Applying Java Functional Programming Features to the ThreadJoinTest Case Study

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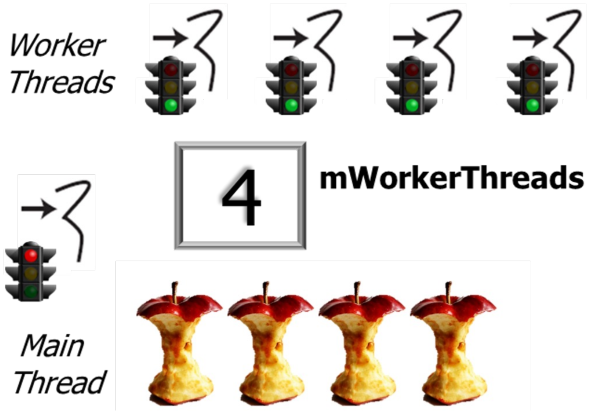
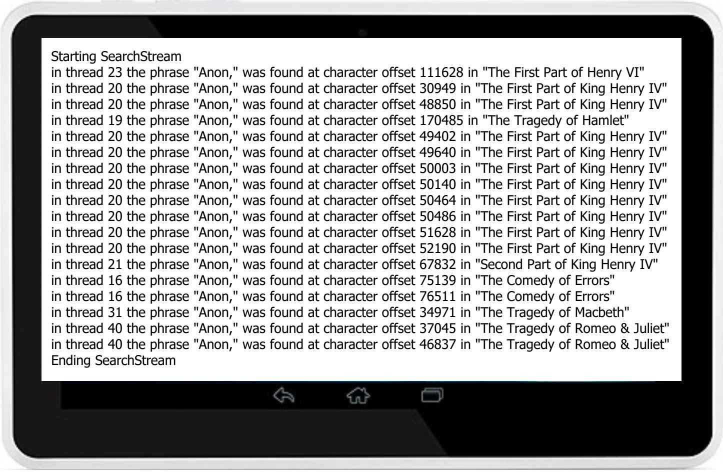
Learning Objectives in this Part of the Lesson

- Understand how Java functional programming features are applied in multi-threaded program





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Ending SearchStream
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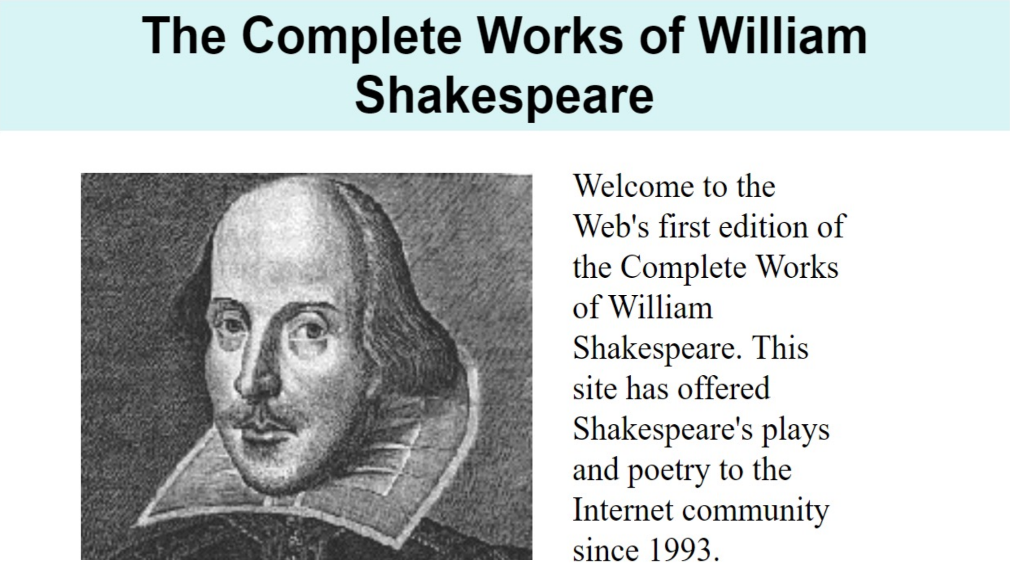
See github.com/douglascraigschmidt/ModernJava/tree/main/CS/ThreadJoinTest

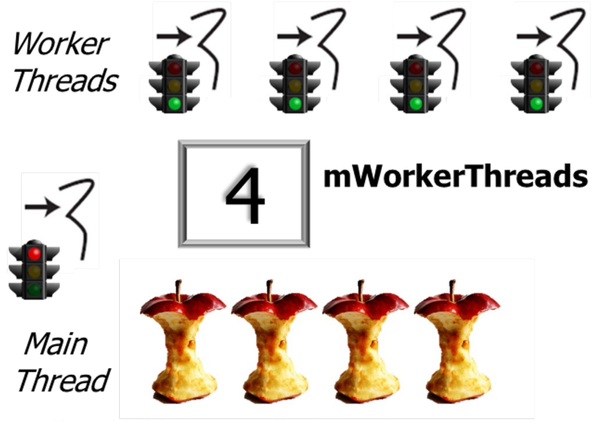
Learning Objectives in this Part of the Lesson

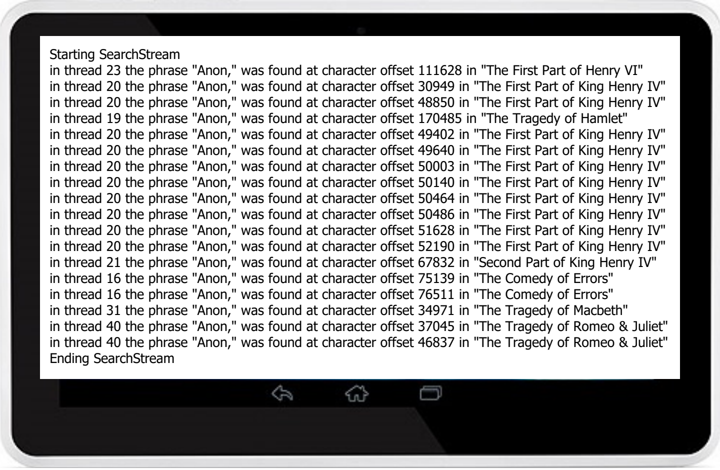
- Understand how Java functional programming features are applied in multi-threaded program
  - This program searches for a list of phrases in the complete works of William Shakespeare



The Complete Works of William Shakespeare

Welcome to the Web's first edition of the Complete Works of William Shakespeare. This site has offered Shakespeare's plays and poetry to the Internet community since 1993.





