COM 1205 Project Description
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Karl Lieberherr and John Sung

Pengcheng Wu, Teaching Assistant

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Introduction

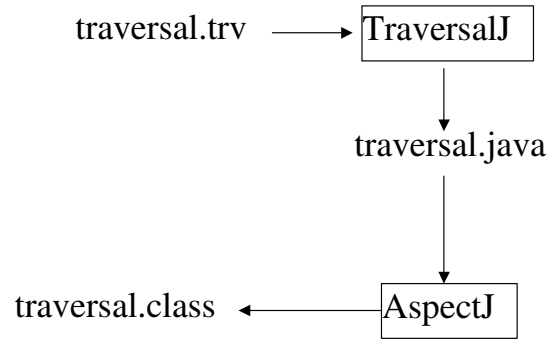
A major software developer, KL Enterprises (KLE), wants to hire COM 1205, Inc. to create a prototype language system that will implement traversals in Java. In order to differentiate themselves from the DemeterJ product, they want to use AspectJ to implement the traversals. AspectJ is open source software from www.aspectj.org.

In order to investigate this further KLE has hired JS Consulting (JSC) to do some prototyping and preliminary research to find out about the implementation issues and provide recommendations.

This document contains a description of the software tools that are available from the prototyping work and the recommendations from TA Consulting. If you have any questions about this document or the project itself, please send e-mail to com1205-grader@ccs.neu.edu. This will reach, KLE and the teaching assistant.

Software System Overview

The TraversalJ software should work as shown in the figure below. It should read in files that contain traversal specifications. Then, it should generate the implementation of the traversal. The implementation is in AspectJ. It allows the traversal code that's spread around many different classes to be in one place.



The main functionality of the TravarsalJ is listed below:

- Obtain Class Graph
- Parse traversal files *.trv
- Process the traversal with the obtained Class Graph
- Using the Traversal Graph, output the implementation of the traversal in AspectJ
- Compile the traversal with the original code

What's provided:

- **CreateClassGraph.java** - using AspectJ and DJ, it intercepts call to function main and creates a Class Graph object. Then, passes it to COM 1205 Inc., middleware using the ClassGraphFactor/Listener interface.

- **AspectJTraversal** - It generates the traversal code in AspectJ given a TraversalGraph or ClassGraph and a Strategy. Also, takes in traversal name for naming various components of the traversal.

COM 1205 Inc.'s Middleware:

- **Traversal Specification Parser** - Write a class dictionary in DemeterJ to parse the traversal language specified.

- **Command Line Processing** - Process command line such that it processes the files listed and an option to specify the destination directory of the generated code.

- **Interfacing with CreateClassGraph** - Write the ClassGraphListener/Factory to obtain the command line arguments and the Class Graph of the program.

- **Processing Graph declarations** - Process the Class Graph declaration such that it can be used within the traversal declaration.

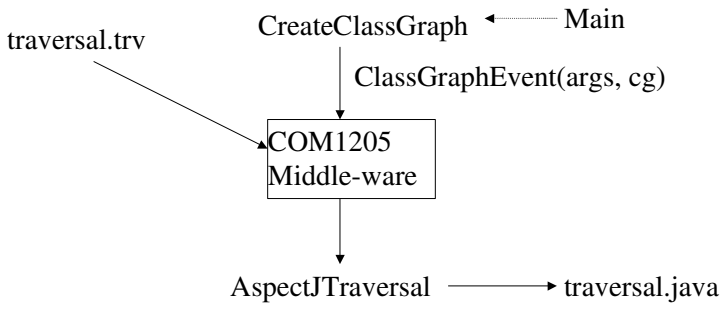
- **Processing Traversal declarations** - Process the traversal declaration using the Class Graph declarations.

- **Outputting Generated Files** - Write the generated traversal code out to file as specified in this document.

- **Testing TraversalJ** - Implement a traversal used in developing TraversalJ, using the TraversalJ's traversal specification and run to see the traversal work.

