

# Modern Java Labs

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## Introduction

The following labs can be downloaded from:

<https://github.com/ThoughtFlow/ModernJava>

Each lab is modeled as a Java package with *init* and *fin* as sub-packages. The *init* package contains the initial code from which to start and the *fin* package contains the final solution. You may simply modify the code directly in *init* or copy the code in another package then modify it. Modular labs (e.g. lab12, lab13 and lab15) are under the modules directory.

Resist the urge to look at the answers in the *fin* package!

## Lab 1: The lambda form

**Objective:** test your understanding of how to implement lambdas.

Use these six pre-created interfaces in lab01.init:

1. Interface1.java  
`public void printSquareOfA(int a);`
2. Interface2.java  
`public int getSquareOfA(int a);`
3. Interface3.java  
`public int getAxB(int a, int b);`
4. Interface4.java  
`public void consume(int a);`
5. Interface5.java  
`public double getPi();`
6. Interface6.java  
`public Double create(double x);`

Implement these lambdas:

1. Implement a lambda squares the parameter value and prints the result conforming to Interface1.
2. Implement a lambda that will return the square of the parameter value using interface 2.
3. Implement a lambda that will return the multiplication of the two parameter values using Interface3.
4. Implement a lambda that will return the value of pi as a double using Interface5.
5. Implement a lambda that returns the square of the parameter value itself conforming to Interface2. Provide a default method that pretty prints a message around getSquareOfA().
6. Implement a static method in Interface3 that multiplies the two numbers. Call the method and print the result.
7. Implement a static method reference for interface4 and use calculateAndConsume with Interface2 to square the value of the parameter and print the results.
8. Implement a lambda that uses the static method Double.valueOf() to implement interface6.

## Lab 2: Standard functional interfaces

**Objective:** test your understanding of how to use the standard functional interfaces.

1. Replace functional interfaces 1 through 5 in lab02.init with their standard functional interface equivalent. Test it with LambdaTest.
2. Use Functions to create a series of functions that:
  - a. Double, square, cube then negate a number using andThen
  - b. Double, square, cube then negate a number using compose
  - c. Use FunctionalComposition in lab02.init as a starting point.
3. Use functional composition to implement lambda that will determine if a student has passed a course based on an array of Double representing test scores. A pass is calculated with these rules:
  - a. All test scores must be > 60%
  - b. Average test score must yield a B average (>= 80%)
  - c. If A and/or B are false, a pass is given if last exam was perfect
  - d. Must have taken all exams
  - e. Use this test data:

```
// True: Passed all
Double[] scores = (Double[]) Arrays.asList(.65, .90, .90, .90, .90, .90).toArray();
// False: Not all passed
scores = (Double[]) Arrays.asList(.59, .90, .90, .90, .90, .90).toArray();
// False: C average - fail
scores = (Double[]) Arrays.asList(.70, .70, .70, .70, .70, .70).toArray();
// True: C average but aced last
scores = (Double[]) Arrays.asList(.70, .70, .70, .70, .70, 1d).toArray();
// True: Failed first but scored perfect on last
scores = (Double[]) Arrays.asList(.59, .90, .90, .90, .90, 1d).toArray();
// False: same as previous but missed a test
scores = (Double[]) Arrays.asList(.59, .90, .90, .90, 0d, 1d).toArray();
```
4. Use Consumer composition to print all log lines to stdout and lines that contain the word "exception" to stderr (as well as stdout).
5. MessageComposition.java defines five methods: Encrypt/decrypt, encode/decode, and obfuscate. Encrypt and decrypt work together to encrypt and decrypt data while encode and decode convert to and from base64. Obfuscate hides credit card number. Use these predefined functions to create two super functions:
  - a. writingFunction obfuscates, encodes and encrypt data
  - b. readingFunction decrypts then decode data
  - c. Only Implement:
    - i. Supplier<Function<List<String>, List<String>>> writingFunction;
    - ii. Supplier<Function<List<String>, List<String>>> readingFunction;