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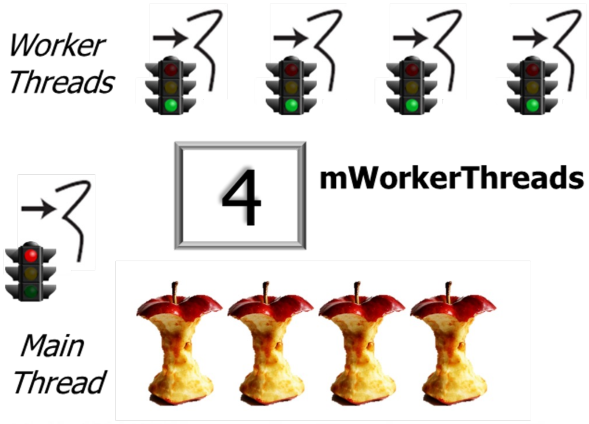
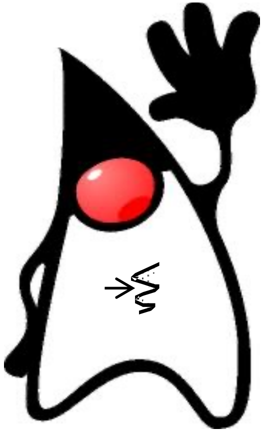
Ending SearchStream
```

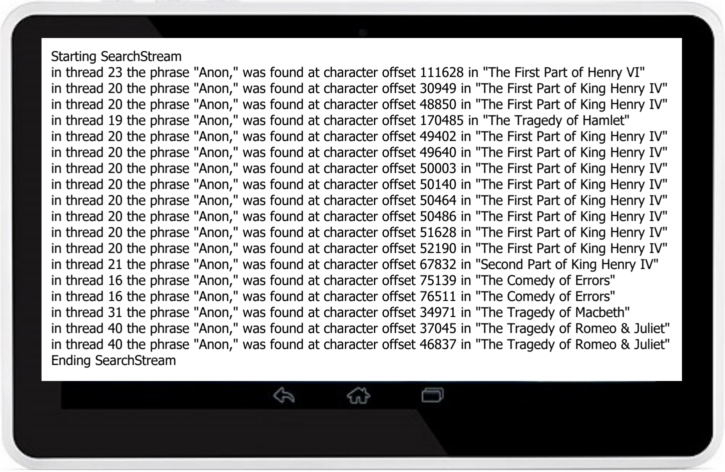
See shakespeare.mit.edu

Learning Objectives in this Part of the Lesson

- Understand how Java functional programming features are applied in multi-threaded program
  - This program searches for a list of phrases in the complete works of William Shakespeare
  - It also demonstrates the use of Java Thread objects







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Ending SearchStream
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See docs.oracle.com/javase/8/docs/api/java/lang/Thread.html

Overview of the ThreadJoin Test Case Study Program

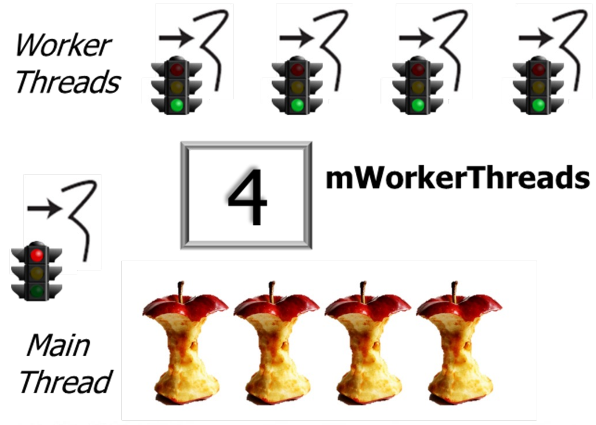
Overview of the ThreadJoinTest Case Study Program

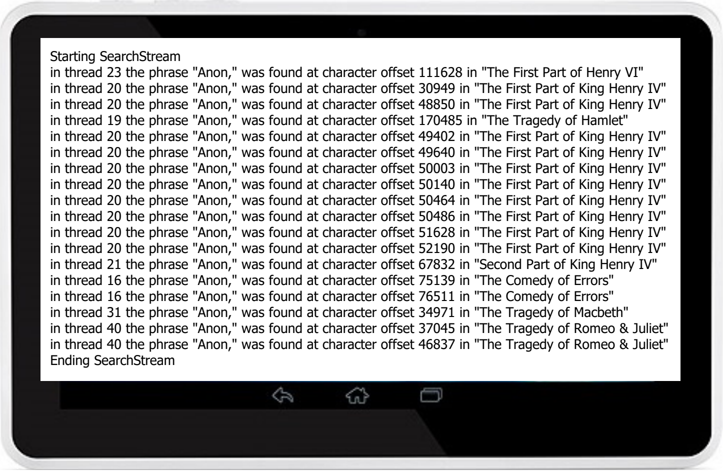
- Use Java functional programming features to create, start, & join Thread objects that concurrently search for phrases in works of Shakespeare

```
var workerThreads = ThreadUtils
   .makeThreads(mInputList,
                this::processInput);

workerThreads
   .forEach(Thread::start);

