove "component.arc" from the checked architecture files.
5. Use the new connection scheme and remove all duplication in "business.arc".
6. Remove the obsolete dummy element in "component.arc".
7. Check that you still see the same architecture violations.

End of Step 5 (step5_crm-domain-example.sonargraph).

Related topics:

- Chapter 11, *Defining an Architecture*
- Section 11.8, “ Connecting Complex Artifacts ”
- Section 11.9, “ Introducing Connection Schemes ”

A.7. Architecture: Advanced Templating

The following steps describe how the information of templates can be changed, so that it fits the context where the templates are applied:

1. We want to create the structure defined in "business.arc" for the "Business" artifact in application.arc. This can be achieved by "extending" the Business artifact and applying "business.arc":

```
extend Business
{
    apply "./business.arc"
}
```

2. Check the context help and modify the architecture.
3. Use the same mechanism in the "Framework" artifact and simply apply the "component.arc" to generate the same structure there.
4. Remove "business.arc" from the checked architecture files. Only "application.arc" should be left as checked architecture file.
5. Verify in the Architecture View that all artifacts are there and the correct components are matched.

6. Experiment with the workspace filters or include / exclude patterns to adjust the matching.

End of Step 6 (step6_crm-domain-example.sonargraph).

Related topics:

- Chapter 11, *Defining an Architecture*
- Section 11.4, “ Extending Aspect Based Artifacts ”

A.8. Architecture: Referencing external Artifacts in Templates

Templates are a good way to apply the same structure to different parts of the architecture. This section demonstrates how to deal with connections from templates to artifacts that are outside of the scope of the template itself. Lets say, we want to control the access to java.lang.reflect and only allow access to it from the artifact "DataServiceInterface" defined in "component.arc". It is shown why a first naive approach is not working, and how the goal can be achieved using the "require" feature.

1. Add the following artifact to this file:

```
artifact Reflection
{
    strong include "External [Java]/[Unknown]/java/lang/reflect/**"
}
```

2. Save the changes and check the assigned elements to the generated instances of the artifact "Reflection". Since there is only a single java.lang.reflection package, the contained types are matched once for the first instance of a "component", and then there are none left to be matched for further "Reflection" instances in other components. This is clearly not what is needed. We want only a single instance of the "Reflection" artifact.

   "strong include" matchers are disabled in templates, to avoid accidential misuse and the above mentioned strange matching results. This is the reason why no matches are shown for any or the created "Reflection" artifacts.

3. We need only a single instance of the "Reflection" artifact in the application architecture. The above approach is not working, and it is now demonstrated how it can be achieved with the "require" feature. You need to define the "Reflection" artifact in its own file, lets say "reflectionAccess.arc". You can remove "strong" from the include matcher.

4. Open the architecture file "application.arc" and add the following statement at the bottom:

   ```
   apply "./reflectionAccess.arc"
   ```

   This creates a single "Reflection" artifact at the top-level of the architecture check.

5. Go back to "component.arc" and add the following statement at the top of the file:

   ```
   require "./reflectionAccess.arc"
   ```

   This now allows using artifacts contained in that file, but does not instantiate them again. Do not forget to define the allowed connection between "DataServiceInterface" and "Reflection".

6. Save the changes and check again for the generated "Reflection" instances in the Architecture view. There is now only a single instance and when you open the Exploration view for "application.arc" you can check which dependencies to "Reflection" are allowed and which represent violations.

This concludes the architecture modeling.

End of Step 7 (step7_crm-domain-example.sonargraph).

Related topics:

- Chapter 11, *Defining an Architecture*

- Section 11.11, “ How to Organize your Code ”

A.9. Headless Check with Sonargraph Build

The following steps describe how *Sonargraph Architect Build* can be used on the build server to generate a report and let the build fail on specific issue types:

1. Download and extract *Sonargraph Architect Build* from the web site *https://www.hello2morrow.com/products/downloads* .
2. If you are interested in Ant: Examine the Ant file "crm-domain-example/build/build.xml" and adjust the properties. Run the target "dist".

   If you are interested in Maven: Examine the Maven file "crm-domain-example/pom.xml" and adjust the properties. Run the goal "package" to create the JAR.
3. Create a workspace profile that uses the created JAR as a target directory.
4. Open the *SonargraphBuild* user manual and check how the workspace profile can be specified as a parameter (only available for command-line and Ant integration).
5. Run the build and adjust the failset: Check for specific issue types only, specific severities, etc.
6. Let the build fail on architecture violations.
7. Check the details of those architecture violations in the generated HTML report.

End of Step 8 (step8_crm-domain-example.sonargraph). The provided example uses the Maven plugin. Note: Workspace profiles can be used with the command-line and Ant integrations. Maven and Gradle provide the option to override the Sonargraph workspace and use the source and class roots as present in the Maven and Gradle build.

Related topics:

- Section 7.7.3, “ Creating Workspace Profiles for Build Environments ”
- Chapter 14, *Build Server Integration*

A.10. Check at Development Time with Sonargraph Eclipse Integration

The following steps describe how to use the Sonargraph Eclipse plugin to execute the quality checks at development time. Start the Eclipse IDE and import the example project.

1. Install the plugin. Section 15.1, “ Eclipse Plugin ” provides details about the plugin's update site.
2. Use the "Sonargraph" menu to activate the plugin by assigning a licsense file or activation code.
3. Assign the Sonargraph system file. Check that the Sonargraph markers appear on the project and root directories.
4. Check that the Sonargraph issues are listed in the problems view. Update the code by introducing / removing violations and check that the markers get updated after saving the changes. ("Build Automatically" must be enabled in Eclipse.)
5. Create a custom "Problems" view and configure it to only show the Sonargraph issues.
6. Switch back to the Sonargraph Architect application. Open the package cycle from the Cycle Groups view and open then the Cycle Breakup view. The dependency to breakup is now much easier to identify, because of the existing architecture definition.
7. Create a delete refactoring for the proposed breakup and save the changes.
8. Create a move/rename refactoring for a compilation unit or package of your choice and save the changes.

9. Refresh the system files in Eclipse using the corresponding Sonargraph menu entry. A new task marker should be visible in the Tasks view and also at the position within the file. Move the violating line up and down and save frequently. The task marker moves accordingly. Comment out the offending lines and see the marker disappear.

10. Open the Sonargraph Refactorings view in Eclipse and execute the refactoring via the context menu.

11. Refresh the system in Sonargraph Architect and notice that the status of the refactoring changed to "Potentially Done". The architect can now review the changes and delete the task.

Related topics:

- Section 15.1, “ Eclipse Plugin ”
- Section 15.1.1, “ Assigning a System ”
- Section 15.1.2, “ Displaying Issues and Tasks ”
- Chapter 9, *Simulating Refactorings*
- Section 9.4, “ Best Practices ”
- Section 15.1.6, “ Execute Refactorings in Eclipse ”

Appendix B. Tutorial - Java

This is a step-by-step tutorial illustrating the analysis of the Open Source project *Apache Cassandra*. It will be demonstrated how to setup the workspace and quickly get an overview of the state of software quality. Some issues are reported by *Sonargraph* right away without further configuration and it will be shown how to analyse cyclic dependencies and duplicate code blocks. *Sonargraph* also allows to easily analyse the dependency structure in more detail. Next it is illustrated how the GroovyScript API can be used to monitor virtually anything that can be detected via static code analysis. The last chapter shows how you can share the results of the analysis.

This tutorial is intentionally kept as short as possible. For more detailed information about certain functionality, links are provided that will steer you to the corresponding chapters of the user manual.

B.1. Setup the Software System

Apache Cassandra is built using *Apache Ant* therefore the Sonargraph Workspace needs to be set up manually, i.e. the definition of *modules* and the location of source and class files. For systems built with Maven or that are represented by an Eclipse or IntelliJ Workspace, the Sonargraph Workspace can be set up automatically. For more information, see Chapter 5, *Creating a System* and Section 7.7, “ Managing the Workspace ” .

B.1.1. Create a new Software System

The initial system is created using "File" → "New" . Select the entry "Manual System" and continue. In the following wizard page, provide the name of the *software system* and specify where the system's files will be stored. For more information about the file structure, see Chapter 4, *Getting Familiar with the Sonargraph System Model* .

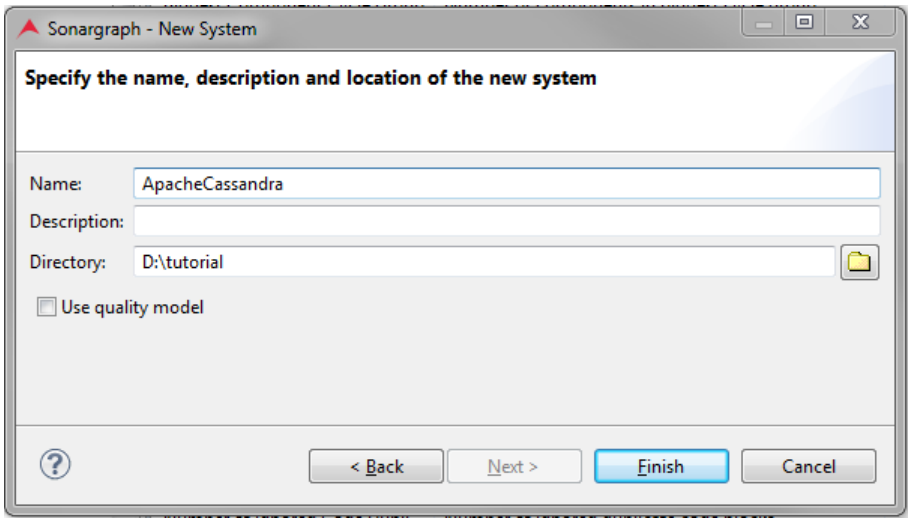


Figure B.1. New Manual System Wizard

Using a Quality Model is explained in Section B.6, “Share Results” , leave this option unchecked for now.

B.1.2. Define the Workspace

As a next step, we need to create one or several modules. A module is the container for source and class root directories and usually represents a Maven module or an Eclipse / IntelliJ project. We will start creating a single module, and refine the workspace later.

A module is created by selecting "File" → "New" and selecting the wizard entry "Manual Java Module". Define the module's name and optionally provide a description.

As a next step, we let *Sonargraph* search for directories containing source and class files. Right-click on the created module in the Navigation view. Select the context menu entry "Manage Java Source/Class Root Directories/Archives..." and specify the root directory of the *Apache Cassandra* project on your disk.

Start the detection and wait until it completes. Now you can move the found directories via drag&drop from the right to the left. We omit directories containing examples or test code.