## Lab 3: Using functionalized collections

**Objective:** test your understanding of how the newly functionalized collections library in Java 8.

Using this interface:

```
public interface MovieDb {  
    /**  
     * Adds a movie to the database with the given categories, name and year  
     * released.  
     *  
     * @param categories The set of categories for the new movie.  
     * @param name The name of the movie.  
     * @param yearReleased The year of release  
     */  
    void add(Set<Category> categories, String name, Integer yearReleased);  
  
    /**  
     * Adds a movie to the database with the given category, name and year  
     * released.  
     *  
     * @param category The category for the new movie  
     * @param name The name of the movie.  
     * @param yearReleased The year of release  
     */  
    void add(Category category, String name, Integer yearReleased);  
  
    /**  
     * Searches for the given movie title and returns as a Movie record.  
     *  
     * @param name The name of the movie to search.  
     * @return The found movie or null if not found.  
     */  
    Movie findByName(String name);  
  
    /**  
     * Searches by category and returns the list of movies for the given category.  
     *  
     * @param category The category name to search.  
     * @return The list of movies matching the category or an empty list.  
     */  
    List<String> findByCategory(Category category);  
  
    /**  
     * Deletes the movie with the given name.  
     *  
     * @param name The name of the movie to delete.  
     * @return True if found and deleted - false otherwise.  
     */  
    boolean delete(String name);  
}
```

- Convert each method in FunctionalMovieDb using the functionalized collection methods of sets, lists and maps.
- Fill in the methods where indicated by “implement this”.
- Refer to ImperativeMovieDb for an implementation using imperative method.
- Test your implementation with TestMovieDb.



## Lab 4: Currying in Java

**Objective:** test your understanding of currying in Java.

1. Implement this function used for currying and partial application:

- `Function<String, Function<String, Function<String, String>>> func`
- Then use partial application to concatenate strings:

```
func.apply("Currying").apply(" is").apply(" great!");
```

2. Define a function that multiplies three numbers using currying and partial application.

- Use the Function functional interface to define *a function that takes an integer and returns a function that takes an integer that returns another function that takes and returns an integer.*

3. Use the currying and partial application techniques to create a function that uses average, best or worst as a statistical method in calculating test scores. Use this type definition as the currying function:

```
Function<GradeCalcType, Function<List<Double>, Double>> curryingFunction;
```

The statistical methods are:

- Average: the average of the test scores is used to determine the grade.
- Best: only the highest score is used to determine the grade - all others are discarded.
- Worst, only the lowest score is used to determine the grade - all others are discarded.
- Use this enum definition:

```
private enum GradeCalcType
{
    AVERAGE,
    WORST,
    BEST
}
```

- Use this to test:

```
public static void main(String... args)
{
    List<Double> scores = Arrays.asList(.65, .75, .85);

    System.out.println(curryingFunction.apply(GradeCalcType.AVERAGE).apply(scores));
    System.out.println(curryingFunction.apply(GradeCalcType.BEST).apply(scores));
    System.out.println(curryingFunction.apply(GradeCalcType.WORST).apply(scores));
}
```

- Use the class CurriedGrading as a starting point.

## Lab 5: Using streams

**Objective:** test your understanding and practice thinking in streams.

Use streams to implement these algorithms:

1. Iterate through numbers from 0 to 100:
  - Print out all the even numbers.
  - Then, modify your algorithm to add only odd numbers 0, 100.
  - Then, modify your algorithm to find the smallest int whose factorial is  $\geq 1,000,000$
2. Take the PredicateComposition from lab2 and convert the four lambdas (isAllPassed, isBAverage, isLastPerfect, isAnyMissed) into stream-based lambdas. *Hint: use `Arrays.stream()` to convert the array of doubles into a stream.*
3. Given a list of strings, print each string that is a palindrome:
  - Then, modify your algorithm to return the original word (unstripped).
4. Implement the Fizz Buzz algorithm:
  - Iterate from 1 to 100.
  - Print "Fizz" for every number divisible by 3 and "Buzz" for every number divisible by 5.
5. Given a list of strings, use collectors to:
  - Find the average length of all the strings that contain a given word (using `Collectors.averagingInt()`)
  - Returns the list of strings that contain a given word in a map (using `Collectors.partitioningBy()`):
    - i. Use this type: `Map<Boolean, List<String>>`
    - ii. Where K is a Boolean for matching and non-matching strings
    - iii. Where V is the list of strings for that category
  - Create a dictionary of each word in the list of strings (using `Collectors.toMap()`)
    - i. Use this type `Map<String, Integer>`
    - ii. Where K is the word
    - iii. Where V is the occurrence count of that word
  - Use `lab05.init.Collection` as a starting point and implement the methods marked with "implement this".



