Creative Project 0: Search Engine

Full Specification

Overview

This assignment is intended to be a review and warm up for CSE 123. It will require you to use the skills and concepts that you should be familiar with from your prior programming experience. It will also serve as an introduction to your first IDE, Visual Studio Code. This is designed to help everyone review and practice the programming skills that will be necessary to succeed in CSE 123. While we don't necessarily expect everyone to find this assignment *easy*, if you find yourself having major difficulties with any of the content, please contact the course staff to get support!

□□ Learning Objectives

By completing this assignment, students will demonstrate their ability to:

- Write functionally correct Java programs that meet a provided specification using compound data types
- Write functionally correct Java classes to represent new, compound data types
- Identify errors in a Java program's state or behavior, and implement fixes for identified errors

Background

Search engines are powerful tools used to help users find information relevant to their needs among very large sets of documents (most often the World Wide Web). While web-based search engines date back to at least the early 1990s, they become more widely used in the mid-90s as both the size and usage of the Web increased. In 1998, Google launched it's search engine based on the PageRank algorithm and almost immediately became the dominant engine, a status which it maintains to this day, with almost 90% of all web searches taking place on Google.

While search engines are generally very large and complex systems, at their core, they rely on two key operations: *indexing*, which makes the vast amounts of data being searched easier and more efficient to work with; and *ranking*, which tries to identify which results are most relevant to the user. Users interact with a search engine by entering a *query*, or a sequence of words or tokens that represent what they are looking for (such as `best coffee near me` or `wireless headphones` or `British adventure novels`). The query is used to identify relevant documents in the index, which are then presented to the user in order of rank.

In this assignment, you will implement simple versions of the indexing, ranking, and query

operations to build a basic search engine for media (books, movies, etc.).

Assignment Structure

For this assignment, we have broken down the larger problem of building the search engine into a series of smaller problems, each presented on its own coding slide. We recommend you proceed through each slide in sequence, then combine the results you produce together in the primary "Search Engine" slide. However, you are also welcome to complete all your work in the Search Engine slide itself. Regardless of which approach you take, ***be sure to upload all of your code to the Search Engine slide, as only work on that slide will be graded.***

Book

First, we'll need to implement a way to represent the media we'll be searching. We've provided you with an interface called `Media` that can be used to represent many different types of media (movies, songs, books, etc.). You will **write a Java class called `Book` that implements the provided `Media` interface and represents a book.** For books, the artists are considered to be the author(s).

Here is the provided `Media` interface for reference:

▼ Expand

```
import java.util.*;

/**
 * An interface to represent various types of media (movies, books, tv shows, songs, etc.).
 */
public interface Media {

    /**
     * Gets the title of this media.
     *
     * @return      The title of this media.
     */
    public String getTitle();

    /**
     * Gets all artists associated with this media.
     *
     * @return      A list of artists for this media.
     */
    public List<String> getArtists();

    /**
     * Adds a rating to this media.
     *
     * @param score     The score for the new rating. Should be non-negative.
     */
    public void addRating(int score);
```

```
    /**
     * Gets the number of times this media has been rated.
     *
     * @return      The number of ratings for this media.
     */
    public int getNumRatings();

    /**
     * Gets the average (mean) of all ratings for this media.
     *
     * @return      The average (mean) of all ratings for this media.
     *              If no ratings exist, returns 0.
     */
    public double getAverageRating();

    /**
     * Gets all of the content contained in this media.
     *
     * @ returns    The content stored in a List of strings. If there is no content, an empty li
     */
    public List<String> getContent();

    /**
    * Produce a readable string representation. of this media
    *
    * If the media has zero ratings, the format will be:
    * "<title> by [<artists>]"
    *
    * If the media has at least one review, the format will be:
    * "<title> by [<artists>]: <average rating> (<num ratings> ratings)"
    *
    * The average rating displayed will be rounded to at most two decimal places.
    *
    * @ returns     The appropriately formatted string representation
    */
    public String toString();
}
```

Constructors

Your class should have one constructor:

```
public Book(String title, List<String> authors, Scanner content)
```

- Creates a book with the provided title, list of author(s), and content in the given `Scanner`.

The title and author(s) should *not* be able to be modified by a client after creation. The `Scanner` parameter to the constructor should be used to access the content of the book, which is what should be returned by the `getContent` method of the `Media` interface. You should treat each token you read

from the `Scanner` as a single piece of content. (Most likely, this will be the actual words in the book, but you do not need to assume that — just read the tokens from the `Scanner`.)

`toString`

In addition to the methods required by the interface, your `Book` class should include a `toString()` method to produce a readable string representation. If the book has zero ratings, the string representation should be:

```
<title> by [<authors>]
```

If the book has at least one review, the string representation should be:

```
<title> by [<authors>]: <average rating> (<num ratings> ratings)
```

The average rating should be rounded to at most two decimal places *in the string representation only*. (The `getAverageRating` method should return the actual average without rounding.)