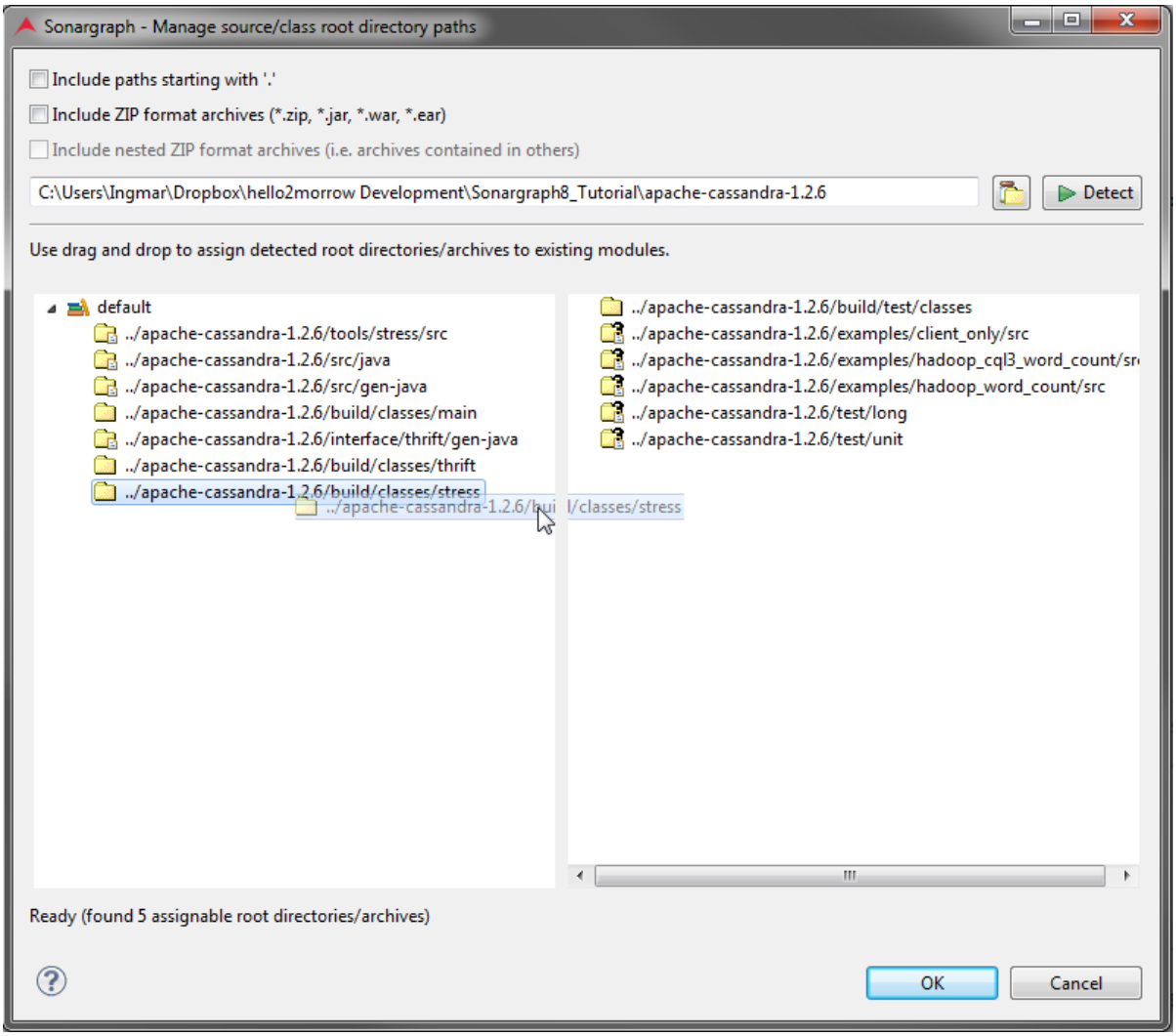


Figure B.2. Root Directories Dialog

The workspace configuration can be examined on the Workspace view. We can see that it is probably best to create additional modules "thrift" and "stress" using the same approach as previously. Now you can use drag&drop in the Workspace view to move directories from the "default" module and rename "default" to "main" using either the context menu or the **F2** shortcut.

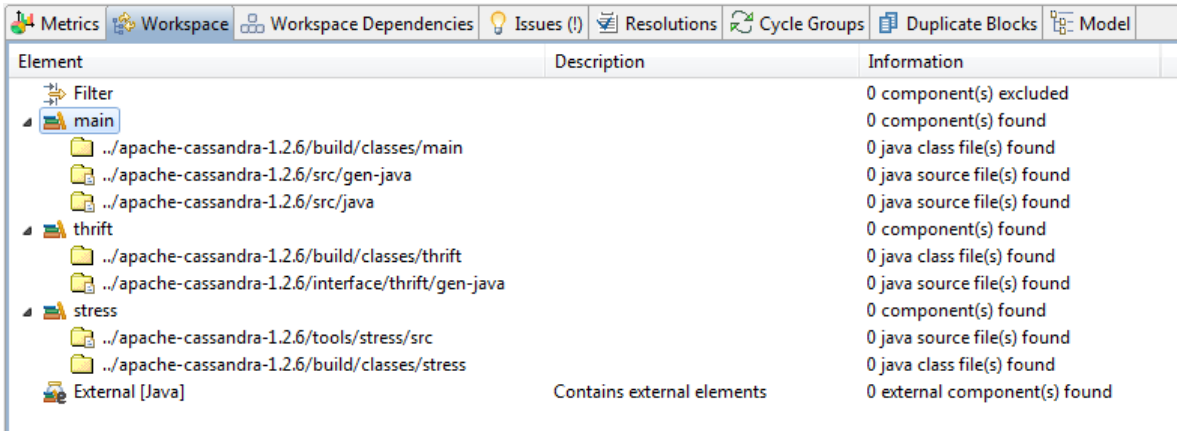


Figure B.3. Workspace View

NOTE

The order of the root directories matters: In case there are classes with the same fully qualified names, the first one found wins. You can change the order of root directories of manual Java modules within the Workspace view using drag&drop.

B.1.3. Define Module Dependencies

Managing module dependencies is especially important when using frameworks like OSGi where you could have a module X and a module Y each one of them containing a type with the fully qualified name a.b.c.Type. Such conflicts are resolvable by defining manual module dependencies. These module dependencies control the type resolution when creating parser dependencies trying to locate the 'to' (Java) type.

If the modules do not define any dependencies all types are visible in all modules. Once there are type resolution conflicts which would show up as 'Ambiguous Target Type' issues manual module dependencies can be used to decide which type(s) should be accessed from which module. If module Z accesses the type a.b.c.Type defined in module X and module Y the conflict is resolved by simply defining a manual module dependency between module Z and the correct target module.

NOTE

If you know how modules are supposed to use each other, define the workspace dependencies explicitly.

B.1.4. Parse the Workspace

To parse the workspace, either chose the menu item "System" → "Refresh" or use the shorcut **F5** . After the parsing has completed, the detected classes are displayed with their package structure in the Navigation view and the Workspace view shows how many items are found in a directory.

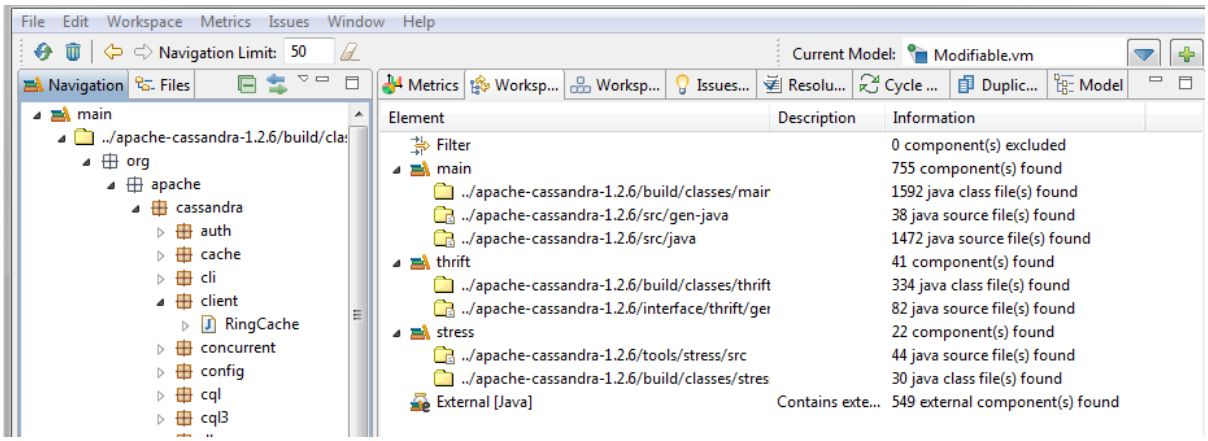


Figure B.4. Workspace View After Parsing

B.2. Initial Analysis

After having parsed the workspace as described in the previous section, basic information about the number of processed source and class files is provided on the workspace view. This section explains how the results of the metric calculation can point out problematic areas.

B.2.1. Detect Problems Using Standard Metrics

The Metrics view is separated into two general areas: The "System Level" and the "Element Level". The "Element Level" tab allows to focus on different levels, e.g. modules, root directories, packages, types, routines, etc. as shown in the following screenshot.

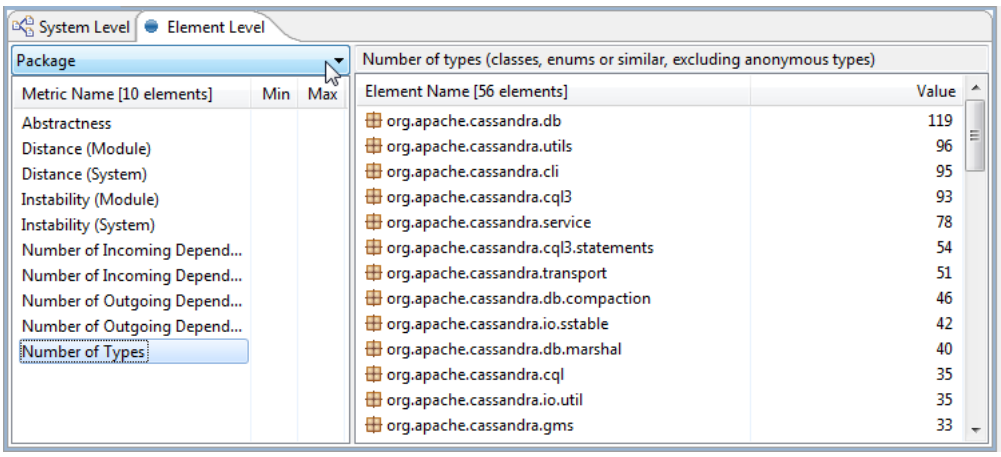


Figure B.5. Metrics View

B.2.2. Adjust Metric Thresholds

The Metrics view allows defining lower and upper-level thresholds for metrics. Issues are created for those elements violating these thresholds and they are clearly marked in the table. If metric thresholds are specified, those values will be saved into a file located at: `<Sonargraph System directory>/Analyzers/MetricThresholds.xml` . Thresholds are defined either via the context menu of a metric or the menu entry "Metrics" → "New Threshold..." .