## Lab 6: Using the executor service with callables and futures

**Objective:** test your understanding of the executor service, callables and futures.

1. Write an application that counts the number of prime numbers in ranges using the `ExecutorService`:
  - Start with the single-threaded implementation `ThreadedPrimeNumberFinder`. Re-implement the method `countPrimes`.
  - Choose the appropriate `ExecutorService` implementation and mind the pool size.
  - Use `submit/invoke`, `call` and `future`, then shutdown the pool.
  - Each range is 1000 elements.
  - Each range is calculated by different threads using the executor service.
  - Print the number of primes found for all ranges.
  - Use the method `Util.isPrime` (`lab.util` package) to determine if a number is prime.
  - There are 78,498 prime numbers between 1 and 1,000,000.
2. Write an application that scrapes the HREF URLs from a given set of html pages, catalogs them inside a map and tallies the occurrence of each distinct URL.
  - Start with `LinkScaper` and use pre-made methods `Util.scrapeHrefs()`, `Util.catalog()` and `Util.merge()` to scrape the urls, catalog them into a map and merge into one map. The map will be keyed by the `stringedUrl`. The value will be the occurrences of that url.
  - The method `invoke` implements a single-threaded version. Use that code to convert to multi-threads
  - Choose the appropriate `ExecutorService` implementation and mind the pool size.
  - Use `submit/invoke`, `call` and `future`, then shutdown the pool.
  - The list of URLs to scrape is given.

## Lab 7: Using Read/Write locks

**Objective:** test your understanding of Java's Read/Write locks

Refactor the movie database from lab07.init to make it thread-safe:

- Use the class ThreadSafeMovieDb as a starting point.
- Use read/write locks to access the database class attribute in a thread-safe way.
- Look for markers in the code for help in locating areas to protect.
- Use the pre-made TestMovieDb to test your implementation.

## Lab 8: Using the Fork/Join framework

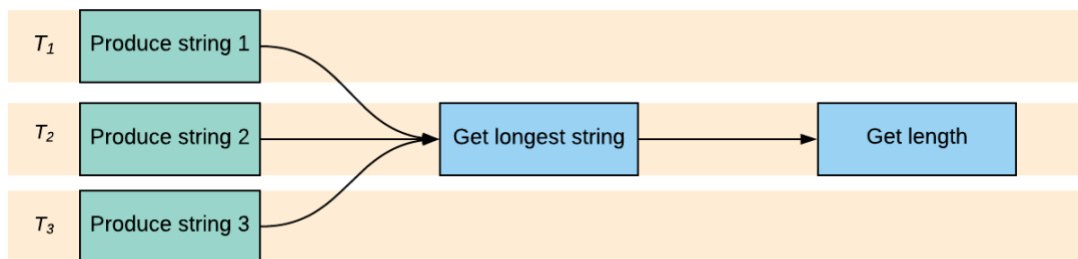
**Objective:** test your understanding of the fork/join framework.