workerThreads
   .forEach(rethrowConsumer
              (Thread::join));
```





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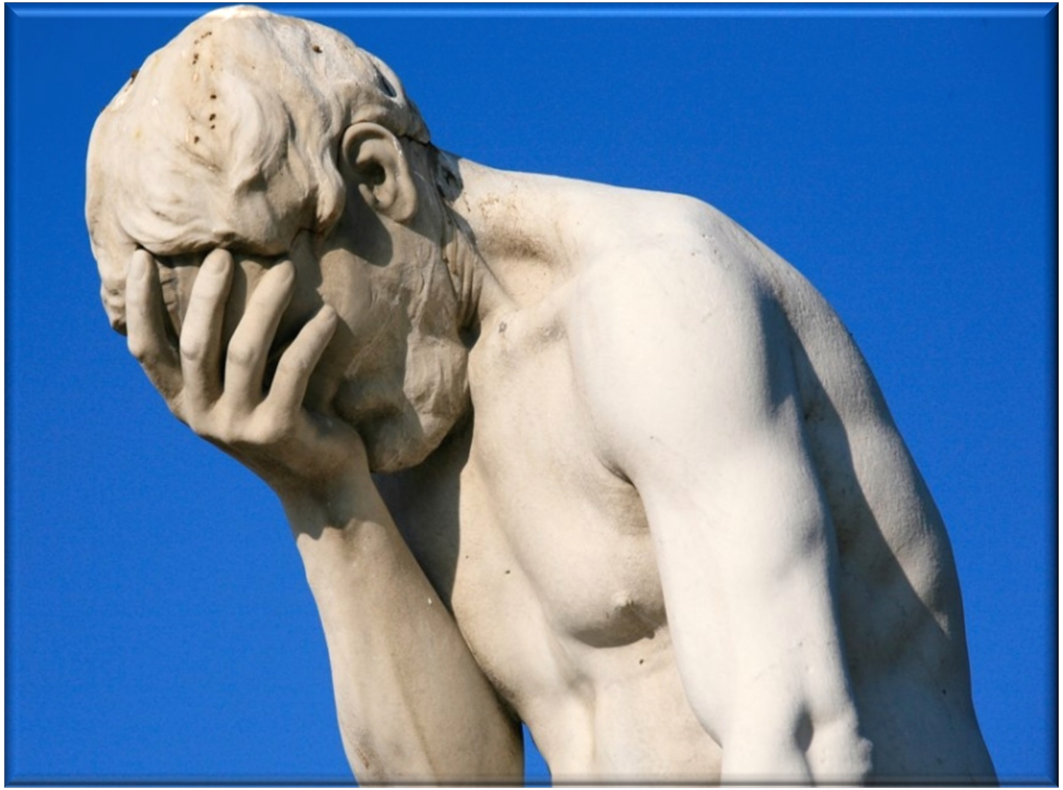
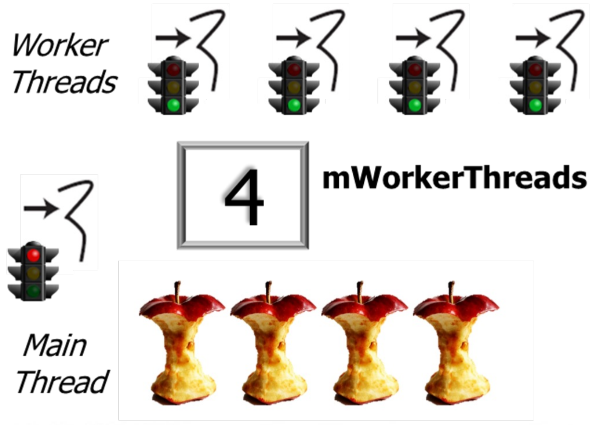
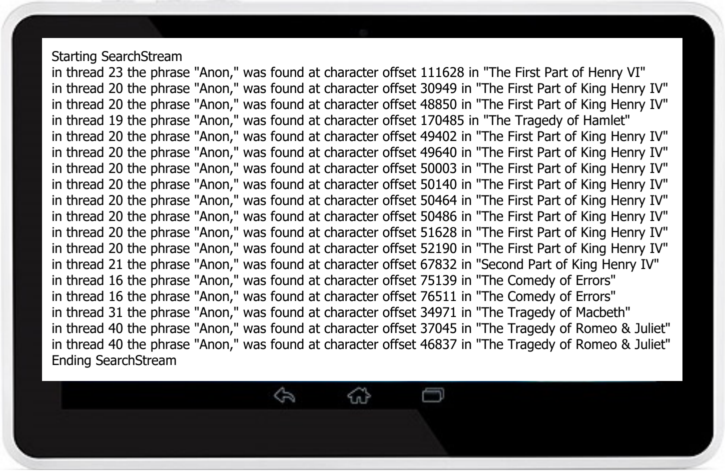
See github.com/douglascraigschmidt/ModernJava/tree/main/CS/ThreadJoinTest

Overview of the ThreadJoinTest Case Study Program

- This program is "embarrassingly parallel"







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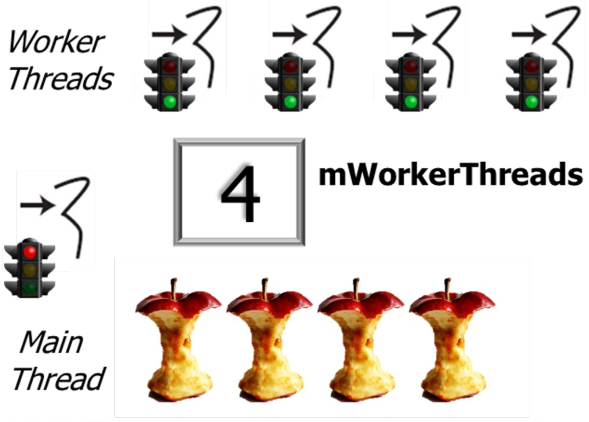
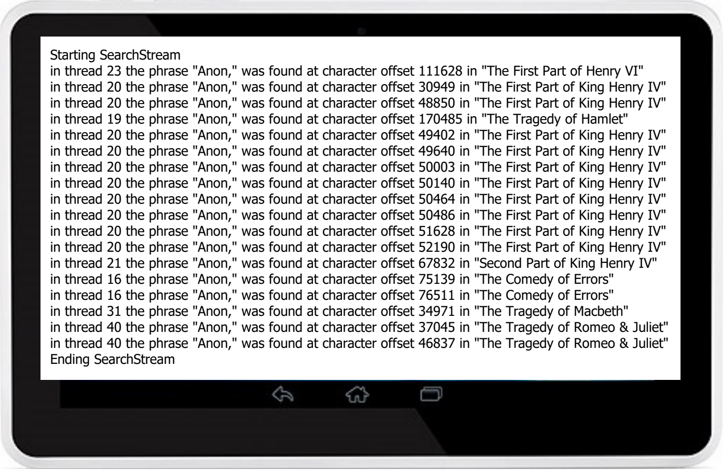
See en.wikipedia.org/wiki/Embarrassingly_parallel

Overview of the ThreadJoinTest Case Study Program

- This program is "embarrassingly parallel"
  - i.e., there are no data dependencies between worker threads





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A laundromat is an apt metaphor for "embarrassingly parallel" processing!

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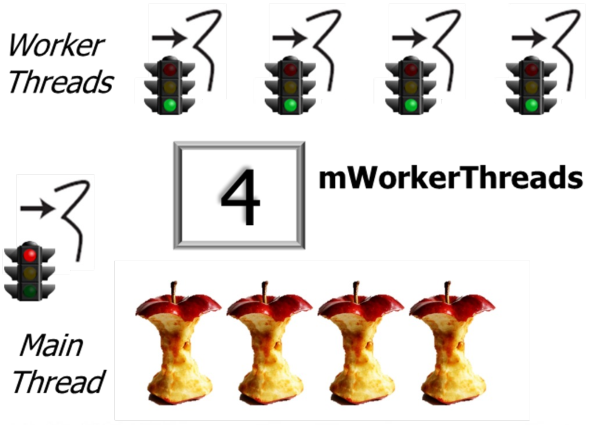

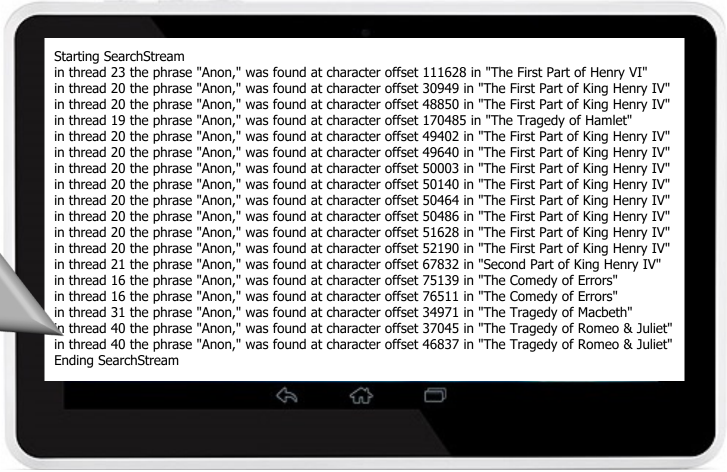

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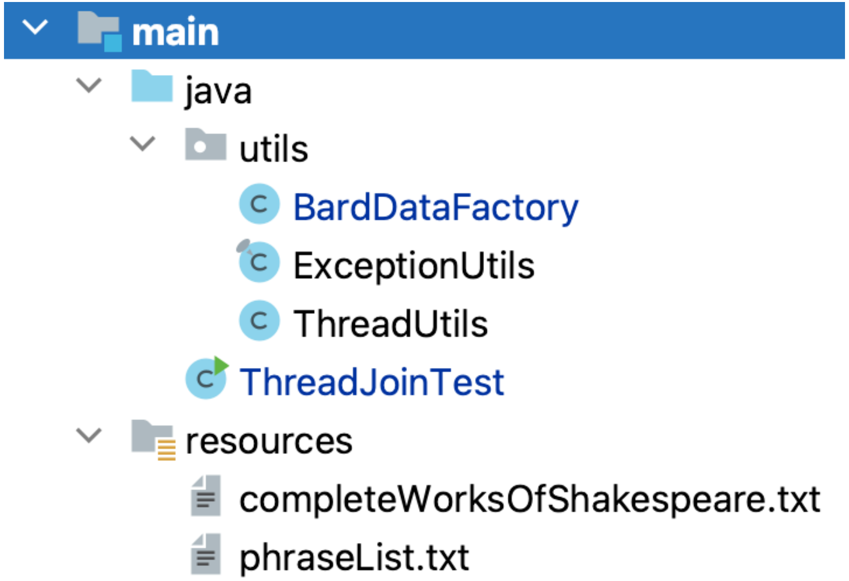
Each work of Shakespeare is processed concurrently in its own Java Thread object

Structure & Functionality of the ThreadJoinTest Program

Structure & Functionality of the ThreadJoinTest Program

- The ThreadJoinTest project source code is organized into several files & packages