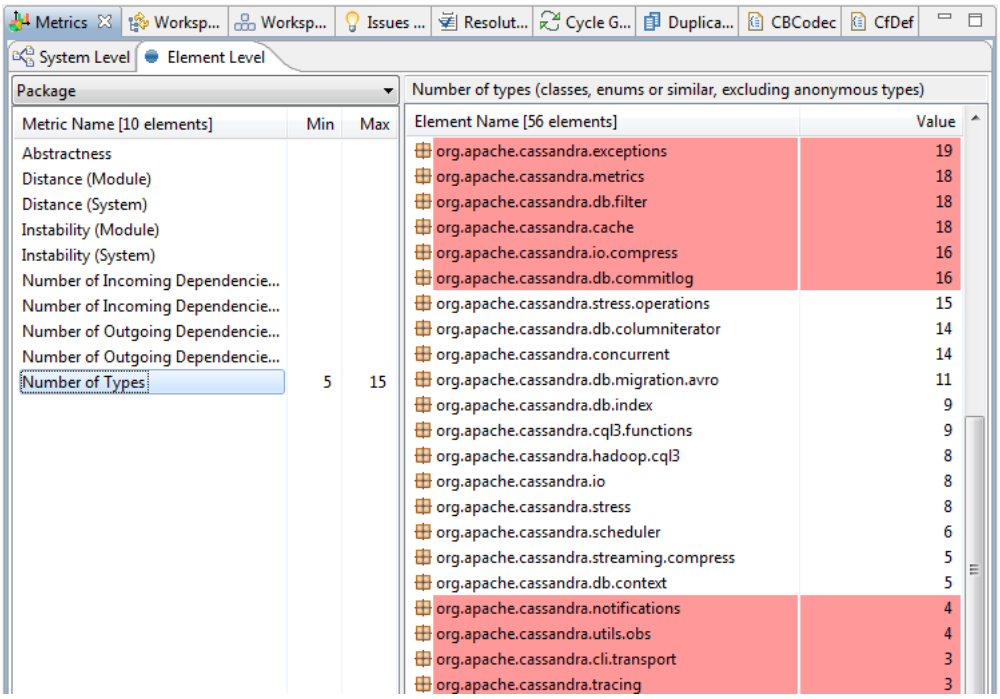
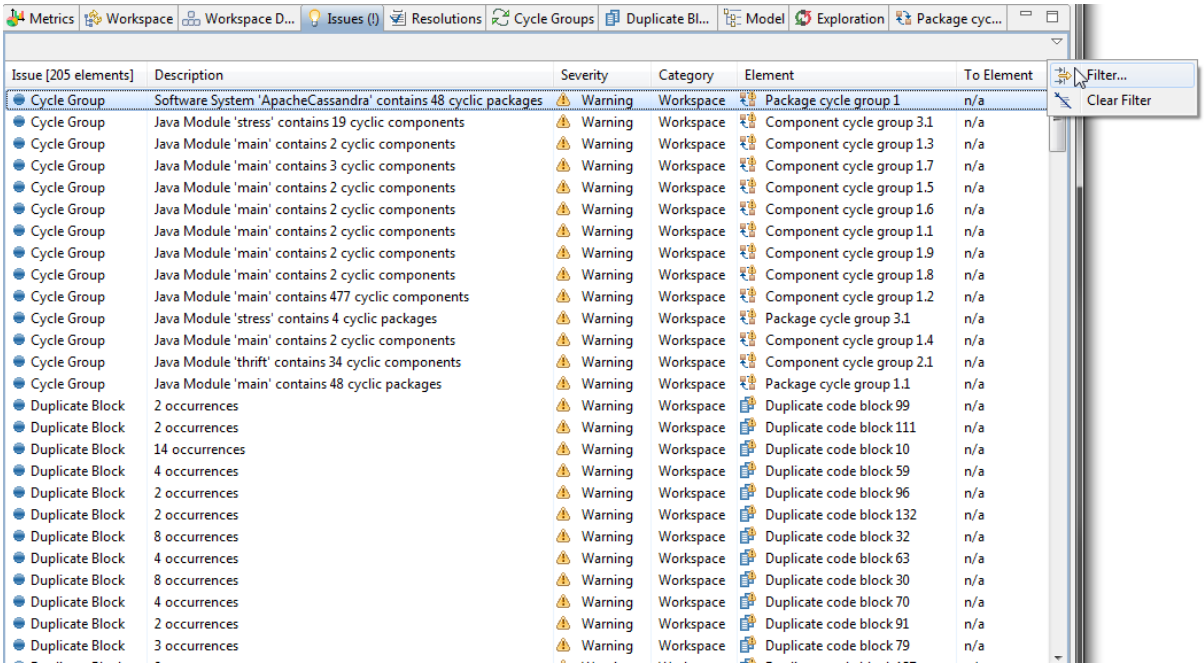


Figure B.6. Metrics View Highlighting Thresholds Violations

B.3. Problem Analysis

Sonargraph lists all problems found in the Issue view. At this stage the view lists issues of type Cycle Group, Duplicate Block and Threshold Violation. If some issues types should be filtered this can be achieved using the filter option as shown in the screenshot.



Issue [205 elements]	Description	Severity	Category	Element	To Element
Cycle Group	Software System 'ApacheCassandra' contains 48 cyclic packages	Warning	Workspace	Package cycle group 1	n/a
Cycle Group	Java Module 'stress' contains 19 cyclic components	Warning	Workspace	Component cycle group 3.1	n/a
Cycle Group	Java Module 'main' contains 2 cyclic components	Warning	Workspace	Component cycle group 1.3	n/a
Cycle Group	Java Module 'main' contains 3 cyclic components	Warning	Workspace	Component cycle group 1.7	n/a
Cycle Group	Java Module 'main' contains 2 cyclic components	Warning	Workspace	Component cycle group 1.5	n/a
Cycle Group	Java Module 'main' contains 2 cyclic components	Warning	Workspace	Component cycle group 1.6	n/a
Cycle Group	Java Module 'main' contains 2 cyclic components	Warning	Workspace	Component cycle group 1.1	n/a
Cycle Group	Java Module 'main' contains 2 cyclic components	Warning	Workspace	Component cycle group 1.9	n/a
Cycle Group	Java Module 'main' contains 2 cyclic components	Warning	Workspace	Component cycle group 1.8	n/a
Cycle Group	Java Module 'main' contains 477 cyclic components	Warning	Workspace	Component cycle group 1.2	n/a
Cycle Group	Java Module 'stress' contains 4 cyclic packages	Warning	Workspace	Package cycle group 3.1	n/a
Cycle Group	Java Module 'main' contains 2 cyclic components	Warning	Workspace	Component cycle group 1.4	n/a
Cycle Group	Java Module 'thrift' contains 34 cyclic components	Warning	Workspace	Component cycle group 2.1	n/a
Cycle Group	Java Module 'main' contains 48 cyclic packages	Warning	Workspace	Package cycle group 1.1	n/a
Duplicate Block	2 occurrences	Warning	Workspace	Duplicate code block 99	n/a
Duplicate Block	2 occurrences	Warning	Workspace	Duplicate code block 111	n/a
Duplicate Block	14 occurrences	Warning	Workspace	Duplicate code block 10	n/a
Duplicate Block	4 occurrences	Warning	Workspace	Duplicate code block 59	n/a
Duplicate Block	2 occurrences	Warning	Workspace	Duplicate code block 96	n/a
Duplicate Block	2 occurrences	Warning	Workspace	Duplicate code block 132	n/a
Duplicate Block	8 occurrences	Warning	Workspace	Duplicate code block 32	n/a
Duplicate Block	4 occurrences	Warning	Workspace	Duplicate code block 63	n/a
Duplicate Block	8 occurrences	Warning	Workspace	Duplicate code block 30	n/a
Duplicate Block	4 occurrences	Warning	Workspace	Duplicate code block 70	n/a
Duplicate Block	2 occurrences	Warning	Workspace	Duplicate code block 91	n/a
Duplicate Block	3 occurrences	Warning	Workspace	Duplicate code block 79	n/a

Figure B.7. Filter Issues

Check Section 8.2, “ Examining Issues ” for more details about filtering.

B.3.1. Examine Cycles

Cycles between any elements should be avoided as they have a negative impact on various properties of the *software system*, e.g. testability, maintainability, understandability, to name a few. Cycles can be examined in more detail by opening the Cycle Groups view. This view additionally shows the involved source files for component cycle groups.

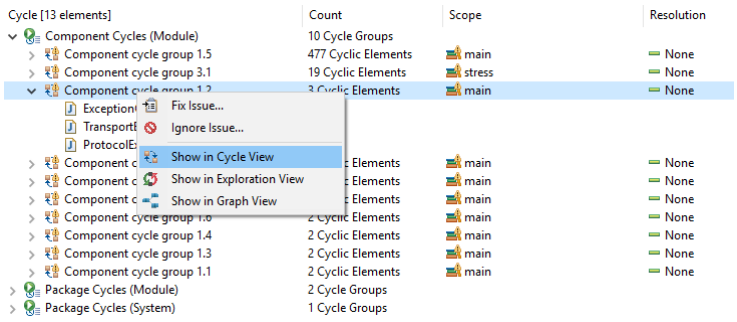


Figure B.8. Cycle Groups View

To analyze individual cycle groups, open the Cycle Group view via the context menu. This view shows the involved elements and when selecting an element or a dependency, details to the dependency are shown in the Parser Dependencies views. Drill-down to the source code is supported via double-click on a dependency.

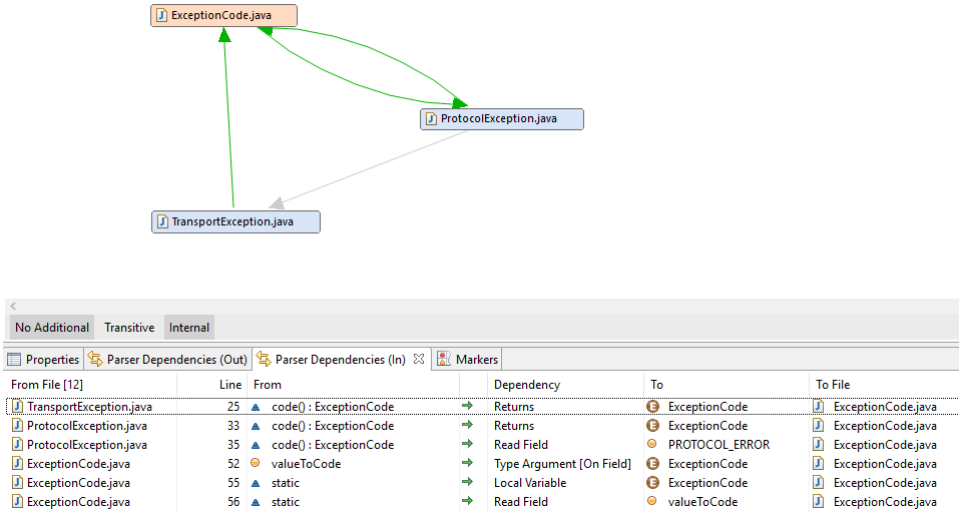


Figure B.9. Cycle View

B.3.2. Examine Duplicate Code

Duplicate code is another type of issue shown in the Issues view. Details of duplicates are shown in the Duplicate Code Blocks view that can be opened via the context menu. This view shows more details about individual duplicates, i.e. the block length, tolerance, and involved files.

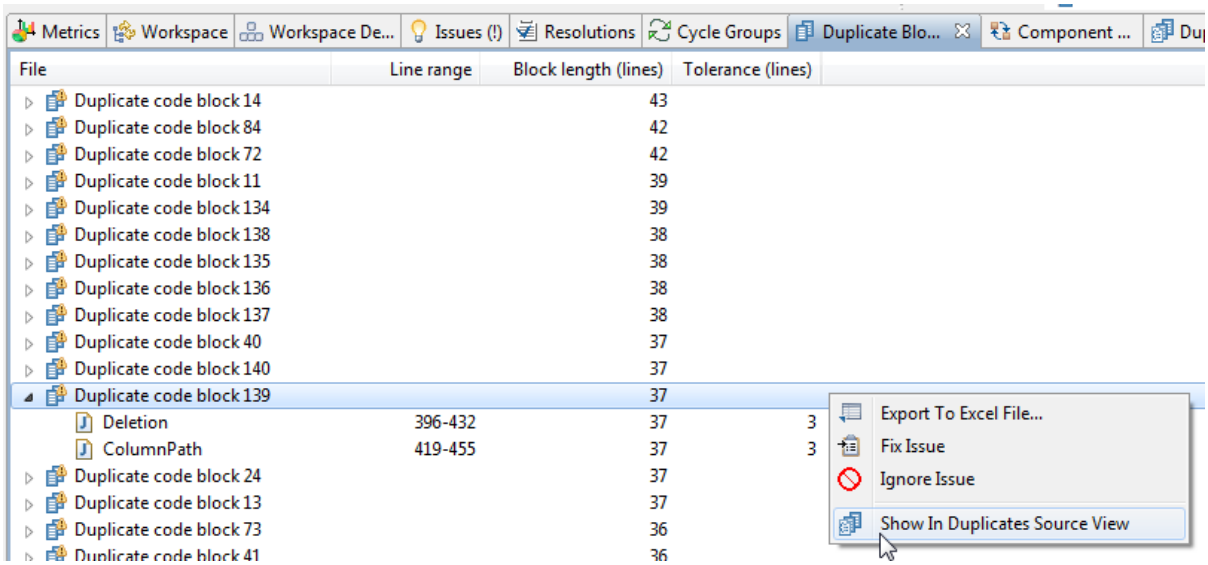


Figure B.10. Duplicate Code Blocks View

The Duplicate Source view highlights the duplicate block and marks the lines within a block that are different.