1. The class in `lab08.init.ForkJoinedPrimeNumberCollector` creates an array of one million booleans where each element indicates whether or not the number at its index is prime. It then lists the numbers that are prime. It already uses the fork/join framework and extends the `RecursiveAction` class but does not divide and conquer the processing. Refactor the `compute` method to:
  - Divide the array in chunks of 1000 elements using `fork()`
  - Populate each array element with `true` if its index is prime – `false` otherwise
  - Rejoin the processing with `join()`.
2. The class in `lab08.init.ForkJoinedPrimeNumberFinder` counts the number of primes as a recursive task of type `Integer`. It already uses the fork/join framework and extends the `RecursiveTask` class but does not divide and conquer the processing. Refactor the `compute` method to:
  - Divide the array in chunks of 1000 elements using `fork()`
  - Count the number of prime numbers in the range
  - Rejoin the processing with `join()` and aggregate the results.
3. The class in `lab08.init.ForkJoinedLinkScraper` uses Fork/Join to scrape HREFs from a List of URLs and catalogs the occurrence of each unique HREF in a Map.
  - Finish the implementation of `LinkScrapeTask`'s `compute` method. Fork the work of calling `Util.scrapeHrefs` and combine the results into one List.
  - Finish the implementation of `LinkCatalogTask`'s `compute` method. Fork the work of calling `Util.catalog` and combine the results using `Util.merge`.

## Lab 9: Using promises

**Objective:** test your understanding of promises.

1. Implement a chained set of promises that:
  - Call `produceString1`, `produceString2` and `produceString3` asynchronously. Each return a string.
  - Get the longest string of the three.
  - Return the length of that string as an integer.
  - Use `PromiseCombiner` as a starting point and implement `weavePromise()`.
  - Should return: 10.



2. Re-implement the prime number finder from lab 8 using promises:
  - Start with `PromisesPrimeNumberFinder` and implement the method `createPromise()`;
3. Add exception handling to the promise:
  - Add exception handling in the promise to handle exceptions. This handler should simply return 0 and continue with the next range.
  - Print an error message but continue anyway.
  - Test with a negative range.
  - Start with `PromisesPrimeNumberFinder` and implement the method `createPromiseWithException()`;
4. Re-implement the URL scraper using promises:
  - Use `Util.scrapeHrefs`, `Util.catalog` and `Util.merge` within chained promises.
  - Mind the merge being done in parallel (hint: use a `concurrentHashMap`)

## Lab 10: Using parallel streams

**Objective:** test your understanding of parallel Streams and spliterators.

1. Re-implement the solution of lab 6 using spliterators (the divide and conquer strategy):
  - Start with `SpliteratorPrimeNumberFinder` and implement these 2 functions:  

```
// Input: The list of integers to test for primeness  
// Output: The list of spliterators of integers representing the range to process  
Function<List<Integer>, List<Spliterator<Integer>>>> spliteratorCreator;  
  
// Input The spliterator of integers to process  
// Output: The number of primes found in the spliterator  
Function<Spliterator<Integer>, Integer> primeCounter;
```
  - Create four spliterators in `spliteratorCreator`.
  - Count the number of primes in `primeCounter`.
  - Each spliterator will be wrapped inside a callable and run by the executor service.
2. Using `lab10.init.StreamedPrimeNumberFinder`, parallelize the stream-based prime number finder:
  - Ensure that it still prints the prime numbers in order
  - Use the pre-existing code `threadPeeker` function to determine whether or not the stream really executed in parallel.

## Lab 11: Reactive programming

**Objective:** test your understanding of reactive programming in Java.

ReactiveProcessor is a queue-based program in which a publisher pushes events to a Subscriber using reactive principles. That is, it is aware of its subscriber and can track any dropped messages. The subscriber can also apply back-pressure to the publisher if it publishes too fast.

Using the ReactiveProcessor in lab11.init as a starting point, finish the implementation by supplying a subscriber and publisher:

- Publisher specs:
  - The event publisher is a function that takes a subscriber and returns the list of messages dropped by the subscriber.
  - The event publisher then offers integers to the subscriber via `SubmissionPublisher.offer()`.
  - It publishes messages from 1 to 1000 and gives the subscriber up to 50ms to process the message. Otherwise, messages are dropped and recorded into a list.
  - The `SubmissionPublisher` is configured with a queue size of 2.
- Subscriber specs:
  - The subscriber is a `Flow.Subscriber` subclass whose parameterized type is an `Integer` (it will receive integers). The subscriber will call the `simulateWork(Integer)` method that already exists in the `ReactiveProcessor`.
  - Implement the code with markers `###Implement me###`
  - Ensure that you request integers in the subscriber (or nothing will happen).