```
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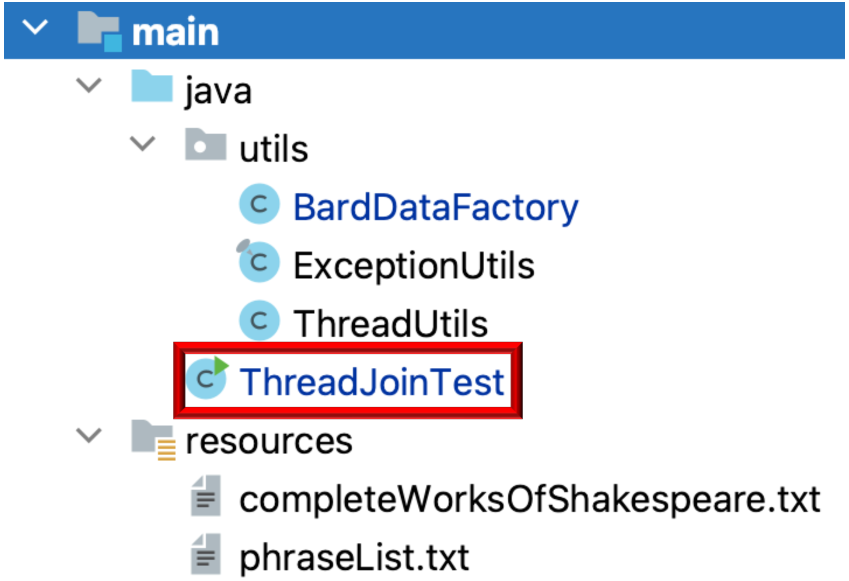
  java
    utils
      BardDataFactory
      ExceptionUtils
      ThreadUtils
    ThreadJoinTest
  resources
    completeWorksOfShakespeare.txt
    phraseList.txt
```

See github.com/douglascraigschmidt/ModernJava/tree/main/CS/ThreadJoinTest

Structure & Functionality of the ThreadJoinTest Program

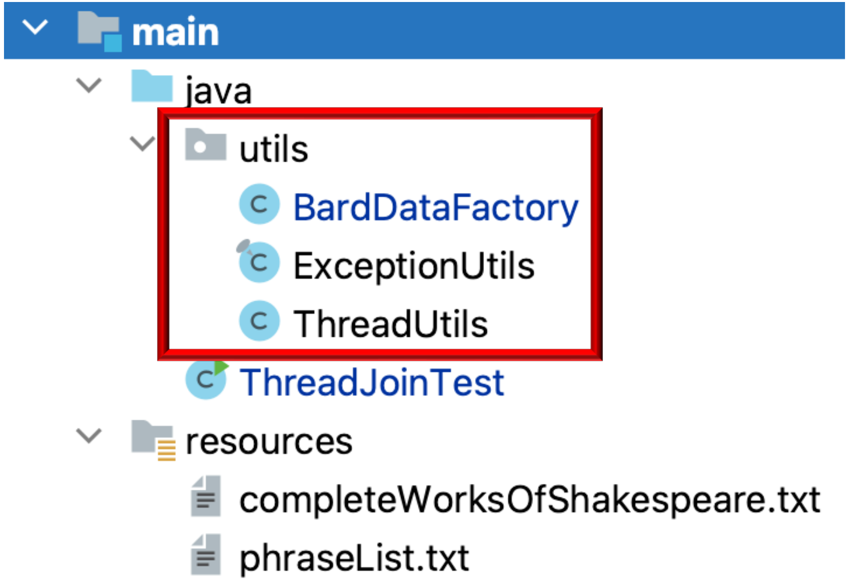
- The ThreadJoinTest project source code is organized into several files & packages
  - ThreadJoinTest
    - The main test driver program that concurrently searches for phrases in the complete works of William Shakespeare



- main
  - java
    - utils
      - BardDataFactory
      - ExceptionUtils
      - ThreadUtils
    - ThreadJoinTest
  - resources
    - completeWorksOfShakespeare.txt
    - phraseList.txt

Structure & Functionality of the ThreadJoinTest Program

- The ThreadJoinTest project source code is organized into several files & packages
  - ThreadJoinTest
  - utils
    - Contains general-purpose reusable classes



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    utils
      BardDataFactory
      ExceptionUtils
      ThreadUtils
    ThreadJoinTest
  resources
    completeWorksOfShakespeare.txt
    phraseList.txt
```
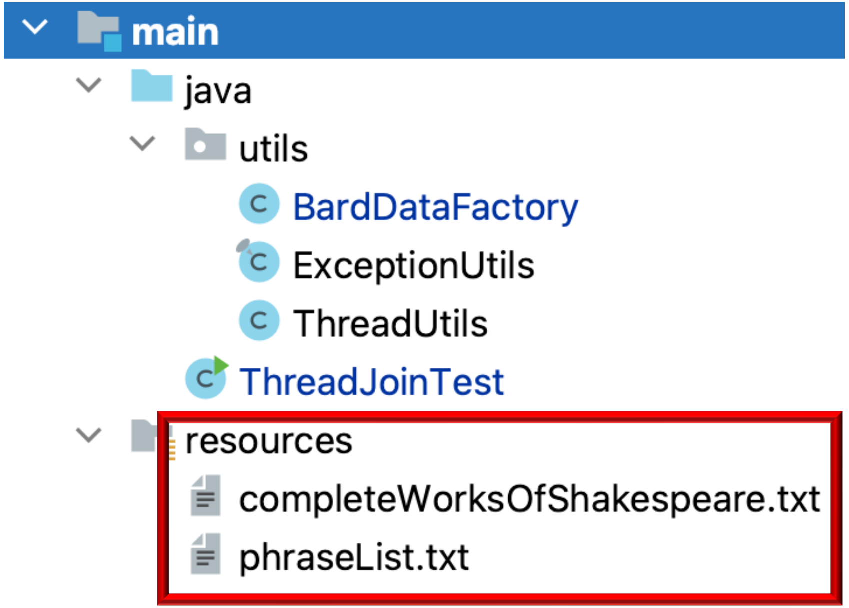