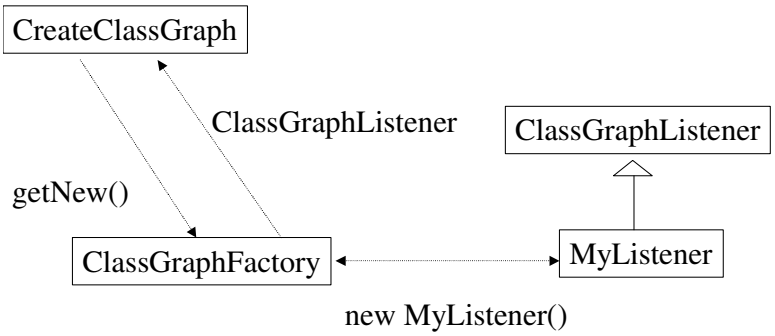
Provided Files

The provided files are basically the software layer above and below the COM1205 Inc.'s middleware. They are very thin, as they only need to do very small amount of low level work. The top layer is the CreateClassGraph layer that obtains the Class Graph and the command line arguments. The Bottom layer is the AspectJTraversal layer that generates the actual Traversal in AspectJ.

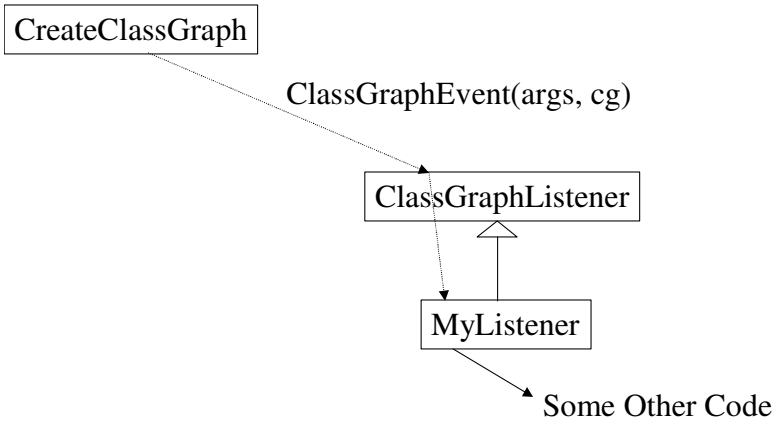


The CreateClassGraph class uses AspectJ to intercept the call to main method. Then, it uses DJ to obtain the Class Graph of the current running program. It also obtains the command-line arguments. It expects two classes, ClassGraphListenerFactory and ClassGraphListener to be defined. ClassGraphListenerFactory allows CreateClassGraph to obtain an instance of type ClassGraphListener. And ClassGraphListener should implement the abstract method ClassGraphEvent(String [] args, ClassGraph cg).

The figure below shows how CreateClassGraph obtains an instance of ClassGraphListener class.



The figure below shows how COM1205 Inc. middleware obtains the command-line arguments and the Class Graph.



COM 1205 Inc. should implement using DemeterJ:

- The relationship between ClassGraphListener and MyListener (this can actually be any class name that you'd like, i.e. MyClassGraphListener, COM1205Listener, etc.)
- The static method getNew() in ClassGraphListenerFactory.
- The abstract method ClassGraphEvent(String [], ClassGraph) in class ClassGraphListener.
- The implementation of the abstract method ClassGraphEvent(..) in MyListener that will start the processing of the traversal files. In a sense, this is the "main" method for COM1205 Inc.'s middleware.

Compiling with the provided code:

- The CreateClassGraph.java and AspectJTraversal.java will be available from the class directory.
- Create a subdirectory under your main project directory and copy the files to there.
- Add the directory in your .prj file's JAVADIRS option.
- Change the COMPILER to ajc and no compiler options.

The AspectJTraversal Methods

There are several methods and data members that you should be aware of in AspectJTraversal.

- **AspectJTraversal(String tn, TraversalGraph tg)** - Given a traversal name String and the TraversalGraph object, generate the traversal implemented in AspectJ.
- **AspectJTraversal(ClassGraph cg, String tn, String st)** - Save as above, but it takes in ClassGraph, traversal name string and Strategy string. It generates the TraversalGraph from the ClassGraph object and the Strategy string.
- **public String getAspectName()** - Returns the aspect name of the generated code. It has the form traversal string + "Traversal".
- **public String toString()** - Returns the generated AspectJ code as a String.
- **static boolean debug** - the data member that is conditioned on for debug printing. If set to true, it outputs information as the traversal code is generated. Defaulted to false.
- **static boolean addPrintingAdvice** - The data member variable that determines whether extra code is generated to output useful information when the traversal methods are called. Defaults to false.