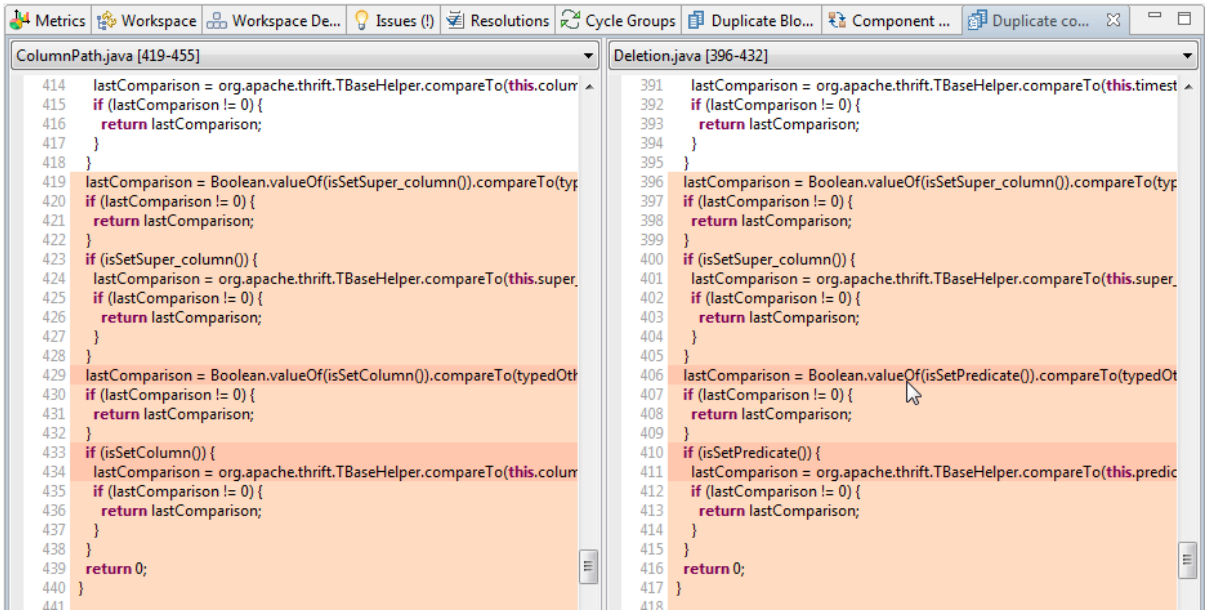


Figure B.11. Duplicate Source View

For more details about configuring the duplicate code analysis, check out Section 7.12.1, “Configuration of Duplicate Code Blocks Computation”.

B.3.3. Handle Issues

Sonargraph allows to handle issues in two different ways via the context menu of the Issue view:

- Ignore: Signifies that the issue will be dealt with later.
- Fix: Signifies that the issue needs to be fixed. An assignee can be specified.

Additionally a TODO-resolution can be defined for any element.

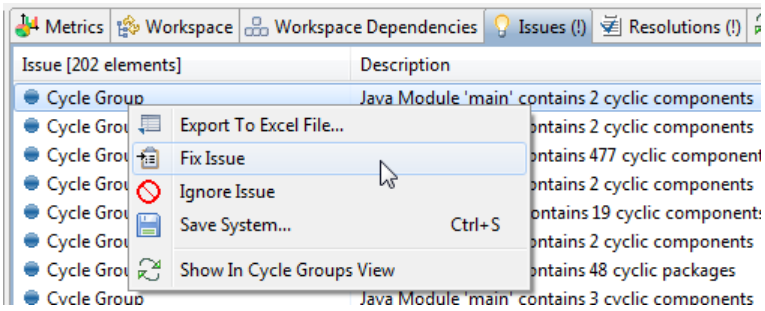


Figure B.12. Add TODO Issue

The details about created resolutions are shown in the Resolutions view, including how many elements are matched. The lower section displays the matched elements and allows the drill-down into a detailed view via the context menu.

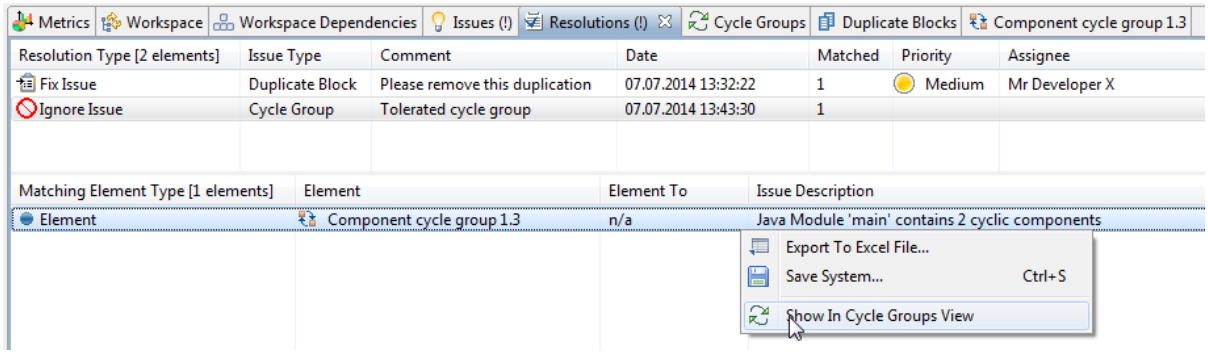


Figure B.13. Resolutions View

More information about issues, resolutions and quality models can be found in chapter Chapter 8, *Handling Detected Issues*.

B.4. Detailed Dependency Analysis

Sonargraph provides different views to analyse dependencies between elements. The most important are the Exploration, Graph and Dependencies views.

B.4.1. Explore Dependencies

The Exploration view can be opened for an arbitrary selection of elements in the Navigation view or via the context menu within other views.

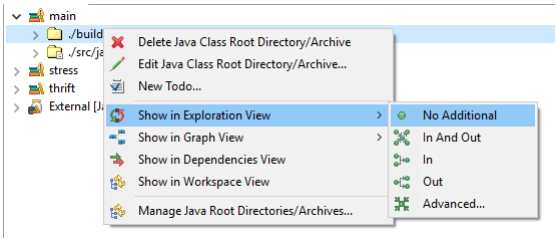


Figure B.14. Open in Exploration View

The Exploration view orders the displayed elements, with elements on top having more outgoing dependencies and elements on the bottom having more incoming dependencies. Clicking on the plus-sign of an element opens nested elements, allowing to drill down to fields. Arcs represent detected dependencies, which can be analyzed in more detail in the Parser Dependencies views and also in the Source view.

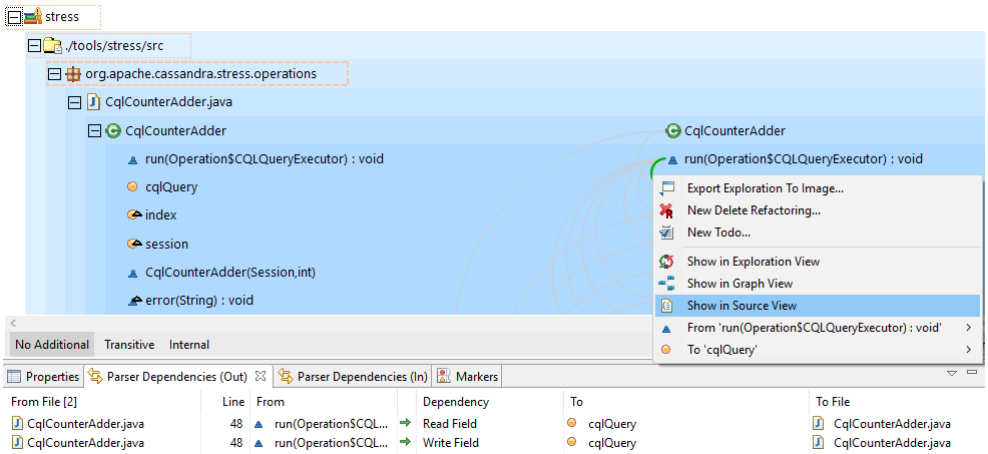


Figure B.15. Exploration View Drilldown

This view offers interactions such as focus and unfocus which can be used to explore the dependencies of an arbitrary selection of elements inside the Exploration view and also provides highlighting, marking and zooming which can be helpful in the analysis of the content that is being displayed. Further details are explained in Section 7.10.1.2, “ Focus Modes ” and Section 7.10.1.6, “ Applying Focus ”.

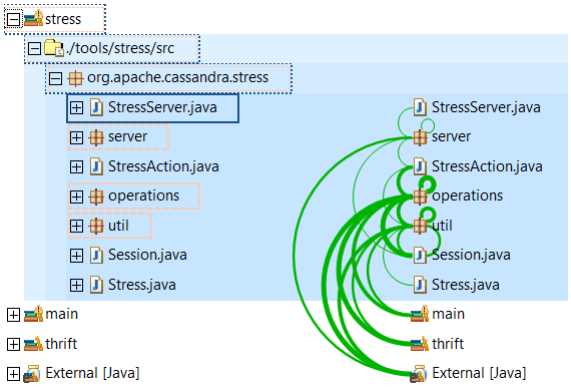


Figure B.16. Exploration View Interactions

B.4.2. Check how Elements are Connected via Graph View

The Graph view can also be opened for an arbitrary selection of elements from the context menu. It shows the selected elements in a levelized graph. For more details about the advantages see Section 7.10.3.1, “ Levels ”. Again, existing parser dependencies can be analyzed using the Parser Dependencies Views.

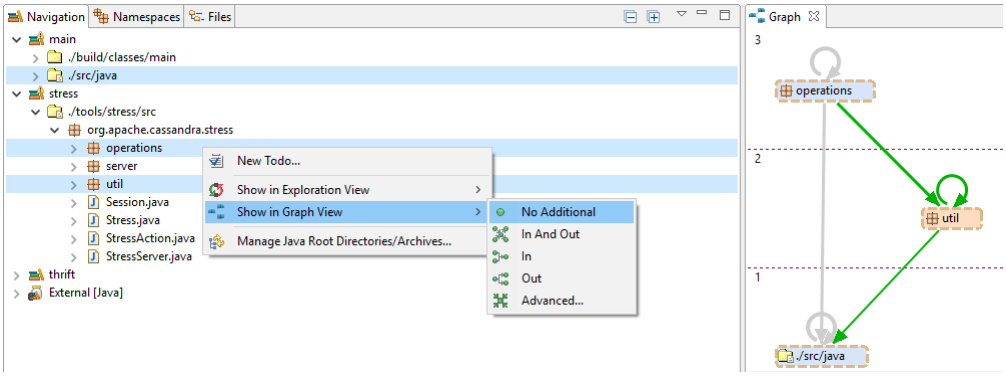


Figure B.17. Graph View

Like the Exploration view, the Graph view also offers focus and unfocus interactions to check the dependencies of an arbitrary selection of elements inside the view. It also offers highlighting and zooming to help in the analysis of the currently displayed content. Additionally, it will automatically group elements that form cycles to make the graphs more comprehensible. By right-clicking on a Cycle Group, it is possible to open the Cycle view to observe the detail of the elements that make part of it. Further details are explained in Section 7.9.2, “ Inspecting Cyclic Elements ”.