Structure & Functionality of the ThreadJoinTest Program

- The ThreadJoinTest project source code is organized into several files & packages
  - ThreadJoinTest
  - utils
  - resources
    - Contains the complete works of Shakespeare & the list of Bard phrases



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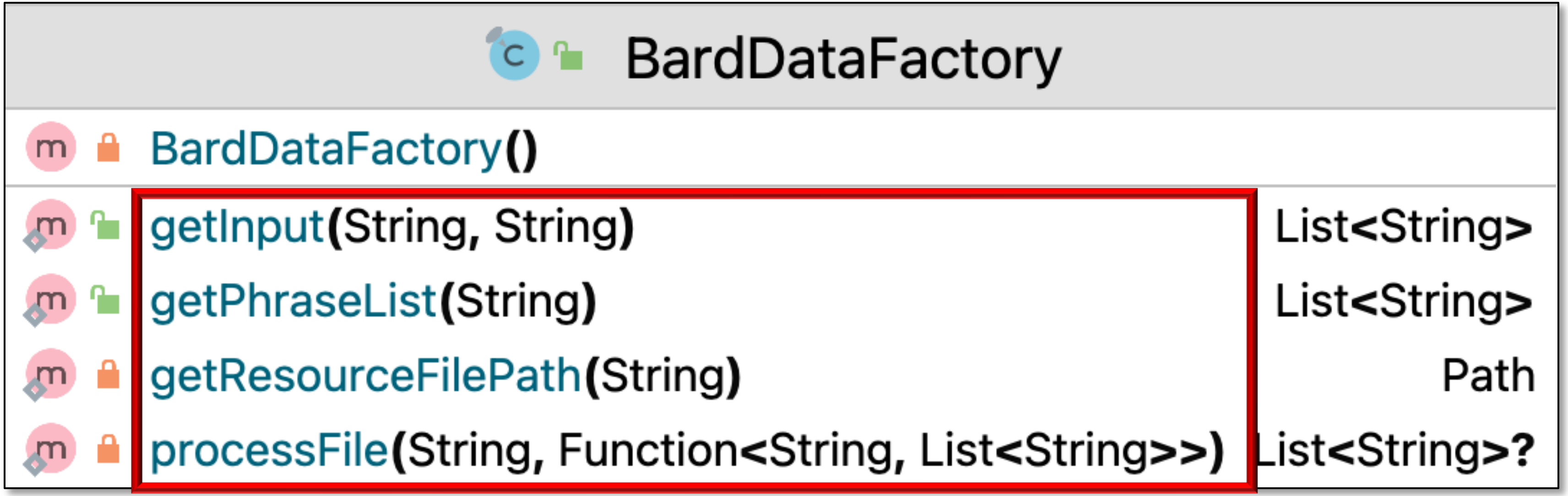
See christirapt.wordpress.com/2017/11/24/why-is-shakespeare-called-the-bard

Obtaining the ThreadJoinTest Program’s Input Data

Obtaining the ThreadJoinTest Program’s Input Data

- The BardDataFactory utility class applies functional programming features to read the contents of text files & return this content as Lists of String objects



BardDataFactory

BardDataFactory()	
getInput(String, String)	List<String>
getPhraseList(String)	List<String>
getResourceFilePath(String)	Path
processFile(String, Function<String, List<String>>)	List<String>?

See CS/ThreadJoinTest/src/main/java/utils/BardDataFactory.java

Obtaining the ThreadJoinTest Program’s Input Data

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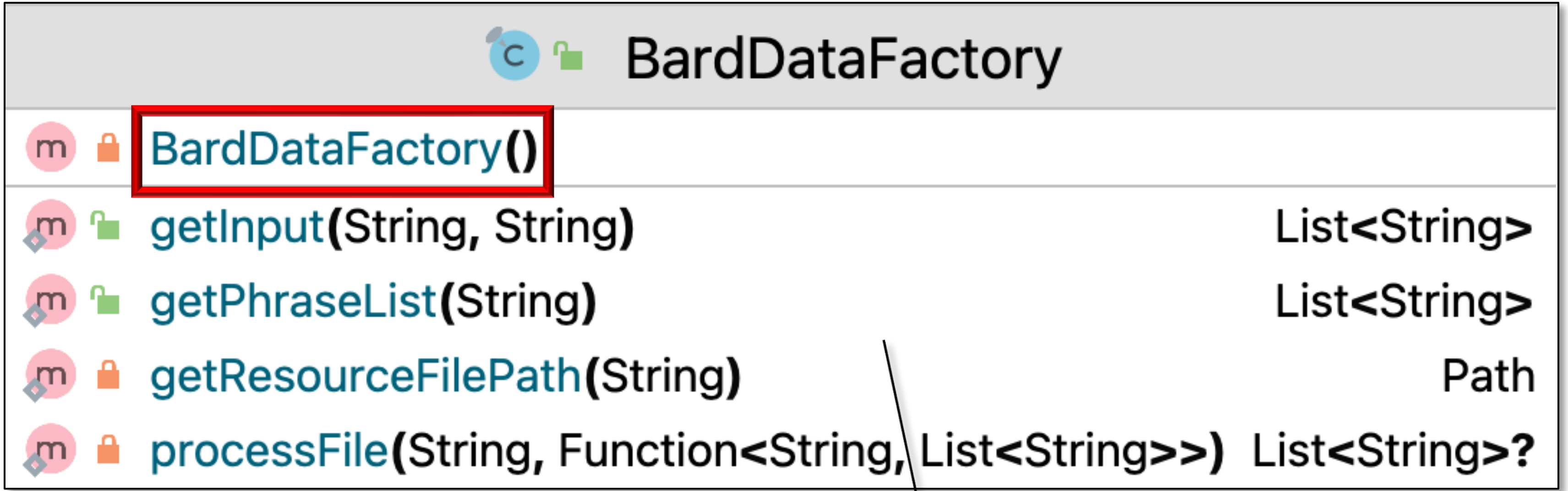

