# System Re-engineering
# Assignment 2:
# Dynamic Code Analysis

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**NOTE:**

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# Dynamic Code Analyzer

Dynamic code analyzer (DynamicCodeAnalyser.java) is implemented as a console application. This application interacts different elements created as part of the assignment 2 course work.

The application and the solution are generic and can be applied for dynamic analysis of any library with minor changes.

The basic design and implementation details in following sections.

## Design

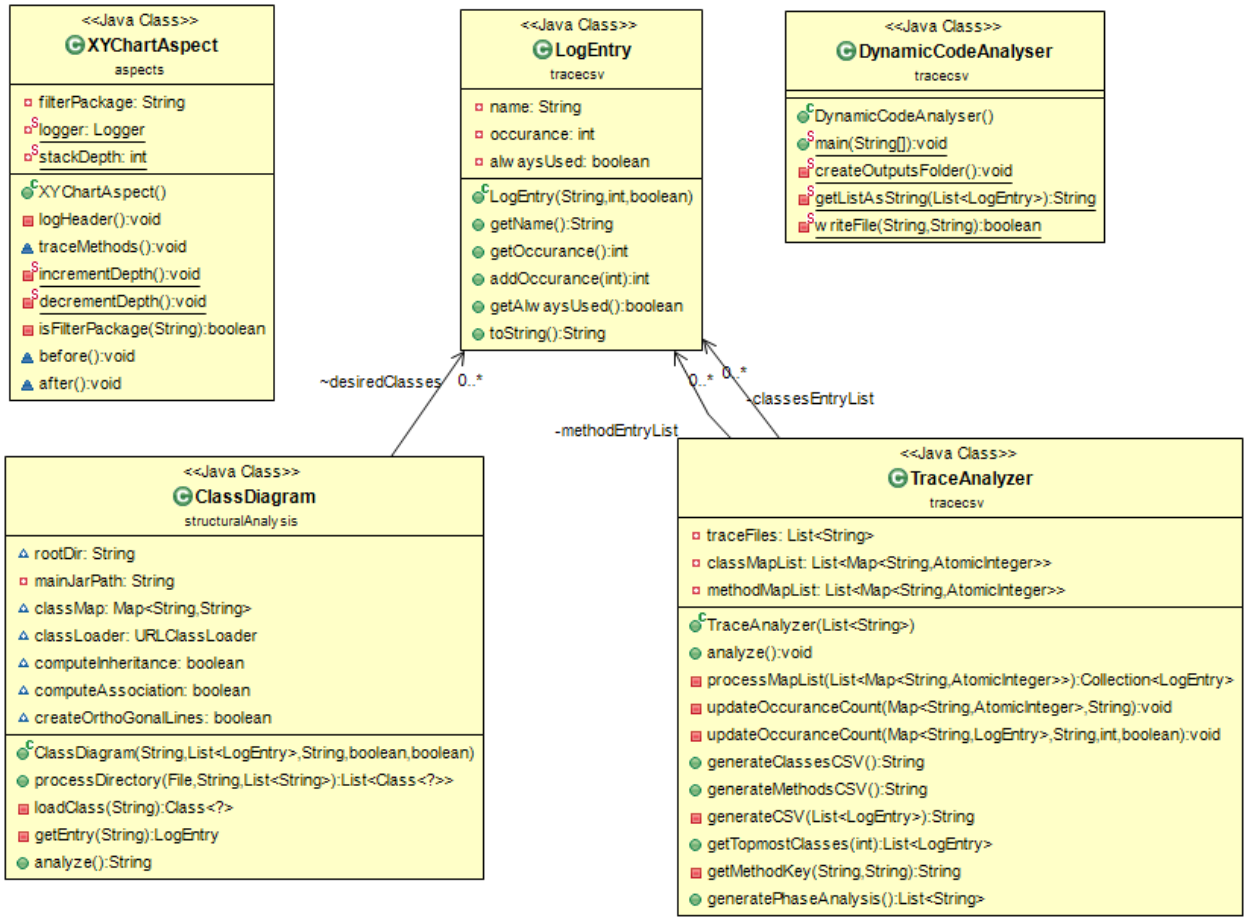



*Figure 1* Dynamic Code Analyzer class design

- **XYChartAspect**
  - This is the aspect class responsible for capturing the function execution trace of the tests within the JFreeChart library.
  - Essentially it has before () pointcut to consider execution trace before getting into a method call and after () pointcut to consider execution trace return from a method call
  - It uses both the pointcuts to capture StackDepth at any given instance of the method call.
  - In addition, it uses *filterPackage* parameter as a filter to capture only the required trace. In case of the coursework, this parameter is set to “org.jfree” for analysis of JFreechart library.
- **TraceAnalyzer**
  - Core class responsible for analyzing the traces generated using the aspect.
  - Generate various outputs required as part of the course work. Each of the output can be generated through relevant public function.