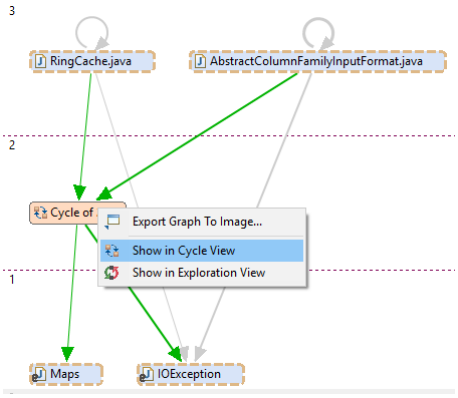


Figure B.18. Graph View Interactions

B.4.3. Check how Elements are Connected via the Dependencies View

If you rather like tabular representations, existing dependencies of elements can be examined in the Dependencies view which is again available via the context menu, but only for a single selection. The Dependencies view is separated into three parts, each allowing to drill down and analyze a specific dependency in more detail. More features of this view are explained in Section 7.10.4, “ Tabular System Exploration ”.

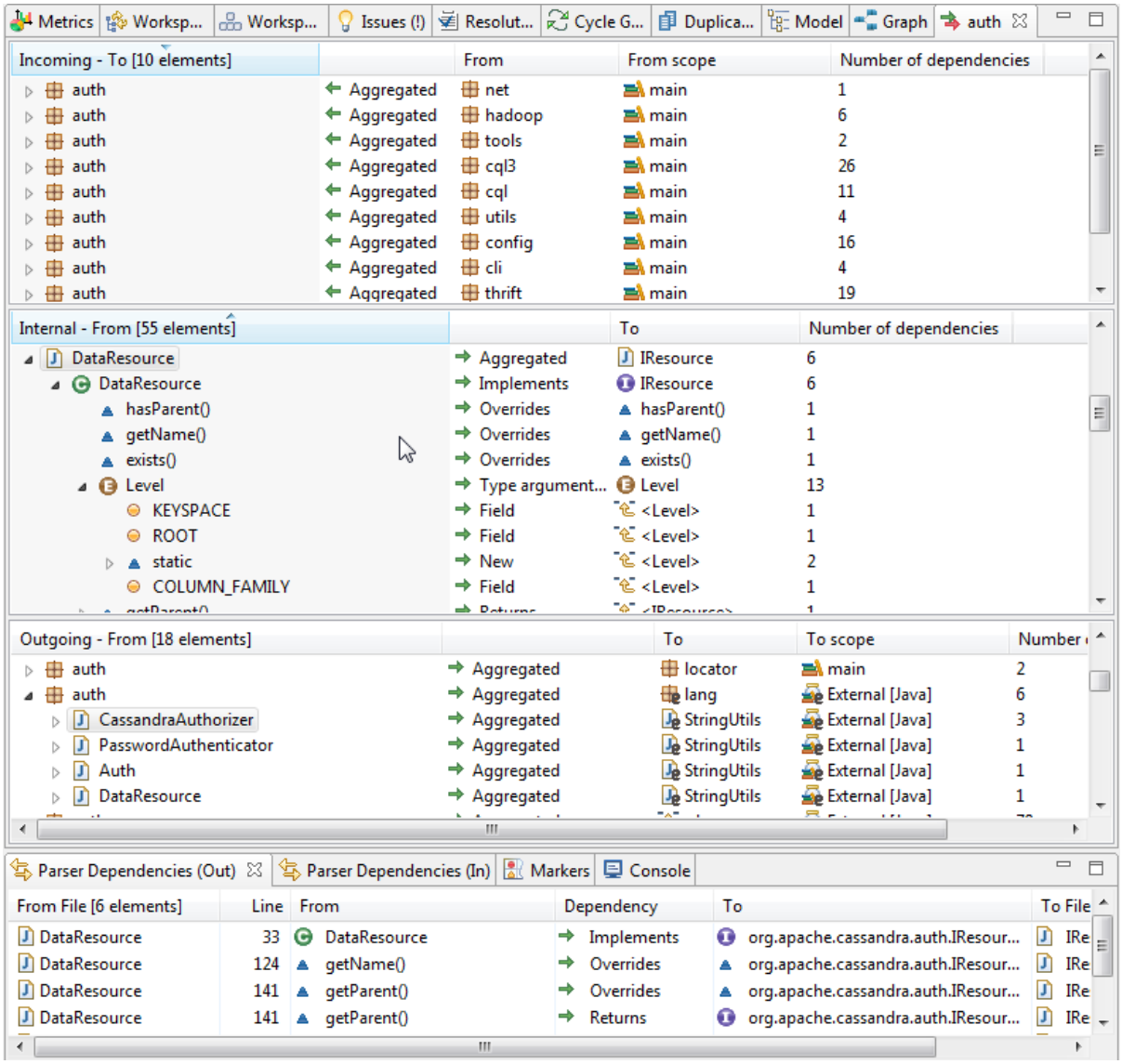


Figure B.19. Dependencies View

B.4.4. Search for Elements

In case you are interested in seeing the dependencies of a particular type, but want to spare the effort of navigating to it via the Navigation view, the Search dialog provides this shortcut. See (Section 7.11, “ Searching Elements ”)

B.5. Advanced Analysis With Scripts

Sonargraph provides an API to access its internal model by Scripts written in Groovy. *Sonargraph* scripts can introduce and calculate new metrics, add issues to the model, and build a list or tree of model elements or dependencies.

B.5.1. Create a New Script

You can create a new script either by menu "File" → "New" → "Other" → "Script" , or by selecting an existing script directory and selecting "Create Script..." from the context menu. The "New Script Wizard" will start, and at least a name for the new script must be given. After pressing "OK" the new script shows up in a Script view, where you can edit, compile and execute it.

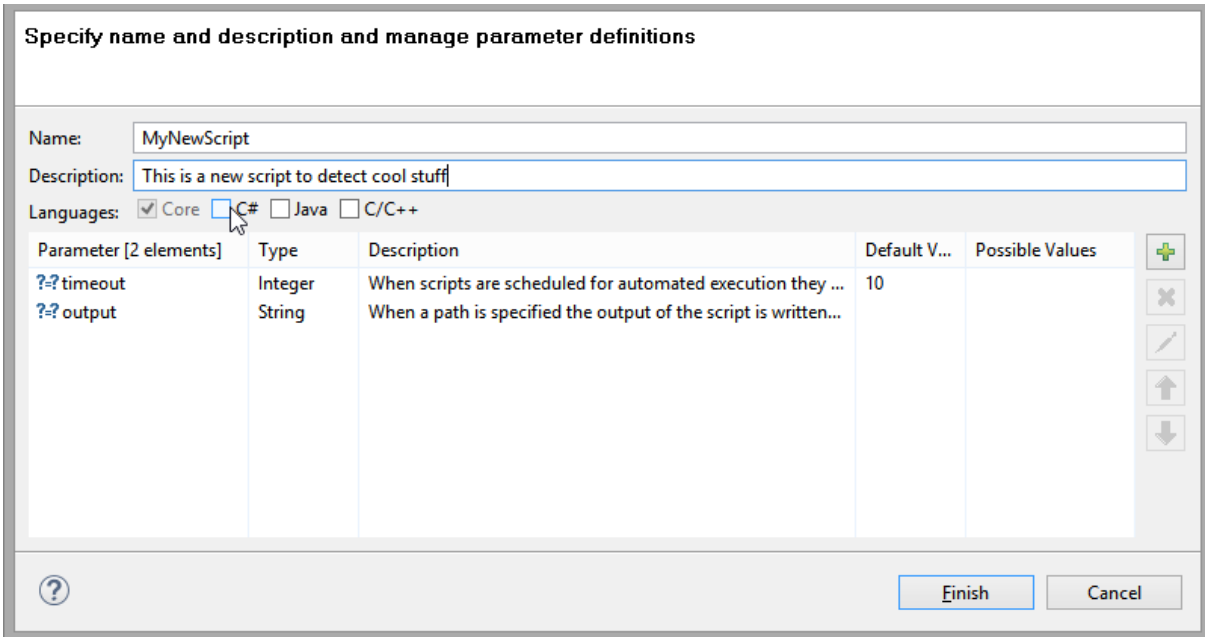


Figure B.20. Create a New Script

More details are provided in: Section 10.3, “ Creating a new Groovy Script ”

B.5.2. Execute Existing Script

To execute an existing script, go to "Files" tab and open directory "Scripts". Double click on a script and a Script view will open. The Script view consists of three parts: On the top the source of the script, in the middle the "Compile"/"Run" and "Update automated Script" buttons, and on the bottom five tabs for the result of the script. Press "Execute" and the script will run. Every tab in the bottom of the Script view that contains some data will show an exclamation mark in its title.

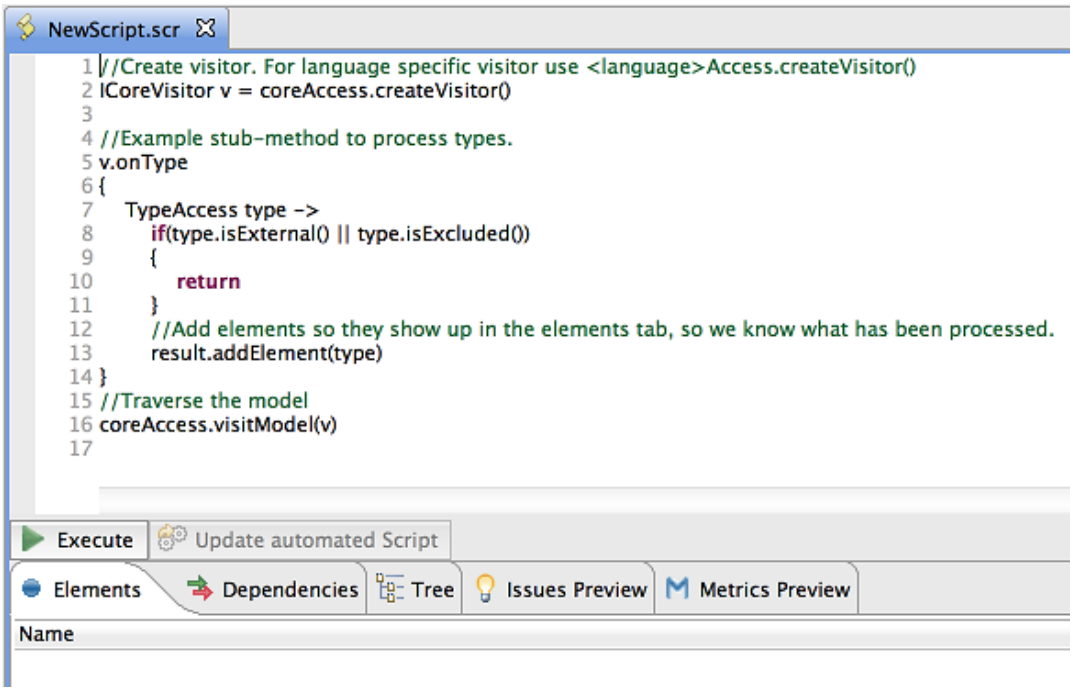


Figure B.21. Execute a Script

More details about how find specific elements or dependencies, create metrics and issues is provided in: Section 10.5, “ Producing Results with Groovy Scripts ”

B.6. Share Results

Once a *system* has been analyzed it is important to share the findings with others. This section explains the different types of export offered by *Sonargraph* .

B.6.1. Work with Snapshots

Sonargraph offers the capability to create snapshots to preserve the state of a *system* at any given time. It is available via "File" → "Save Snapshot..." and creates an archive file containing all the generated information in compact binary format together with the source files. This snapshot can be archived or passed on to co-workers for further evaluation. No data contained in a snapshot can be modified.

Snapshots can be opened via "File" → "Open From Snapshot..." .