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getInput(String, String)	List<String>
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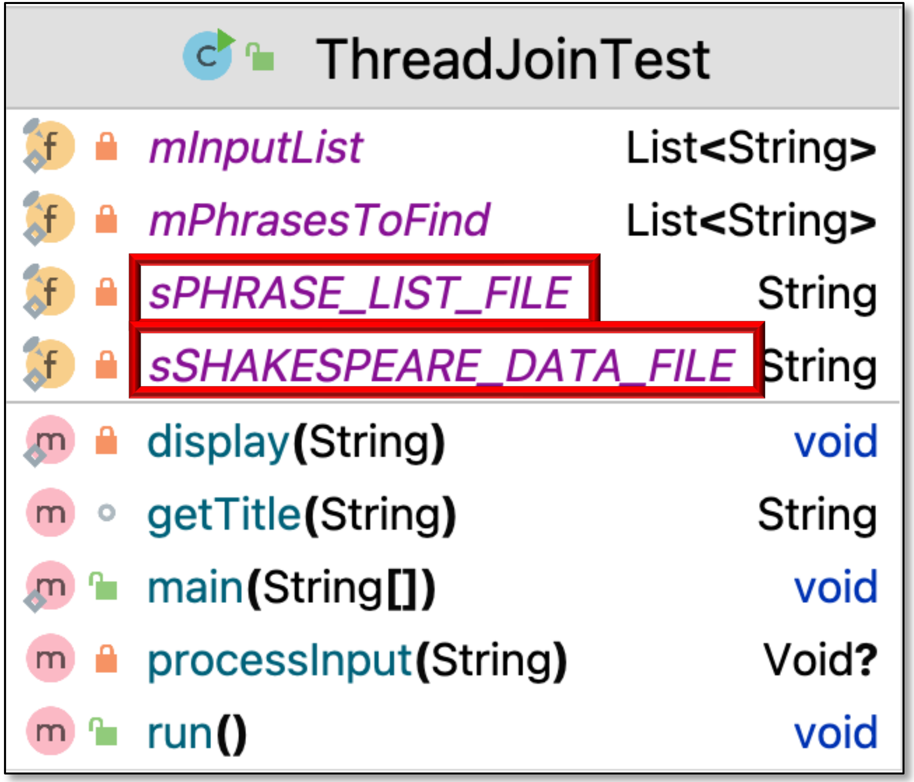
getResourceFilePath(String)	Path
processFile(String, Function<String, List<String>>)	List<String>?

A utility class in Java is defined as final & has only static methods, no non-static state, & a private constructor

See www.quora.com/What-is-the-best-way-to-write-utility-classes-in-Java/answer/Jon-Harley

Obtaining the ThreadJoinTest Program’s Input Data

- The BardDataFactory reads the works of Shakespeare & the Bard phrases to search for from two text files



ThreadJoinTest

mInputList	List<String>
mPhrasesToFind	List<String>
sPHRASE_LIST_FILE	String
sSHAKESPEARE_DATA_FILE	String
display(String)	void
getTitle(String)	String
main(String[])	void
processInput(String)	Void?
run()	void

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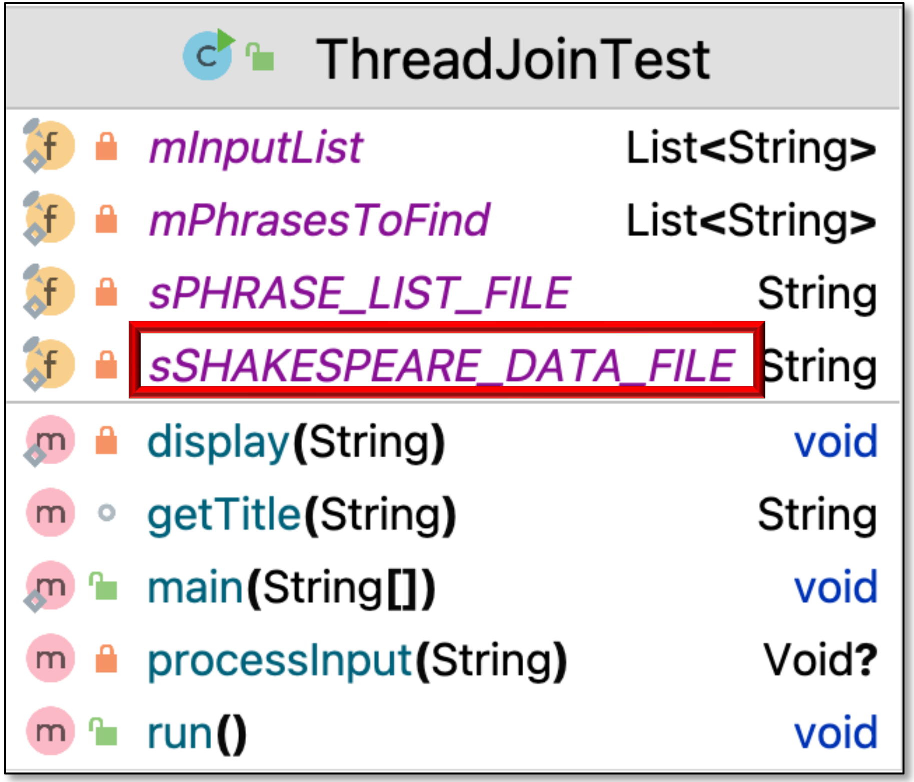
- The BardDataFactory reads the works of Shakespeare & the Bard phrases to search for from two text files

```
List<String> mInputList =
  BardDataFactory.getInput
    (sSHAKESPEARE_DATA_FILE,
     "@");
...
@The Tragedy of Hamlet
...
@The Tragedy of Julius Caesar
...
@The Tragedy of Macbeth
...
```