Traversal Specification

The traversal specification file has three major components, the ClassGraph declarations, traversal declarations and aspect definition for the ClassGraph and traversal declarations.

The ClassGraph declaration can have two different forms. Default or Class Graph Slice. The default declaration is the ClassGraph object that's obtained from CreateClassGraph. It has the form:

```
declare ClassGraph cg1;
declare ClassGraph defaultCG;
declare ClassGraph oneMoreDefaultCG1;
```

The Class Graph Slice form of the Class Graph declaration looks like a DJ Class Graph declaration with a Class Graph and a strategy.

```
declare ClassGraph cg2 = new ClassGraph(cg1, "from A to B
via C");
declare ClassGraph cg3 = new ClassGraph(cg2,
                        "from Me via Telephone to You");
```

Notice that the Class Graph Slice form of the Class Graph declaration needs to match the previous declaration of the ClassGraph with the first argument of the ClassGraph constructor. This is designed to make this look very much like DJ code.

The Traversal Declaration has the form:

```
declare TraversalGraph t1 = new TraversalGraph("from A to B
via C", cg2);
```

following the API for DJ.

Your class dictionary should accept behavior declarations but they are ignored by the rest of TraversalJ.

```
declare Behavior b1 = new Behavior(t1, SummingVisitor);
```

A Visitor Declaration has the form:

```
declare Visitor SummingVisitor;
```

Your class dictionary should also handle Strategy Declarations and it should handle them in a similar way as DJ.

```
declare Strategy s1 = new Strategy("from a to b");
```

The last language feature is the aspect declaration. This is designed to look like AspectJ code. If interested in AspectJ, check out www.aspectj.org. It basically contains list of ClassGraph declarations and traversal declarations. Here's an example of an aspect declaration.

```
aspect MyTraversal {
   declare ClassGraph defaultCG;
   declare ClassGraph cg1 = new ClassGraph(defaultCG,
         "from * bypassing {java.lang.String} to *");

   declare TraversalGraph t1 = new TraversalGraph("from
CompoundFile to SimpleFile", defaultCG);
   declare Visitor MyVisitor; // MyVisitor defined in
// MyVisitor.java using DJ format
   declare Behavior b1 = new Behavior(t1, MyVisitor);
   declare Strategy s1 = new Strategy("from a to b");
   declare TraversalGraph t2 = new TraversalGraph(s1, cg1);
// …
```

```
}
```

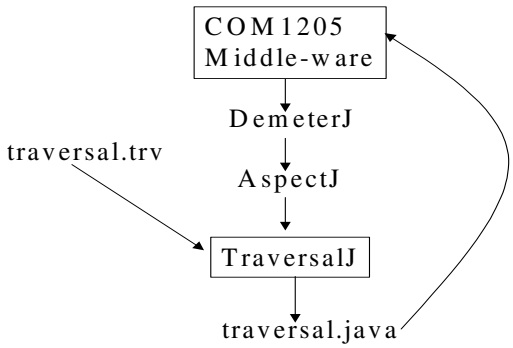
A file can contain one or more aspect definitions. Thus, it's valid to start another definition of an aspect after the first definition.

Testing TraversalJ

During your development of TraversalJ you should create some traversal specification file to test your project. After you feel that you have everything completed to your satisfaction, you should test the TraversalJ project by generating a traversal in AspectJ from a traversal defined in TraversalJ in the TraversalJ specification. Then, generate the file traversal, recompile and run TraversalJ again. But you should set AspectJTraversal.addPrintingAdvice to true. This will generate extra code that will print the traversal methods.

- Set AspectJTraversal.addPrintingAdvice to true somewhere in your code.
- Compile TraversalJ.
- Implement a non-trivial AspectJTraversal used in TraversalJ in the TraversalJ's traversal specification language.
- Run the TraversalJ on the file you wrote in the previous step and store the file into different directory.
- Modify your .beh file to call the traversal method for the starting class object.
- Then, recompile with the newly generated file by setting the JAVADIRS to be the one specified previously.
- Rerun the TraversalJ. You should see bunch of calls (method signature) in the output along with all of the other output. This verifies that it actually generated the correct traversal for the given traversal specification.