Repeat with a publisher whose range is -1 to 10 to simulate an error.

## Lab 12: Creating JPMS modules in the IDE

**Objective:** test your understanding of creating JPMS modules in the IDE.

In the directory `modules/lab12.fin`, there are two JPMS modules:

- `com.lab12.movement`
- `com.lab12.axle`

Use those to create a modular IDE project.

- Create two IDE modules each with its own hierarchy and module-info class. Use the pre-defined module-info class.
- `com.lab12.movement` is the root module with no dependencies
- `com.lab12.axle` depends upon `movement`.

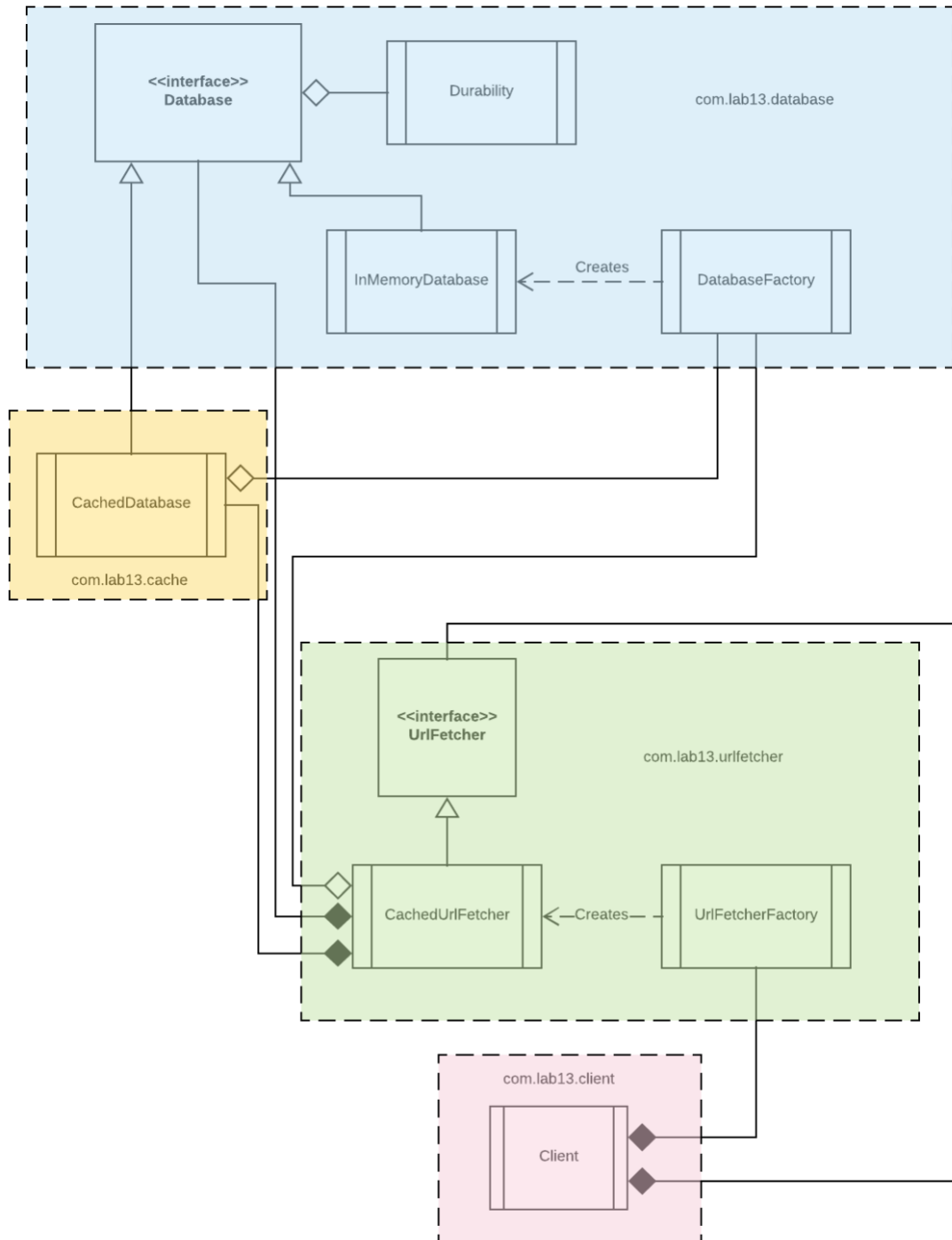
Define the project and run the class `com.lab12.axle.api.TestAxle`.