- **ClassDiagram**
    - This class was originally created by neilwalkinshaw on 24/10/2017 for Reverse-Engineering a Class Diagram using Reflection lab session
    - It has been extended or modified for System Re-engineering assignment 2 - Dynamic analysis to generate class diagram
    - This has been made generic in terms of receiving the classes and main jar information from the client so that it only deals with the processing and generation of class relationship and association diagram.
    - It also accepts inheritance and association as parameters in the constructor and is used as settings for processing the class diagram as dot files.

## Trace logging

AspectJ compiler is used to generate the XYChartAspect as aspect.jar.

*ajc -cp C:\aspectj1.8\lib\aspectjrt.jar -outxml -outjar aspects.jar XyChartAspect.aj*

This jar along with Junit and hamcrest-core-1.3.jar on top of classes and the main jar of JFreeChart library with dependencies is executed on each of the tests.

*java -javaagent:C:\aspectj-1.8.12\lib\aspectjweaver.jar -cp aspects.jar; jfreechart\target\jfreechart-1.5.0-SNAPSHOT-jar-with-dependencies.jar; jfreechart\target\test-classes;../Assignment2\Libs\junit-4.12.jar;..\Assignment2\Libs\hamcrest-core-1.3.jar org.junit.runner.JUnitCore* ***org.jfree.chart.AreaChartTest***

In general, this can be executed on  any test case and the output is traces.csv file capturing

DateTime, ClassName, FunctionName, Parameters, Line, StackDepth

## Trace log Analysis

Once the all the traces are generated, the traces can be moved to a common folder. With the use of Dynamic Code Analyzer application. The traces can be processed and required outputs can be generated.

## Process

As part of the process and using the console application, the user needs to provide following information highlighted in the console output below. Once the valid data is provided, the application generates the data in [Outputs] folder.

```
[                          Welcome to Dynamic Code Analyzer                                    ]
This application will process the trace files generated by aspects.jar and process them to
create several outputs.
1. Generate the summary of the process as Classes.csv, Methods.csv2. list of Topmost Classes
based on the total occurrence
3. Class relationship dot file to Dot application to generate the class diagram4. Generate the
time series data to analyzed using the PhaseAnalysis.R script.

Please select the folder with trace files (generated using the aspects.jar):
C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\dataFiles\outputs\TraceFiles
Please select the folder with classes (aka .class) files:
C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\jfreechart\target\classes
Please select the location of the main jar (used to generate trace files) required to generated
class relationship dot file:
C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\jfreechart\target\jfreechart-1.5.0-SNAPSHOT-jar-with-dependencies.jar
Please select the number of classes to be considered to generate class relationship dot file
(based on total number of occurrences) for ex: 25:
50
Classes CSV
Generated classes.csv file.
```