`Comparable<Book>`

Finally, your `Book` class should implement the `Comparable<Book>` interface, and you should implement *a comparison algorithm of your choice*. **Your comparison must make use of at least one method or field of the `Book` class**, but can otherwise work in any way you see fit. You may wish to keep in mind that we will ultimately be creating a search engine, so comparing media in a way that the ones most likely to be relevant to a search appear first might be useful, but this is not required (and would be challenging without knowing the search terms).

Inverted Index

Next, we will to create an index for our search engine to use. In particular, we will use an approach called an *inverted index* that maps content to locations where that content can be found. In this case, we will map the content obtained from the `getContent` method of the `Media` interface to each `Media` object that contains that content.

Write a method in the `SearchClient` class called `createIndex` that creates an inverted index for a list of documents. Your method should take one parameter, a list of `Media` objects. Your method should return a map where the keys are individual tokens that appear within each of the `Media` objects (as returned by the `getContent` method) and the values are sets of `Media` objects in which those tokens appear.

Suppose we have a list of `Media` objects `docs` that, when printed out, produce the output:

```
docs = [One by [a1], Two by [a2], Three by [a3]]
```

and where each element contained the following tokens:

```
docs.get(0).getContent() = [Raiders, of, the, Lost, Ark]
docs.get(1).getContent() = [The, Temple, of, Doom]
docs.get(2).getContent() = [The, Last, Crusade]
```

In this case, an inverted index would return the following map:

```
{ark=[One by [a1]], crusade=[Three by [a3]], doom=[Two by [a2]], last=[Three by [a3]],
 lost=[One by [a1]], of=[Two by [a2], One by [a1]], raiders=[One by [a1]],
 temple=[Two by [a2]], the=[Two by [a2], Three by [a3], One by [a1]]}
```

The keys of the returned map should be case-insensitive (i.e. treat "The" and "the" as the same word). The keys of the returned map should be in sorted order, while the sets in the values should prefer fast lookup speed.

Search Queries

Finally, we'll put the pieces together into our simplified search engine by implementing a way to get only the documents that are relevant to a user's search. Write a method in the `SearchClient` class called `search` that takes two parameters: an index in the format created by your `createIndex` method and a String representing the query for the search. Your method should return a set consisting of the media in the index that are relevant to the search query based on *any criteria of your choice*. **Your search criteria must make use of the index somehow**, but can otherwise work in any way you see fit. The set returned from the `search` method should be ordered based on the implementation of the `Comparable` interface in the media classes (e.g. your `Book` class).

Testing Requirements

We have provided an incomplete `Testing.java` file that you should update lines according to the guiding comments within. You should only have to change 12 lines of code within this file so that it compiles and accurately tests your implementations.

> ⚠ **WARNING:** We've provided you a test that checks if your `Testing.java` file compiles and no tests fail. It does not check that the appropriate updates were made according to the comments within the file. It is your responsibility to make sure that you're updating the file correctly.

We recommend reading over this file to better understand how to write JUnit tests. As the quarter progresses, we will be providing you with less testing guidance, so if you have any questions or confusion, it's best to ask them now!

Implementation Guidelines

As always, your code should follow all guidelines in the Code Quality Guide and Commenting Guide. In particular, pay attention to these requirements and hints:

- You should avoid re-implementing the functionality of already existing methods by just calling

those existing methods.
- You should make all of your fields private and you should reduce the number of fields only to those that are necessary for solving the problem.
- Each of your fields should be initialized inside of your constructor(s).
- You should comment your code following the Commenting Guide. You should write comments with basic info (a header comment at the top of your file), a class comment for every class, and a comment for every method other than main.
    - Make sure to avoid including *implementation details* in your comments. In particular, for your object class, a *client* should be able to understand how to use your object effectively by only reading your class and method comments, but your comments should maintain *abstraction* by avoiding implementation details.
- Any additional helper methods created, but not specified in the spec, should be declared ***private***.

Feeling Stuck?

While we expect this assignment to be review, it's still OK if you find this assignment a bit challenging! Remember that learning is a challenging process, and you don't have to do it alone!

- You can visit the Introductory Programming Lab (IPL) to talk with a TA about programming concepts or get help on assignments.
- You can stop by instructor office hours to discuss course concepts or get help on assignments or discuss the course in general.
- You can post questions on the discussion board! You can make questions public (anyone can see them) or private (only course staff can see them). This is a great way to asynchronously get help on an assignment or ask questions about the course.

It is OK to get stuck and feel challenged by this assignment. However, note that this is intended to be a warm-up for the type of programming we will be doing for the rest of the quarter, and the tasks we will be solving in future weeks will be more complex than these problems and rely on a solid grasp of the skills practiced in this assignment. If you feel like you cannot do this assignment at all, we recommend reaching out to the course instructor (cse123-instructors@cs.washington.edu) or the CSE undergrad advisors (ugrad-adviser@cs.washington.edu) to discuss more about academic planning and which programming course might be a good fit for your goals.