B.6.2. Define Quality Standards using Quality Models

A Quality Model allows defining a standard configuration that needs to be applied to several *systems*. It contains analyzer configuration (e.g. for metric thresholds) and scripts. Menu entries "File" → "Export Quality Model..." and "File" → "Import Quality Model..." can be used to export and import a Quality Model. Additionally, a Quality Model can be specified during creation of a system. See Section 5.1, “Quality Model” .

B.6.3. Export to Excel

Many *Sonargraph* views offer the export of the displayed data to *Microsoft Excel* . In case you are working on a non-Windows platform, the exported files can also be opened using *Open Office Calc* . For example the Metrics view lets you export all Metrics data (system level and all element levels) into a single Excel file.

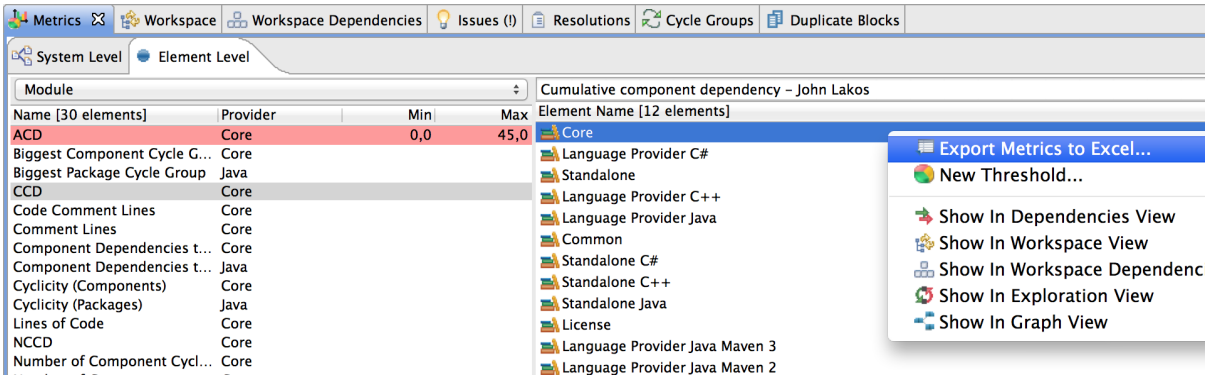


Figure B.22. Export Metrics to Excel Context Menu

Appendix C. Tutorial - C#

This is a step-by-step tutorial illustrating the analysis of the Open Source project *NHibernate*. It will be demonstrated how to setup the workspace and quickly get an overview of the state of software quality. Some issues are reported by *Sonargraph* right away without further configuration. *Sonargraph* also allows to easily analyse the dependency structure in more detail. As this functionality is mostly language-independent, we refer you to the appropriate sections within the Java Tutorial.

This tutorial is intentionally kept as short as possible. For more detailed information about certain functionality, links are provided that will steer you to the corresponding chapters of the user manual.

C.1. Setup the Software System

C.1.1. Create a new Software System

Sonargraph offers to import Microsoft Visual Studio C# Solution files. Select menu "File" → "New" and select the wizard "System based on C# Visual Studio Solution file". Specify the name of the directory of the *Sonargraph* system and where its files will be stored. It is a best practice to store the system close to the actual source code and place it under version control. Using a Quality Model is explained in Section B.6, “Share Results” ; you can leave this option unchecked for now.

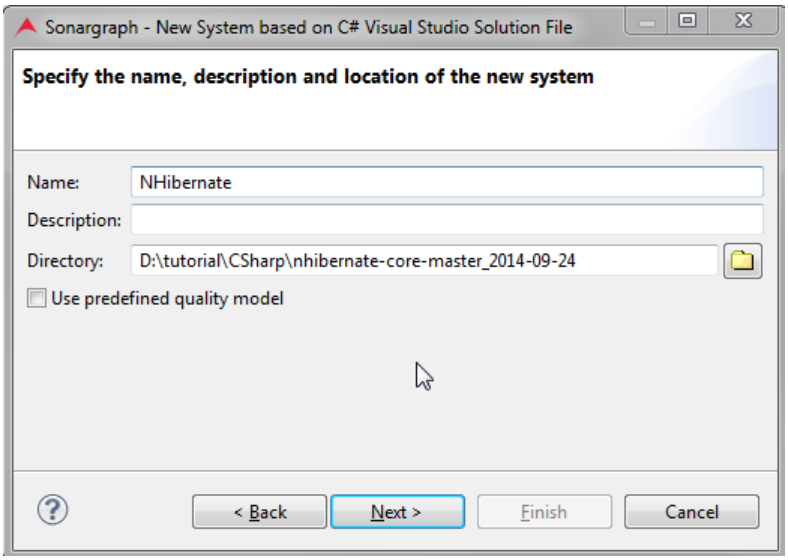


Figure C.1. System based on C# Visual Studio Solution File

The next wizard page allows to specify the Microsoft Visual Studio Solution file and then shows the modules that will be imported. Select the configuration and platform combination that you want to apply.

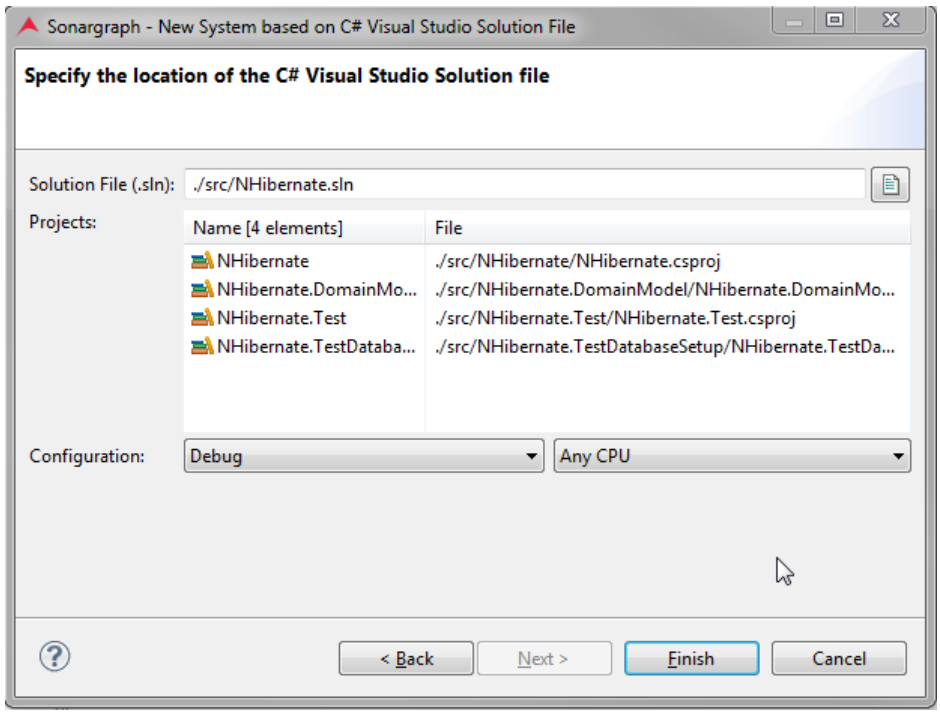


Figure C.2. Select C# Solution File, Configuration and Platform

Related topics:

- Chapter 2, *Licensing*
- Chapter 5, *Creating a System*
- Section 6.3, “Creating or Importing a C# Module”

C.1.2. Configure the Workspace

After the initial import of the Microsoft Visual Studio Solution file the Issues view shows several errors about assemblies that could not be located.

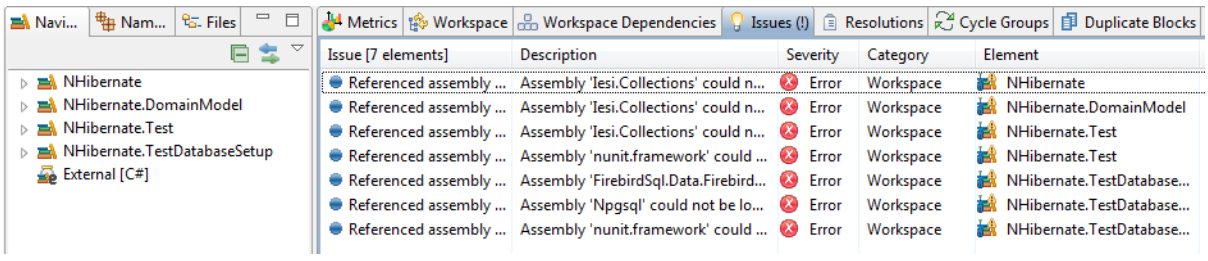


Figure C.3. Issues after initial Import of Microsoft Visual Studio Solution File

The missing assemblies need to be located using the menu "System" → "Configure C# Module(s)..." The modules with problems are indicated with "(!)".

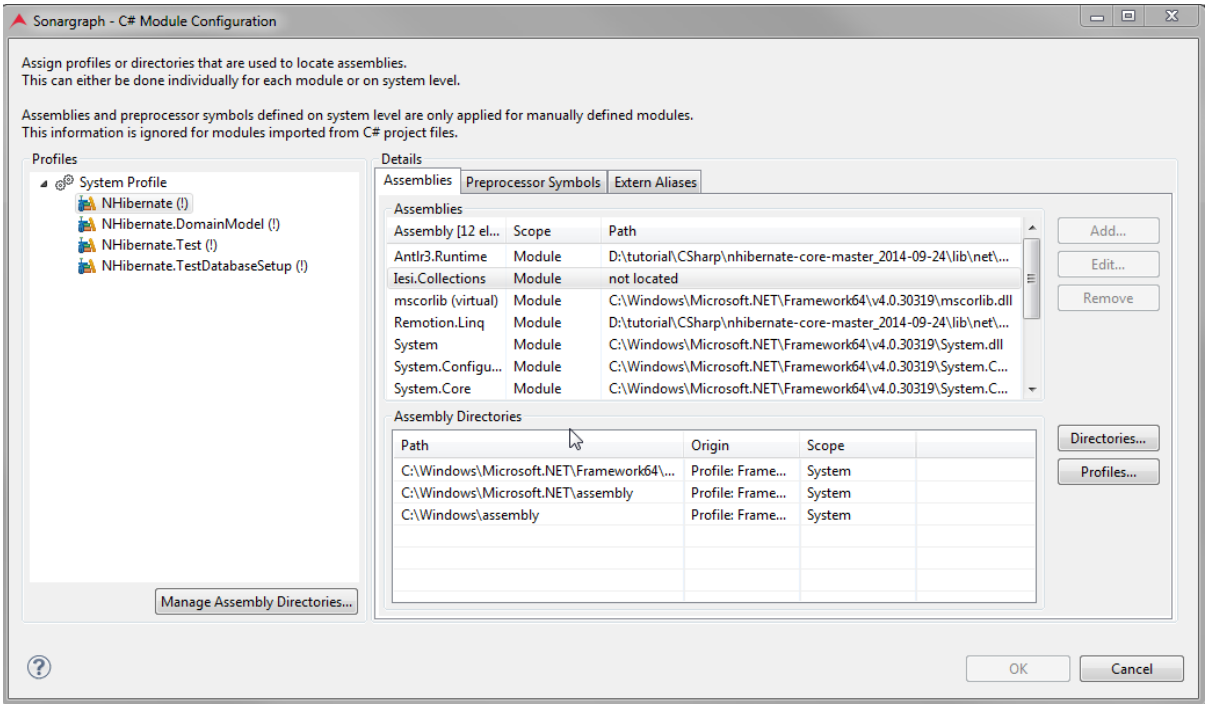


Figure C.4. C# Module Configuration Dialog

The easiest way to resolve these is to use the "Manage Assembly Directories..." dialog.