The figure below shows the process:



Suggested Project Phases

This section describes the project phases for implementing the TraversalJ traversal code generator. It is highly recommended that COM1205 Inc. follow these phase as it optimizes for maximum points in case of incomplete project by the project deadline.

The recommended phases are divided into 4 phases listed below:

- Phase1 – Generate Class Dictionary for the traversal language
- Phase 2 – Implement –d directory option, basic traversal with default Class Graph
- Phase 3 – Implement Class Graph and Strategy declaration and definition
- Phase 4 – Test code by generating a traversal used in TraversalJ

In Phase 1, you should generate the Class Dictionary for the traversal language. You may start small with just the default traversal and work your way up .

In Phase 2, you should implement the ClassGraphListener/Factory interface and the -d option. You should be able to obtain the String array of command-line arguments and find the directory specified by the "-d" destination directory option. And, also be able to access the ClassGraph object. You should also implement the basic traversal code generation using AspectJTraversal layer.

In Phase 3, you should implement the ClassGraph declaration and Class Graph Slice declarations. Also Strategies. It should be able to recognize previously declared ClassGraph's and generate the correct traversal with a ClassGraph passed to it.

In Phase 4, you should select a non-trivial traversal that's within TraversalJ and implement it using TraversalJ's traversal language. Then, generate the traversal code, recompile and run. Make sure that you turn on the option to generate printing advice and call the traversal method somewhere in your .beh files.

In this project breakdown, Phase 2 is the biggest steps as you need to implement the ClassGraphListener/Factory interface and traversals that will use AspectJTraversal to generate the traversal code. You should attempt to finish this part with 1 week left 'til the deadline. Don't forget to save some time for the write-up as it may take longer than anticipated.

After each phase, you should save the state of the project to some other directory. This allows you to roll back to the last phase if you happened to took the wrong approach in solving the next phase. Not only that, if your program does not compile and you need to submit it, then you can submit the last save of the project. This is usually a good practice for big projects.

Debugging Strategies

This section outlines some debugging strategies for TraversalJ. Some of the strategies listed here can be useful in general.

Debug Printing

When inserting printing methods for observing what the program is doing, it best to make it conditional. The conditional printing should be predicated on a boolean variable that can be set by any other classes, i.e. public. This allows you to turn all of the debug printing on an off. In the C or C++ program, you can use macros to create these printing methods easily. But in Java, you need to just have an if statement for the println methods. Look at AspectJTraversal as an example.

You should also utilize the PrintingVisitor and DisplayVisitor with the universal traversal to printout the object graph. This will help you to understand what's going on with the parsing of the input file.

Debugging Traversals

When a traversal does not work the way you intended, it can be daunting to attempt to find out what's going on. Here are couple of hints:

- You may use the debug printing method.
- You could also print out the traversal graph specified by the strategy using DJ.
- You should also check the demeterj compilation output very carefully, it outputs lots of messages and some warnings or errors could be missed.
- You can take a look at Java code in gen directory to see what's really happening.
- You can attempt to use jdb or ajdb (AspectJ debugger) to poke around.

Miscellaneous Parts

This section describes all the miscellaneous parts of the TraversalJ program.

Command-Line Processing

The only command line option is the "-d" option which specifies the directory in which the output of the file should be written. All of the other strings in the string array should be treated as a traversal specification file, *.trv.

So, a sample arguments in .prj for TEST_ARGS could be:

-d trav MyTraversal1.trv MyTraversal2.trv

MyTraversal.trv -d gen/trav

Output File Name Format

The output file name format should be of the form where the traversal variable name is appended with the string "Traversal". Given traversal declarations:

```
declare TraversalGraph t2 = new TraversalGraph("from Here
via Points to There", cg2);

declare TraversalGraph myTrav = new TraversalGraph("from A
via X to B", default);
```

TraversalJ should generate two .java files with names t2Travesal.java and myTravTraversal.java. There's a method getAspectName() in AspectJTraversal to return the correct file name format without the .java extension.