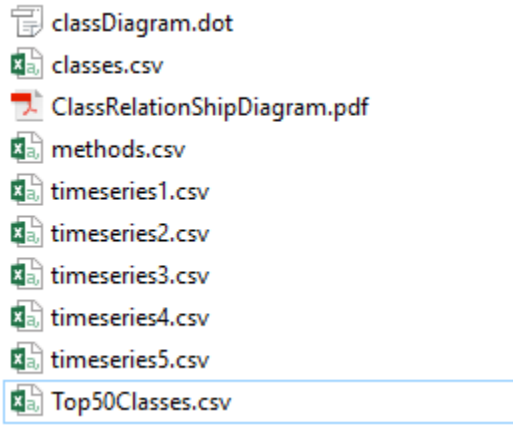
```
Methods CSV
Generated methods.csv file.

Top 50 classes are:
org.jfree.chart.axis.TickUnit 4780
org.jfree.chart.util.Args 2156
org.jfree.chart.plot.XYPlot 1712
org.jfree.chart.ui.RectangleInsets 1690
org.jfree.data.xy.XYSeries 1312
org.jfree.data.xy.XYSeriesCollection 1198
org.jfree.chart.plot.Plot 1133
org.jfree.chart.axis.ValueAxis 1038
org.jfree.chart.JFreeChart 957
org.jfree.chart.axis.DateTickUnitType 882
org.jfree.data.Range 864
org.jfree.chart.axis.Axis 752
org.jfree.chart.axis.NumberAxis 685
org.jfree.data.xy.XYDataItem 672
org.jfree.chart.renderer.AbstractRenderer 478
org.jfree.chart.event.ChartChangeEvent 426
org.jfree.chart.block.AbstractBlock 370
org.jfree.data.xy.AbstractXYDataset 306
org.jfree.data.general.Series 286
org.jfree.chart.renderer.xy.AbstractXYItemRenderer 272
org.jfree.data.xy.XYBarDataset 249
org.jfree.data.general.DatasetUtils 233
org.jfree.chart.ui.Size2D 225
org.jfree.chart.title.Title 190
org.jfree.data.xy.IntervalXYDelegate 186
org.jfree.chart.axis.NumberTickUnitSource 177
org.jfree.chart.block.BlockBorder 160
org.jfree.chart.util.AbstractObjectList 144
org.jfree.chart.text.TextUtils 137
org.jfree.chart.StandardChartTheme 135
org.jfree.chart.axis.DateTickUnit 132
org.jfree.chart.block.RectangleConstraint 125
org.jfree.chart.LegendItem 125
org.jfree.chart.title.LegendTitle 125
org.jfree.chart.ui.RectangleEdge 124
org.jfree.chart.axis.TickUnits 123
org.jfree.chart.ui.TextAnchor 90
org.jfree.chart.block.BlockContainer 90
org.jfree.chart.title.LegendGraphic 82
org.jfree.chart.plot.DefaultDrawingSupplier 80
org.jfree.chart.util.BooleanList 76
org.jfree.chart.text.TextBlock 75
org.jfree.chart.axis.DateAxis 74
org.jfree.chart.text.TextFragment 70
org.jfree.chart.axis.DateAxis$DefaultTimeline 61
org.jfree.chart.text.TextLine 60
org.jfree.data.general.AbstractSeriesDataset 58
org.jfree.chart.title.TextTitle 50
org.jfree.data.general.AbstractDataset 48
org.jfree.chart.axis.NumberTickUnit 45
Generated Top50Classes.csv file.

Class Relationship and Association diagram (.dot format):
Generated classDiagram.dot file (use dot to generate the class diagram).

Time Series
Processing trace file: C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\dataFiles\outputs\TraceFiles\XYAreaChartTest_Trace.csv
Processing trace file: C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\dataFiles\outputs\TraceFiles\XYBarChartTest_Trace.csv
Processing trace file: C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\dataFiles\outputs\TraceFiles\XYLineChartTest_Trace.csv
Processing trace file: C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\dataFiles\outputs\TraceFiles\XYStepAreaChartTest_Trace.csv
Processing trace file: C:\Users\Shashi\Documents\MS\SEM2\SRE\Assignment2\assignment2-
shashidarette\dataFiles\outputs\TraceFiles\XYStepChartTest_Trace.csv
Generated timeseries1.csv file.
Generated timeseries2.csv file.
Generated timeseries3.csv file.
Generated timeseries4.csv file.
Generated timeseries5.csv file.
All the outputs are generated in [Outputs] folder.
```

The outputs are:



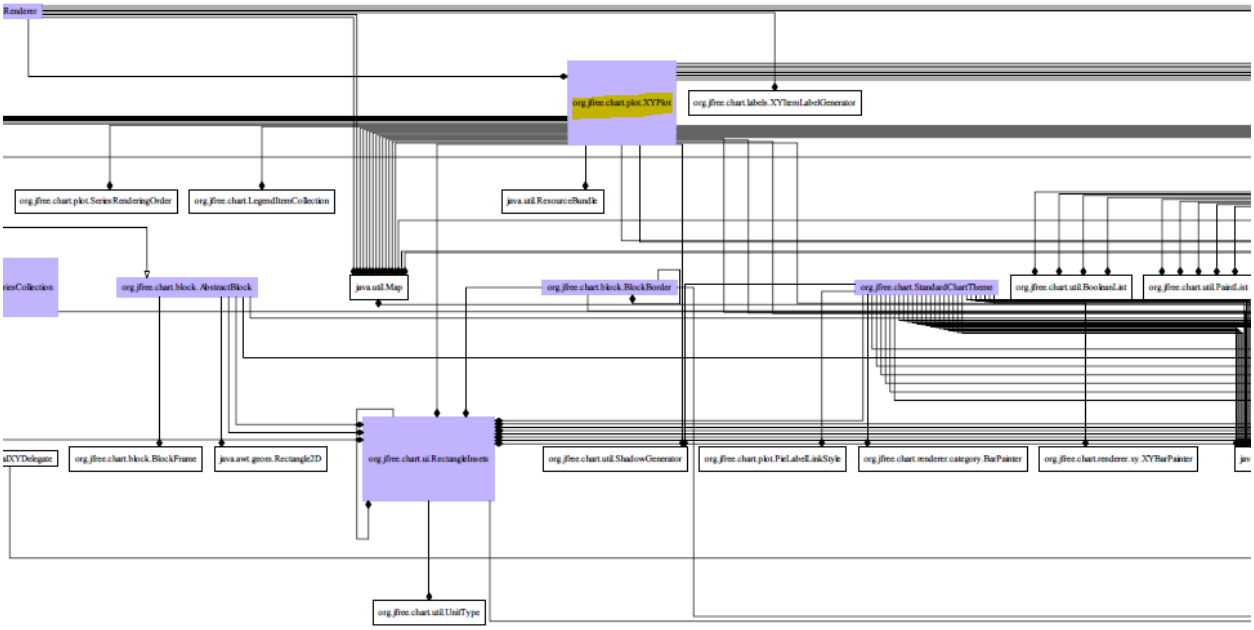

# Output generation

## Classes and Methods CSV

These CSV files contain the list of classes and methods present in all the given trace files as part of the course work. There are 62 out of 87 classes (from classes.csv) & 398 of 556 methods (from methods.csv) are used is all the traces.

## Class Diagram and Insights

The class diagram generated essentially shows the classes hierarchy and association. Specifically, for XYPlot and JFreeChart classes. Both form part of core classes and are essentially involved in all the traces marked in blue although other utility classes as axis.TickUnit, plot.Plot, xy.XYSeries, ui.RectandleInsets form a major part of the execution and hence are an essential part of the library.