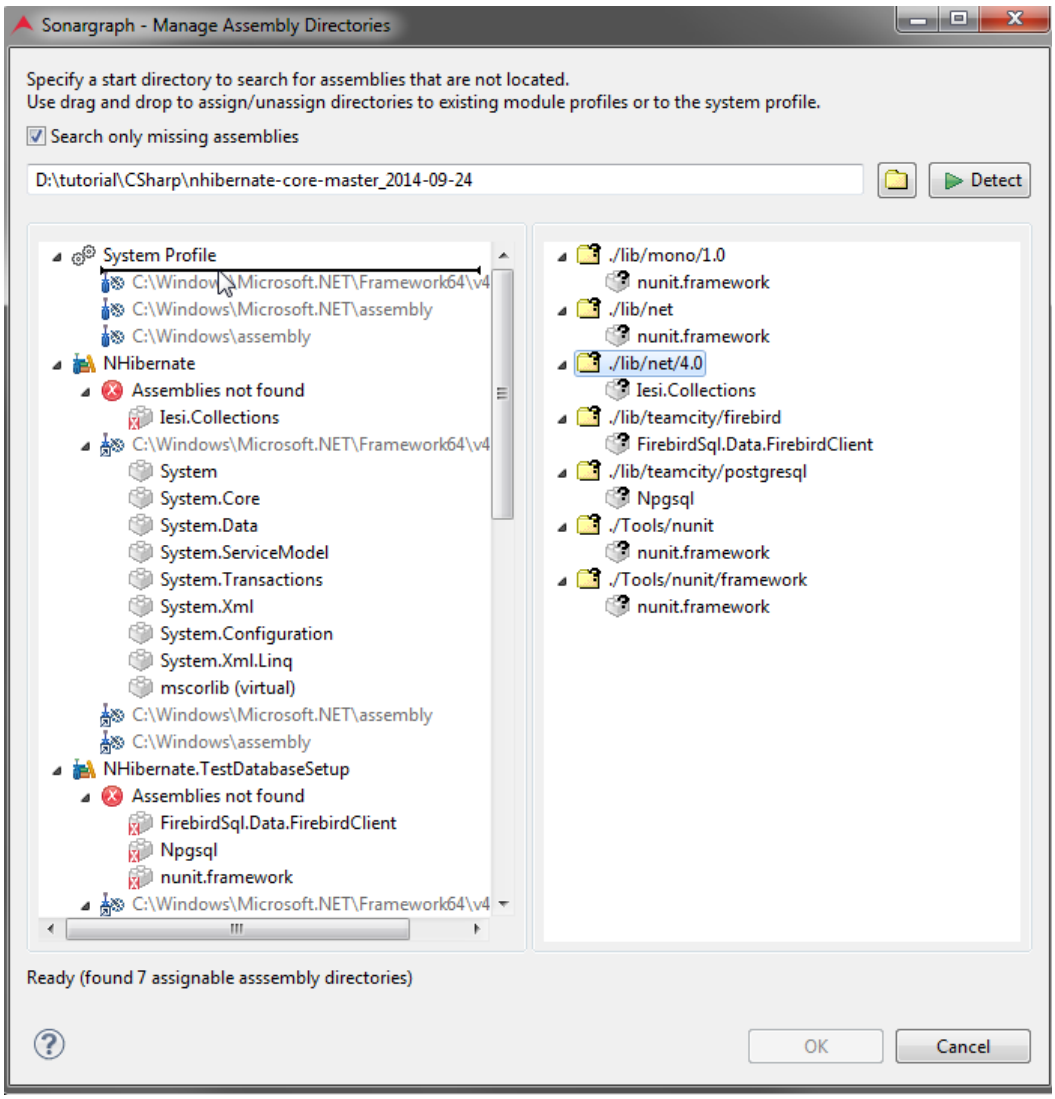


Figure C.5. Manage Assembly Directories - Systeme Profile (Unresolved Assemblies)

The directories assigned to the System Profile are applied to all modules. Drag & drop directories "./lib/net" and "./lib/net/4.0" from the left to the "System Profile" node on the right. Repeat that same action for the remaining modules with missing assemblies and close the dialog. Check that no more "(!)" are present in the "C# Module Configuration" dialog and close it.

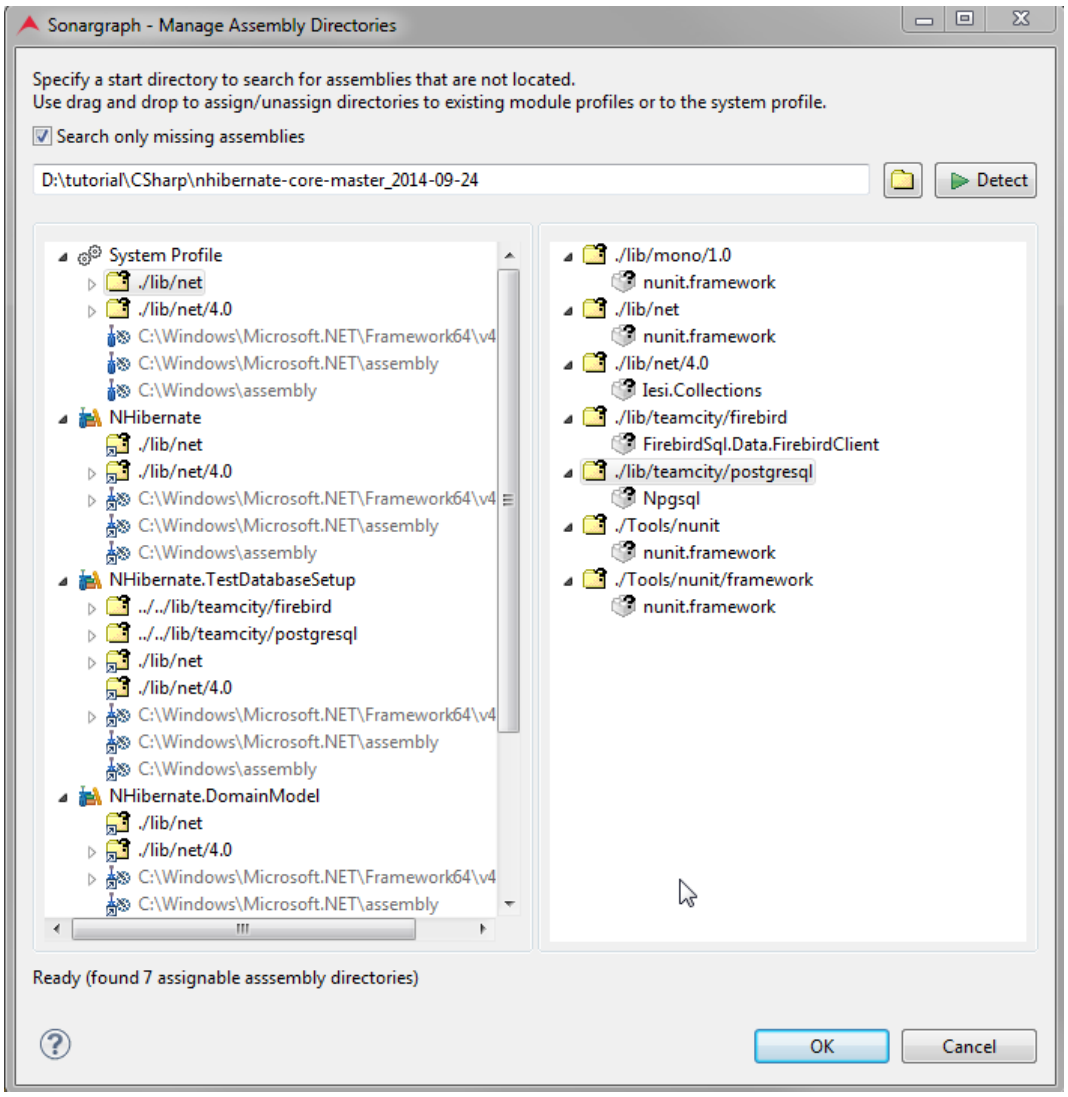


Figure C.6. Manage Assembly Directories - Systeme Profile (Resolved Assemblies)

Check on the Issues view that the problems with the referenced assemblies are gone. Hit **Ctrl+S** to save the configuration and then **F5** to parse the system.

The Workspace Dependencies view is one possibility to see, how different modules depend on each other and on external assemblies.

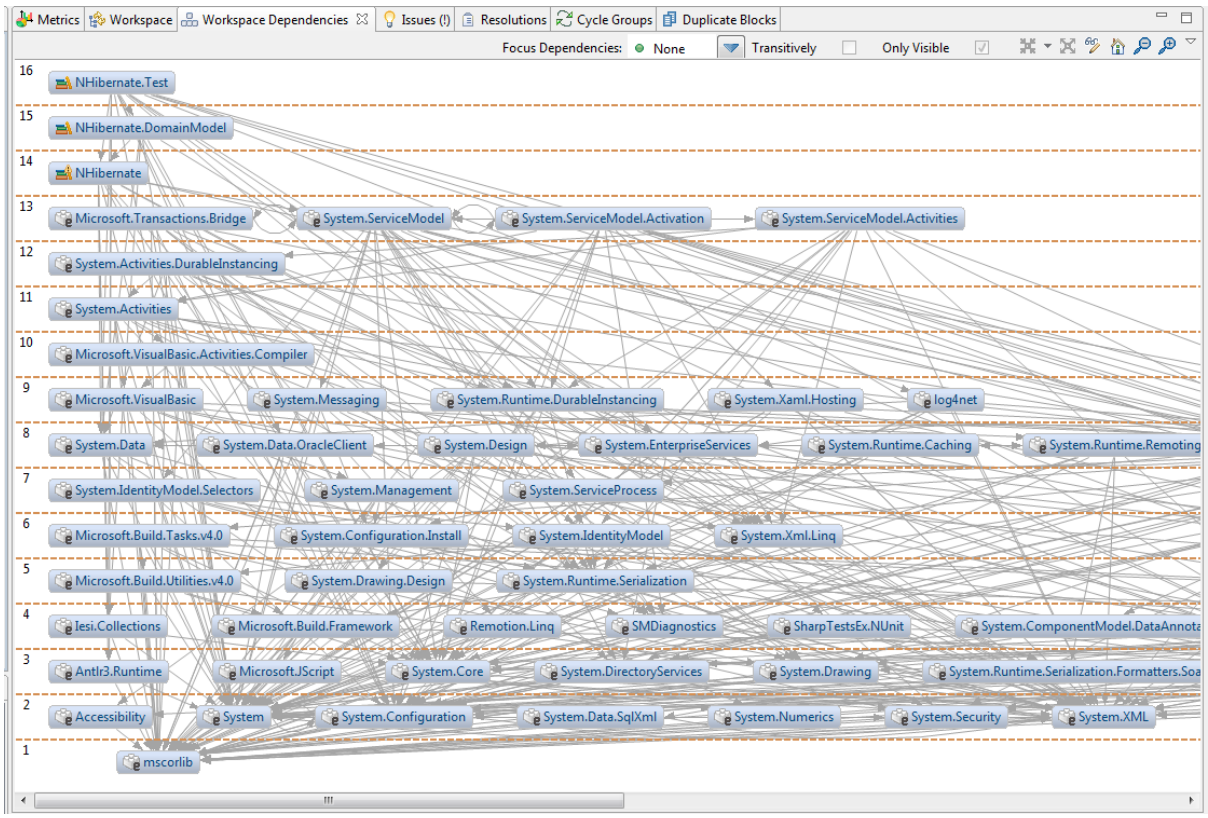


Figure C.7. Workspace Dependencies View for NHibernate

Related topics:

- Chapter 8, *Handling Detected Issues*
- Section 7.7.2, “ Managing Module Dependencies ”
- Section 6.3.4, “C# Module Configuration”

C.2. Further Steps

After the workspace for a C# system has been defined, the further steps to analyze are the same as for a Java system. Please check the following sections of the Java tutorial:

- Section B.2, “Initial Analysis”
- Section B.3, “Problem Analysis”
- Section B.4, “Detailed Dependency Analysis”
- Section B.5, “Advanced Analysis With Scripts”
- Section B.6, “Share Results”

Appendix D. Tutorial - C++

This is a step-by-step tutorial illustrating the analysis of the Open Source project *POCO*. It will be demonstrated how to setup the workspace using different importers and quickly get an overview of the state of software quality. Some issues are reported by *Sonargraph* right away without further configuration. *Sonargraph* also allows to easily analyse the dependency structure in more detail. As this functionality is mostly language-independent, we refer you to the appropriate sections within the Java Tutorial.