What happens if you try to instantiate `com.lab12.movement.Rim` from `Axle`?

## Lab 13: Modules

**Objective:** test your understanding of modules.

Consider this class diagram:





Note that:

- `com.lab13.database` has no dependencies
- `com.lab13.cache` depends upon `com.lab13.database`
- `com.lab13.urlfetcher` depends upon `com.lab13.database` and `com.lab13.cache`. It depends upon `Durability` defined in `com.lab13.database`, which is exposed in its `UrlFetcher`.
- `com.lab13.client` depends upon `com.lab13.urlfetcher`.

Using the pre-existing code in `modules/lab13/init`, modularize this application such that:

- Each box is in its own Java module (use the names shown in the diagram)
  - Create IDE modules.
- Create a module-info class that follows the class diagram dependencies. Expose the least number of classes to outside packages (strong encapsulation).
- Make `com.lab13.cache` an optional module and `UrlFetcher` must work with or without it.
- Repackage any class as necessary to meet the stated objectives.

Run the class `com.lab13.client.Client` to test your configuration:

- Without caching
- With caching.

## Lab 14: Create jmod files and jlink distributions

**Objective:** test your understanding of the jmod and jlink tools

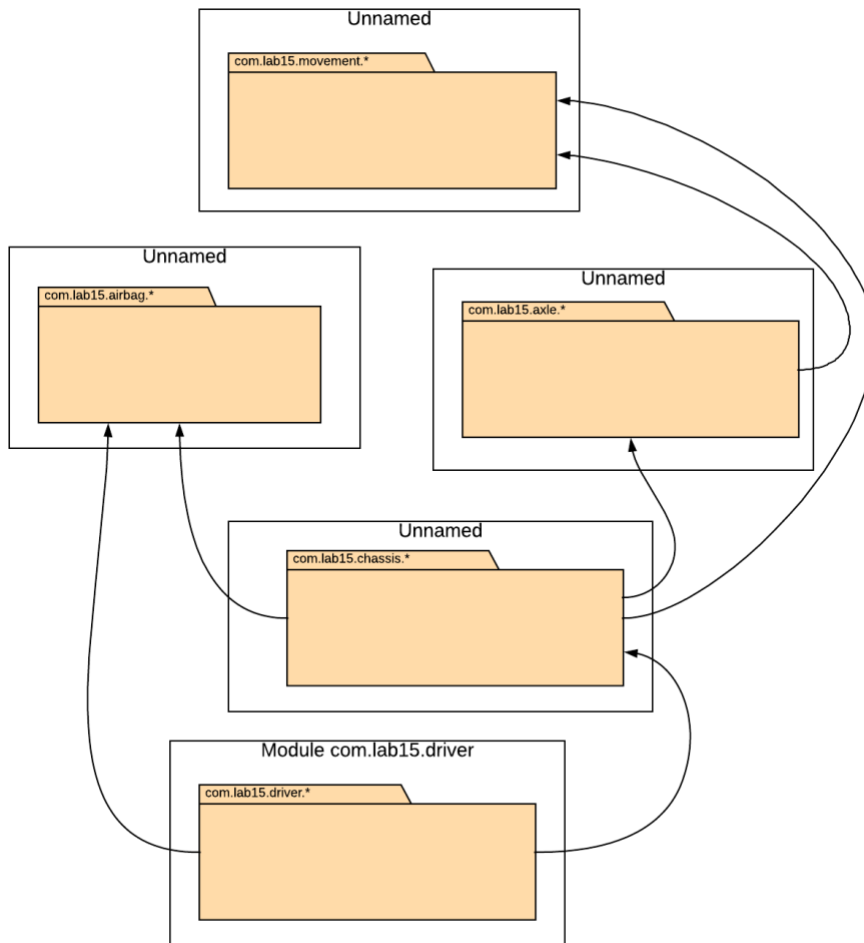
Use the pre-created application in lab14 init, which is a copy of lab13, to create a self-contained image file that requires no JVM installation to run:

- Start with lab14/init/build script. It contains the javac command.
- Create a jmod file for all four modules
- Describe the contents of each jmod file
- Create a jlink distribution with an auto-launch of `com.lab14.client/com.lab14.client.Client`
- Run the generated jlink auto-run script.
- Package this under lab14.jmods (for the jmod files) and lab14.jlink for the distribution.
- Complete the build and run script.

## Lab 15: Modular Jars

**Objective:** test your understanding of modular jars.

Consider this dependency graph where each package is contained in a jar:



The package `com.lab15.driver` has already been modularized but will no longer work with the rest of the non-modular application. Budget has been allocated to convert two packages into modules: which two packages would you pick?

Tasks:

- Create the module-info class for module `com.lab15.driver`
- Create the module-info class for two more packages only
- Use automatic modules for any remaining dependency.
- Use build and run scripts to both build and run the application. (No need to configure the module in the IDE.)

## Lab 16: HTTP 2

**Objective:** test your understanding of the HTTP 2 client library in Java.

Using `lab16.init.HttpFunctions` as a starting point, complete the following methods using the pre-made templates (implement the code marked by `### Implement me###`):

1. Perform an HTTP GET using a String-based body as a response in `getBodyAsString`.
2. Perform an HTTP GET using a stream-based body as a response in `getBodyAsStream`
3. Perform an HTTP POST writing the response to a file using `postResponseToFile`.

Follow the instructions in each method by implementing the Function and Consumer as specified.

## Lab 17: Process API

**Objective:** test your understanding of the process API.

Write a REPL shell that performs commands on processes running on your host. Start with the class `ProcessHandlerRepl` in `lab17.init` and fill in the missing methods (marked by `### Implement me ###`):

- `start program output`: Starts a linux program sending output to output.
- `find program`: Prints the PID of the given program if found
- `kill pid`: Kills the process with the given PID.
- `stats pid`: Prints the user under which the given PID is owned and the CPU duration in seconds consumed so far.
- `all`: Prints the PID of all processes running on the host.

The remainder of the program is already written.

## Lab 18: JShell

**Objective:** test your understanding of the JShell REPL engine.

Start JShell and perform this series of commands:

1. Copy the find and stats method from Lab16.fin.ProcessHandleRepl.
2. List the contents of the methods.
3. Import the missing java.time.Duration class.
4. Invoke the method find("jshell") and note the PID.
5. Define the variable PID as a long and initialize it with the PID from the previous step.
6. Edit the stats method and remove the parameter. Hard code the method to always use the PID constant.
7. Save all declared methods and constants to file context.txt
8. Save the command history to file history.txt
9. Reset jshell
10. Reload the saved methods and constants
11. Call stats again
12. Exit out of jshell and list the history.

## Lab 19: Garbage collection

**Objective:** test your understanding of garbage collection settings and profiling.

Use the class Infinite.java in lab19.fin as the application to profile.

1. Configure the GC thusly:
  - a. Use the G1 garbage collector
  - b. Turn on debug heap profiling and output to file /tmp/GC.log
  - c. Set the minimum heap to 100Mb and the max heap to 200MbHow many eden (young), survivor and old GC cycles occurred?  
What was the size of each region?
2. Repeat the same exercise with the Epsilon GC.