ThreadJoinTest

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sPHRASE_LIST_FILE	String
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Each work begins with '@', which is matched by a Java regular expression

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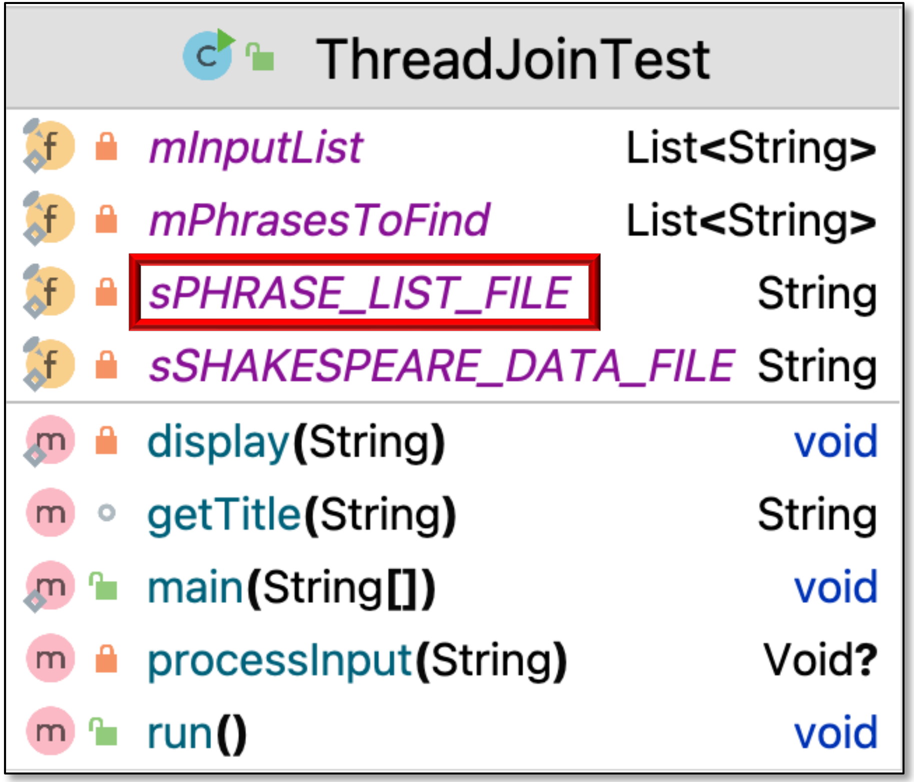
```
List<String> mPhrasesToFind =
   BardDataFactory.getPhraseList
      (sPHRASE_LIST_FILE);
...
Beware the Ides of March
Brevity is the soul of wit
All that glisters is not gold
Sit you down, father; rest you
my kingdom for a horse!
Off with his head!
Neither a borrower nor a lender be ...
```



ThreadJoinTest

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main(String[])	void
processInput(String)	Void?
run()	void

Each phrase appears on a separate line

Obtaining the ThreadJoinTest Program's Input Data

- Process the contents of a File associated with filename using the Function

```
static List<String> processFile
   (String filename, Function<String, List<String>> fileProc) {
   var uri = getResourcePathFile(filename);


   String contents = new String(Files.readAllBytes(uri));


   var strings = fileProc.apply(contents);

   strings.removeIf(String::isEmpty);

   return strings;
}
```

See CS/ThreadJoinTest/src/main/java/utils/BardDataFactory.java

Obtaining the ThreadJoinTest Program’s Input Data

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   strings.removeIf(String::isEmpty);

   return strings;
}
```

This filename identifies a File to process

Obtaining the ThreadJoinTest Program's Input Data

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  var uri = getResourcePathFile(filename);

  String contents = new String(Files.readAllBytes(uri));

  var strings = fileProc.apply(contents);

  strings.removeIf(String::isEmpty);

  return strings;
}
```

The Function that processes the file in some manner

This method applies a Java Function to factor out common code

Obtaining the ThreadJoinTest Program’s Input Data

- Process the contents of a File associated with filename using the Function

```
static List<String> processFile
   (String filename, Function<String, List<String>> fileProc) {
   var uri = getResourcePathFile(filename);
```

Convert filename into a Path URI

```
   String contents = new String(Files.readAllBytes(uri));


   var strings = fileProc.apply(contents);

   strings.removeIf(String::isEmpty);

   return strings;
}
```

Obtaining the ThreadJoinTest Program's Input Data

- Process the contents of a File associated with filename using the Function

```
static List<String> processFile
   (String filename, Function<String, List<String>> fileProc) {
   var uri = getResourcePathFile(filename);
```

```
static Path getResourceFilePath(String filename)
    throws URISyntaxException {
    return Paths
      .get(ClassLoader.getSystemResource(filename)
      .toURI());
}
```

```
   return strings;
}
```

This helper method gets a Path to the designated File in the resources folder

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static List<String> processFile
   (String filename, Function<String, List<String>> fileProc) {
   var uri = getResourcePathFile(filename);

   String contents = new String(Files.readAllBytes(uri));


   var strings = fileProc.apply(contents);

   strings.removeIf(String::isEmpty);

   return strings;
}
```

Open the File & read its contents into a String

See docs.oracle.com/javase/8/docs/api/java/nio/file/Files.html#readAllBytes

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- Process the contents of a File associated with filename using the Function

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static List<String> processFile
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   var uri = getResourcePathFile(filename);


   String contents = new String(Files.readAllBytes(uri));


   var strings = fileProc.apply(contents);

   strings.removeIf(String::isEmpty);

   return strings;
}
```

Apply the Function to process the File contents & return a List of String objects

See docs.oracle.com/javase/8/docs/api/java/util/function/Function.html#apply

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- Process the contents of a File associated with filename using the Function

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static List<String> processFile
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   var uri = getResourcePathFile(filename);


   String contents = new String(Files.readAllBytes(uri));


   var strings = fileProc.apply(contents);

   strings.removeIf(String::isEmpty);

   return strings;
}
```

Use a Predicate method reference to remove empty String objects in the List

See docs.oracle.com/javase/8/docs/api/java/util/Collection.html#removeIf

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- Process the contents of a File associated with filename using the Function

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  var uri = getResourcePathFile(filename);


  String contents = new String(Files.readAllBytes(uri));


  var strings = fileProc.apply(contents);

  strings.removeIf(String::isEmpty);

  return strings;
}
```