This tutorial is intentionally kept as short as possible. For more detailed information about certain functionality, links are provided that will steer you to the corresponding chapters of the user manual.

D.1. Setup the Software System - Compiler Definitions

Sonargraph internally uses the C/C++ parser of EDG (Edison Design Group, www.edg.com). To successfully parse your code the parser must be able to emulate your real compiler. To do that we use the concept of compiler definitions. Such a definition contains information like where to find the implicit system include directories and a list of predefined macros. Sonargraph comes with a couple of ready to use compiler definitions, eg. the Visual C++ family, the GNU compiler family, CLang and a few others.

There is always one compiler definition that is considered to be active. This is the one that is used for parsing your code. After a successful parser run Sonargraph will remember the compiler definition used and automatically activate it the next time you open the same project. When you parse a project for the first time we will use the compiler definition that is currently activated. To check your available compiler definition and to make sure the right one is activated you can go to the C/C++ preference pages. From there you can manage the available compiler definitions, modify existing ones or even create new ones.

If there is no compiler definition for your compiler we recommend to use our compiler definition wizard to create one. You start the wizard by selecting "New..." → "Configuration / New Compiler Definition". If you have used our other tool Sotograph before you can import Sotograph compiler definitions directly in the first step of the wizard. Otherwise just follow the instructions of the wizard.

If the C/C++ parser finds issues, they will be recorded in the C/C++ parser log window. You can open the parser log by selecting "Windows" → "Show View - C/C++ Parser Log". Errors recorded there are usually not a problem for the quality of the analysis. In the worst case a dependency might be missing if the parser cannot properly resolve a symbol. If there are many problems in this view this could indicate a problem with your compiler definition. An parser run will only fail if there are too more than 1000 errors in a compilation unit or if referenced include files cannot be found.

D.2. Setup the Software System - Makefile Capturing

This section describes how to create a new C++ system using command capturing files. Select "New" → "System based on C/C++ Make command capturing files" . Specify the name of the directory of the *Sonargraph software system* and where its files will be stored. It is a best practice to store the *software system* close to the actual source code and place it under version control. Using a Quality Model is explained in Section B.6, “Share Results” ; you can leave this option unchecked for now.

You will have to do a complete rebuild of your system while passing a special shell to the 'make' command. The special shell will create raw files named 'h2m-capture.txt' for each 'Makefile' that executes compile commands during the make process. These files contain a complete list of the compile commands and are used to extract the right options for the C/C++ parser. Sonargraph will then translate these files into files named 'h2m-capture-rel.txt' Do not delete the translated capturing files, instead add them to your version control system. They are used each time Sonargraph opens your system. If you change options or add or remove files from your build you have to repeat the capturing process. Please note, that your top level 'Makefile' must be either in the same directory as the *software system* or in a sub-directory of that directory. Here are the commands you need to execute on the level of your top-level 'Makefile':

Example D.1. Command Capturing Process

```
SG_DIR=<replace with Sonargraph installation directory>
$SG_DIR/bin/h2mcs clean
make clean
make <optional-targets> SHELL=$SG_DIR/bin/h2mcs
```

After executing those commands you should find 'h2m-capture.txt' files in the relevant project directories; 'make clean' can be replaced with another command you use to force a complete rebuild of your system. On Windows platforms the capturing process currently only works in combination with Cygwin.

Once the 'h2m-capture.txt' files have been generated you can choose which of them you want to use to create the modules.

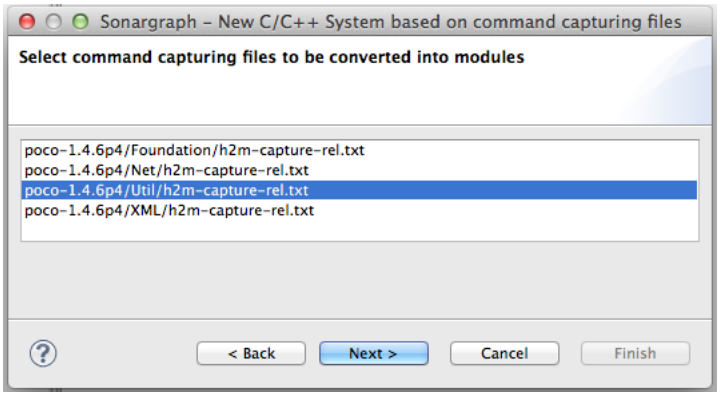


Figure D.1. Select C++ Modules to Import from Capturing Files

If you want, you can change the name and configuration for each of the modules by editing the corresponding fields.

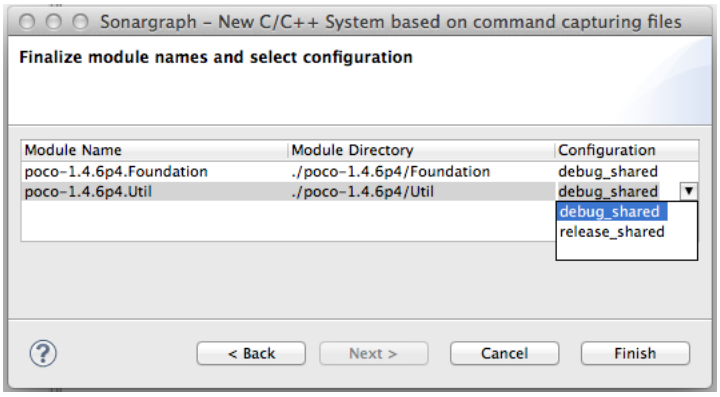


Figure D.2. Renaming and Configuring C++ Modules to Import from Capturing Files

Each generated 'h2m-capture.txt' results in the creation of one module in the *Sonargraph* workspace. You can see the created modules in the Navigation view.

The next step to get started with your analysis is perform a refresh so the required information is picked up from the set-up modules.

D.3. Setup the Software System - Visual Studio Import

This section describes how to create a new C++ system by importing a Visual Studio Solution file. Select "New" → "System based on C/C++ Visual Studio 2010 Solution file" . Specify the name of the directory of the *Sonargraph* system and where its files will be stored. It is a best practice to store the system close to the actual source code and place it under version control. Using a Quality Model is explained in Section B.6, “Share Results” ; you can leave this option unchecked for now.

On the next wizard page, select the solution file to import and the configuration and platform combination.

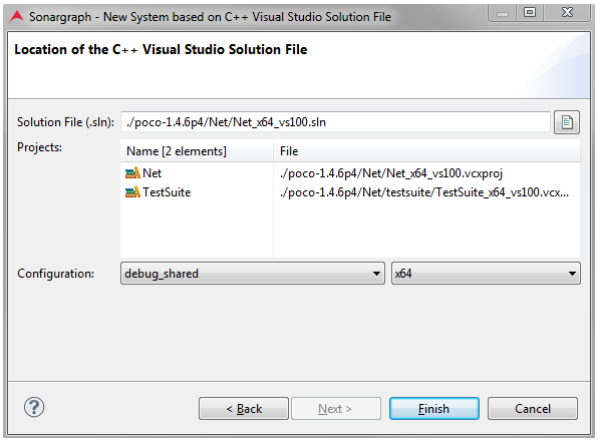


Figure D.3. Specify Visual Studio Solution File

If the system is refreshed and the active compiler definition does not match the imported solution, you might run into the following two problems which can both usually be fixed by selecting the correct compiler definition on the preference page as described in Section 3.7, “C/C++ Compiler Definitions” . In this case, the correct compiler definition is "VisualCpp_11.0_x86".

1. MSBuild Exception: Sonargraph uses internally MSBuild to determine the source files to compile and the compiler options to be used. Usually, if MSBuild fails some built-in variable is not resolved correctly.

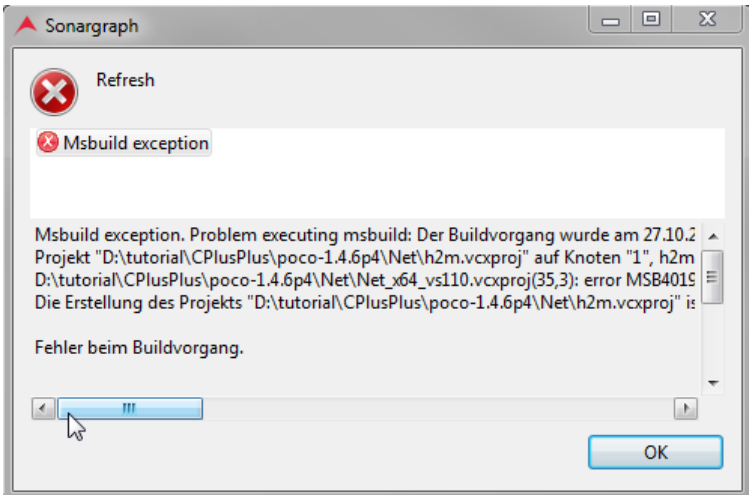


Figure D.4. MSBuild Exception

2. Parse Error: The parsing is aborted if a header file cannot be found. Check the folder where the header file can be found on disk and select a compiler definition that contains this folder as part of its --sys_include options.

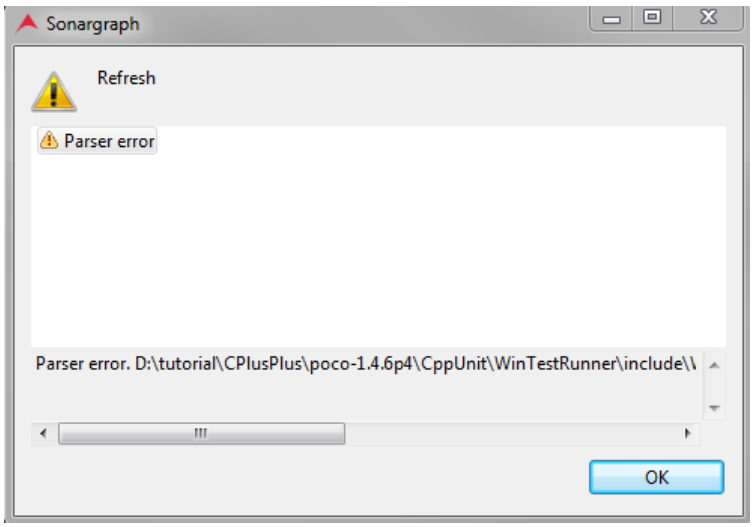


Figure D.5. Parse Error (Missing Header File)

D.4. Further Steps

After the workspace for a C/C++ system has been defined, the further steps to analyze it are the same as for a Java system. Please check the following sections of the Java tutorial:

- Section B.2, “Initial Analysis”
- Section B.3, “Problem Analysis”
- Section B.4, “Detailed Dependency Analysis”
- Section B.5, “Advanced Analysis With Scripts”
- Section B.6, “Share Results”

Appendix E. Sonargraph Script API Documentation

Script API is documented via JavaDoc that is available within the help system of the application and can be accessed using a standard browser. Different packages exist for the language-independent core functionality and language specific parts.

Link to JavaDoc of Sonargraph Script API.

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