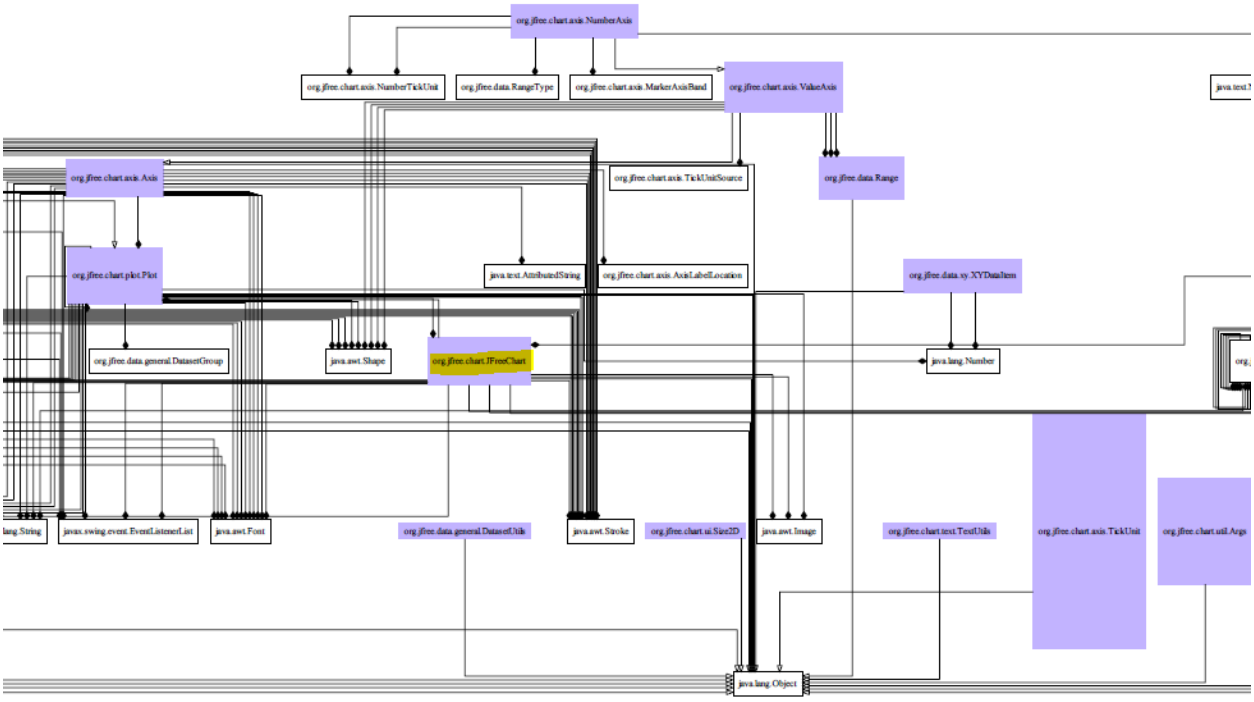



*Figure 2* Part of the class diagram generated by the tool showing XYPlot

## Time Series, phase execution analysis & insights

From the TraceFiles, TraceAnalyzer also generates time series data for each of the trace files individually.

They also show where functions are called in all the traces with a light blue dot ( ) and else with an orangish dot

( ).

The plots are represented in the images below.


*Figure 3* XYAreaChartTest time-series plot

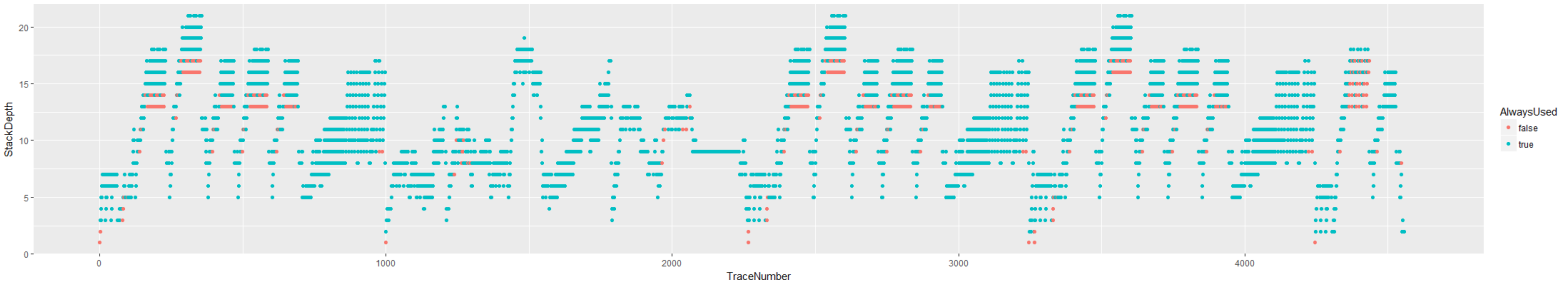



*Figure 4* XYBarChartTest time-series plot


*Figure 5* XYLineChartTest time-series plot


*Figure 6* XYStepAreaChartTest time-series plot

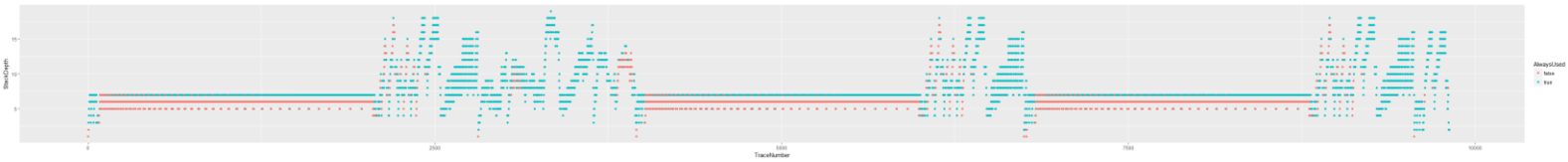


*Figure 7* XYStepChartTest time-series plot

Few of the valuable insights are as below:

- All the traces show majority methods which are used in all implying the code and design developed highly cohesive.
- All the traces show maximum Stack Depth of around 20-25. This means the number of calls being made to various aspects of JFreeChart is uniform. This implies low cyclometric complexity and high maintainability.
- From XYStepChart time series plot its evident that specific functions are called repeatedly to perform required to create step chart.

## Final Overview

From the outputs generated, there are 62 out of 87 classes (from classes.csv) & 398 of 556 methods (from methods.csv) are used is all the traces. The class diagram shows high relatability and association amongst classes. All the traces time series plot show majority methods which are used in all. These insights can be used to imply that JFreeChart and per say XYPlot is very cohesive. Further analysis can be done to look for instances of re-engineering aspects, otherwise JFreeChart is well designed in general from an engineering perspective.