Return the List of non-empty String objects

Obtaining the ThreadJoinTest Program’s Input Data

- Return contents associated w/filename as a List of non-empty String objects

```
static List<String> getInput(String filename, String splitter) {



    return processFile
      (filename,
       content -> Arrays.asList(content.split(splitter)));
}
```

Obtaining the ThreadJoinTest Program's Input Data

- Return contents associated w/filename as a List of non-empty String objects

```
static List<String> getInput(String filename, String splitter) {
```

Identifies the File containing the complete works of Shakespeare

```
  return processFile
    (filename,
     content -> Arrays.asList(content.split(splitter)));
}
```

Obtaining the ThreadJoinTest Program's Input Data

- Return contents associated w/filename as a List of non-empty String objects

```
static List<String> getInput(String filename, String splitter) {

  return processFile
    (filename,
     content -> Arrays.asList(content.split(splitter)));
}
```

This splitter is the '@' character that separates each work of Shakespeare

The '@' character is used as a regular expression to split the File into works

Obtaining the ThreadJoinTest Program’s Input Data

- Return contents associated w/filename as a List of non-empty String objects

```
static List<String> getInput(String filename, String splitter) {




   return processFile
     (filename,
      content -> Arrays.asList(content.split(splitter)));
}
```

Call processFile(), passing a Function that splits the File associated with 'filename' by the 'splitter’ regular expression & returns a List containing the complete works of Shakespeare

See docs.oracle.com/javase/8/docs/api/java/lang/String.html#split

Obtaining the ThreadJoinTest Program's Input Data

- Return phrases associated w/filename as a List of non-empty String objects

```
static List<String> getPhraseList(String filename) {




  return processFile
    (filename,
     content -> Arrays.asList(content.split("\\R")));
}
```

See CS/ThreadJoinTest/src/main/java/utils/BardDataFactory.java

Obtaining the ThreadJoinTest Program’s Input Data

- Return phrases associated w/filename as a List of non-empty String objects

```
static List<String> getPhraseList(String filename) {
```

Identifies the File containing the Bard phrases to search for

```
  return processFile
    (filename,
     content -> Arrays.asList(content.split("\\R")));
}
```

Obtaining the ThreadJoinTest Program's Input Data

- Return phrases associated w/filename as a List of non-empty String objects

```
static List<String> getPhraseList(String filename) {



  return processFile
    (filename,
     content -> Arrays.asList(content.split("\\R")));
}
```

Call processFile(), passing a Function that splits the File associated with 'filename' by the newline regular expression & returns a List containing Bard phrases to search for

Obtaining the ThreadJoinTest Program’s Input Data

- Return phrases associated w/filename as a List of non-empty String objects

```
static List<String> getPhraseList(String filename) {




  return processFile
    (filename,
     content -> Arrays.asList(content.split("\\R")));
}
```

"\\R" is a regular expression that matches any line separator (e.g., "\r", "\n", or "\r\n”)

See docs.oracle.com/javase/8/docs/api/java/util/regex/Pattern.html

Applying BardDataFactory in the ThreadJoinTest Program

Applying BardDataFactory in the ThreadJoinTest Program

- ThreadJoinTest defines static fields that are initialized by BardDataFactory methods

```
public class ThreadJoinTest {
  static final List<String>
    mInputList = BardDataFactory
      .getInput
         (sSHAKESPEARE_DATA_FILE,
          "@");

  static final List<String>
    mPhrasesToFind = BardDataFactory
      .getPhraseList
         (sPHRASE_LIST_FILE);
 ...
}
```

See CS/ThreadJoinTest/src/main/java/ThreadJoinTest.java

Applying BardDataFactory in the ThreadJoinTest Program

- ThreadJoinTest defines static fields that are initialized by BardDataFactory methods

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public class ThreadJoinTest {
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         (sPHRASE_LIST_FILE);
 ...
}
```

A List of the complete works of Shakespeare

Applying BardDataFactory in the ThreadJoinTest Program

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    mPhrasesToFind = BardDataFactory
      .getPhraseList
         (sPHRASE_LIST_FILE);
 ...
}
```

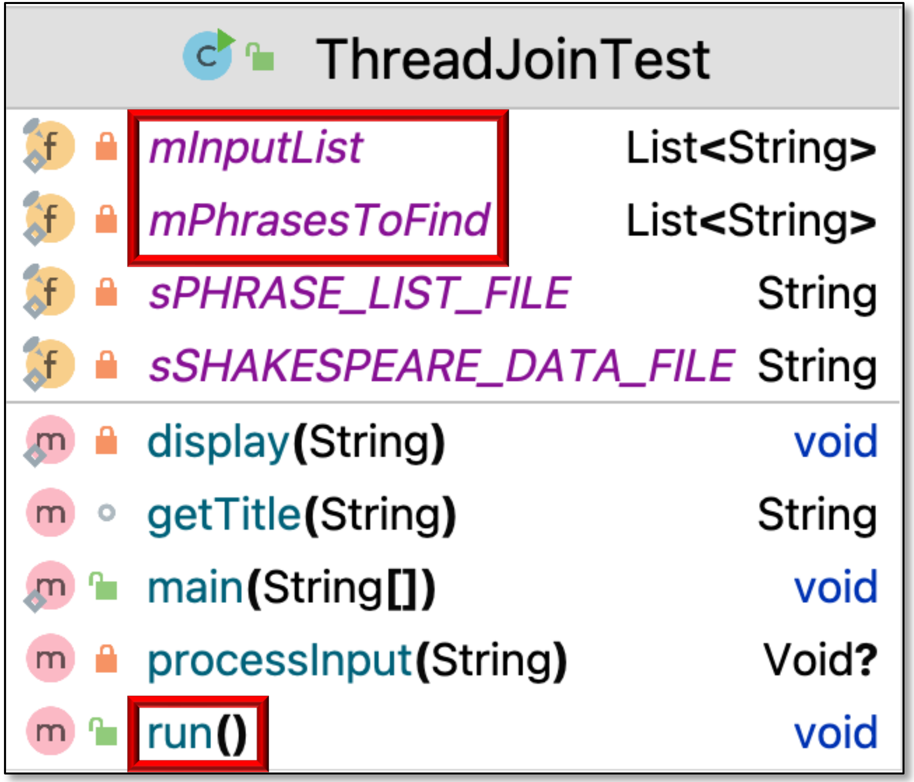
A List of the Bard phrases to search for

Applying BardDataFactory in the ThreadJoinTest Program

- The main program creates & runs an instance of ThreadJoinTest that uses these Lists to guide its processing

```
public void main(String[] a) {
  new ThreadJoinTest().run();
}
```

Create/run an object that searches for all Bard phrases concurrently



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mInputList	List<String>
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See CS/ThreadJoinTest/src/main/java/ThreadJoinTest.java

End of Applying Java Functional Programming Features to the ThreadJoin Test Case Study