.prj Options

JAVADIRS - List the directories for the provided files and generated traversal code for testing.

COMPILER - For this project, it should be changed to ajc, the AspectJ compiler

COMPILE_ARGS - This should be blank since no arguments are needed.

TEST_ARGS - This is to specify the actual command line to TraversalJ. It should be able to handle -d option and a list of traversal specification files.

TEST_INPUT - This doesn't matter, but until the command-line option is implemented it should specify a traversal specification file for phase 1.

Project Write Up

For the project documentation you should document the Class Graph as a UML diagram, the traversals used in TraversalJ, which traversal you chose to implement and some analysis of TraversalJ. The Class Graph UML diagram should be in same format as the ones from Homework1. It should have all of the is-a and has-a relationships. This should include only the classes defined in your .cd file.

The traversal documentation should include the code and a high level description of what the traversal is doing, i.e. This traversal is used to visit all the commands. It uses the strategy from CommandList to {Command1, Command2}. It does blah blah blah for Command2 and blah blah blah for Command2.

The documentation for the testing phase of the project should include the place in which the traversal that you picked is located in .beh file and where you call the generated traversal method. It should also include step by step instructions on how to compile, run, and test your project. This should also be include in the README file that should be in your project directory at the time of your submission.

The analysis should document your analysis of the utility of TraversalJ in general. Discuss possible productivity gains and in which areas these productivity increases can be gained. There is no right answer for this section, but you should demonstrate that you have thought about this subject and give some logical rational for your analysis. It should also include possible reasons for having the listener and factory pattern for the interface between ClassGraphListener/Factory and COM1205 Inc.'s middle-ware.

Make sure to include the names of the project members.

README

This file should include the names of the persons that has worked on this project and the step by step directions on how to compile, run, and test your project. Also, include the places in which the traversal that was selected to test and where the traversal method is called.

Submission

For submission, use submission-com1205. run demeterj clean and zip to package the project.

You can do this multiple times, but it's highly discouraged. We may mistake yours as late or grade your earlier submission.

Due Dates

Project Submission: Tuesday, November 26, 2002, 11:59pm

Write-Up: Tuesday, Dec. 3, 2002, 11:59pm.

Non-CCS Project Environments

There are some software hoops that you'll need to go through in order to compile and run the Java program.

The basic steps in creating your own project environment are:

- Obtaining DemeterJ
- Obtaining AspectJ from www.aspectj.org
- Setting up path and classpath environment variables for DemeterJ and AspectJ

Linux Environment

If you have a Linux machine then you should be all set with the steps mentioned above. No other extra care is needed. If you happen to want to develop on a Windows machine then you need to read on and follow the directions listed in the next section.

Windows Environment

On Windows98, there's a limitation on how long the command line can be and if you have long classpath variable, then demeterj's compilation system will not work correctly when attempting to run. The limitation could be in Windows 2000 as well, but I don't have a machine to test it out on.

Also, AspectJ's compiler doesn't seem to like the command-line options that DemeterJ is passing to it. Thus, you need to actually execute these steps yourself. It would be best to write a batch file to compile, test, and recompile with generated traversal code.

Here are the steps involved:

First copy the provided files to a directory under the main project directory. For this example call the directory "interf".

```
mkdir interf
copy c:\download\*.java interf
```

Run demeterj to generate gen\classes directory. It'll might give some compilation error if you have any code that accesses AspectJTraversal.

```
demeterj
```

Then, run the AspectJ compiler on it from the gen\classes directory:

```
cd gen\classes
ajc ..\..\interf\*.java
```

Then, run demeterj to regenerate, run ajc to compile everytime you change your code.

```
demeterj
cd gen\classes
ajc ..\..\interf\*.java ..\.*.java
```

If you want to run the test:

```
set classpath = gen\classes;%classpath%
mkdir trav
java Main -d trav myTrav1.trv
```

If you want to compile with generated code:

```
cd gen\classes
ajc ..\..\interf\*.java ..\..\trav\*.java ..\*.java
```

This seems like it's daunting at first, but if you have two command prompt running with doskey installed then it's much easier. One is used for running ajc and the other is used for demeterj and running the test cases. This coupled with emacs for windows and emacs' shell buffer, you have a very good system for developing TraversalJ.