Submission

When you are ready to submit, go to the "Final Submission " slide, read the statement and fill in the box, then click "Submit" in the upper-right corner. You may submit as many times as you want until the due date.

You can see your previous submissions by clicking the three dots icon in the upper-right and selecting "Submissions and Grades." By default, we will grade your latest submission from before the deadline. However, if you would like us to grade a different submission, you can select that submission on the

left side of the window and click "Set final." Note that we will not grade any submission made after the deadline-- if you mark a submission after the deadline as final, we will grade your most-recent on-time submission instead.

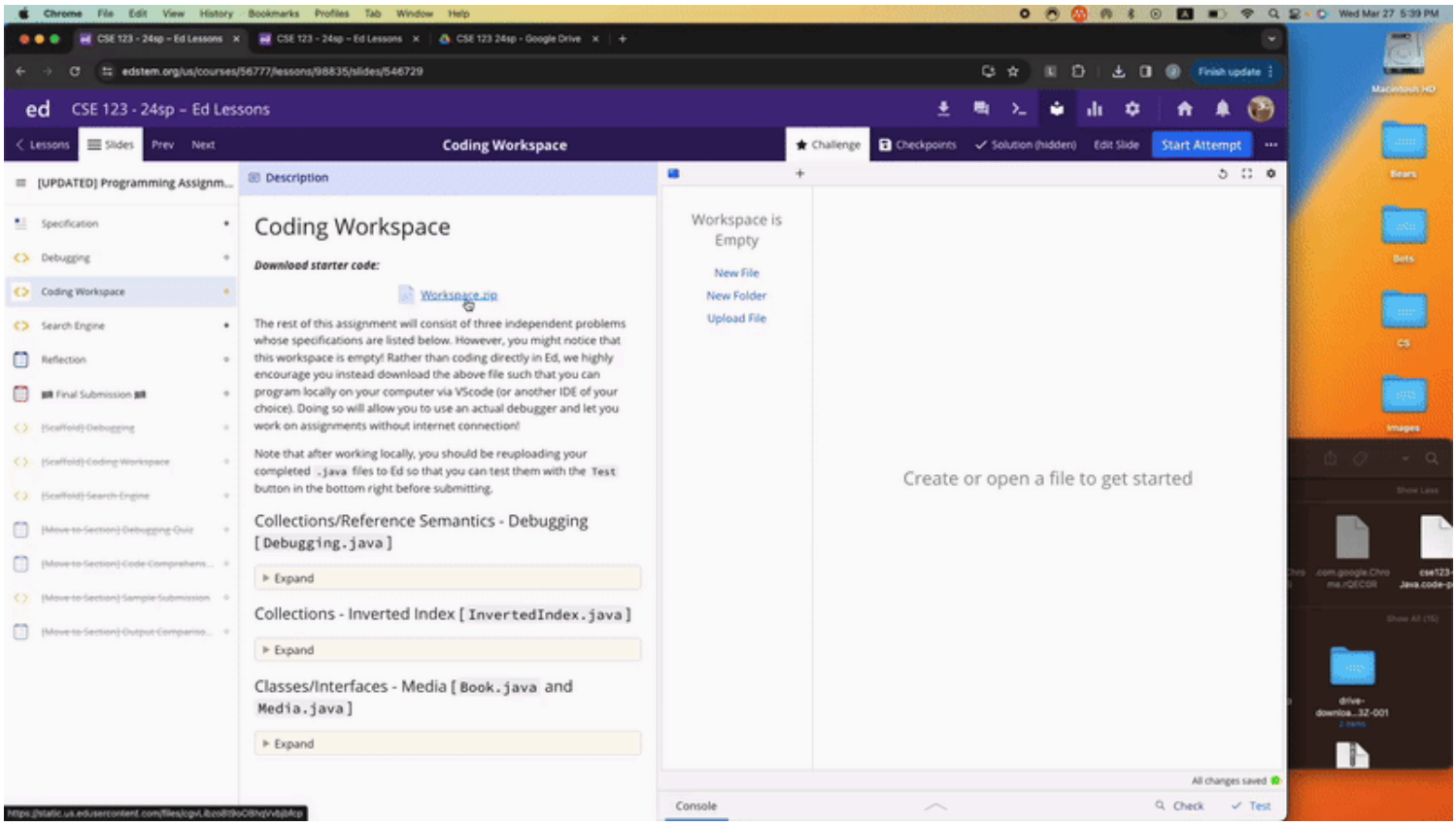
Please make sure you are familiar with the resources and policies outlined in the syllabus and the assignments page.

Recommended Development Process

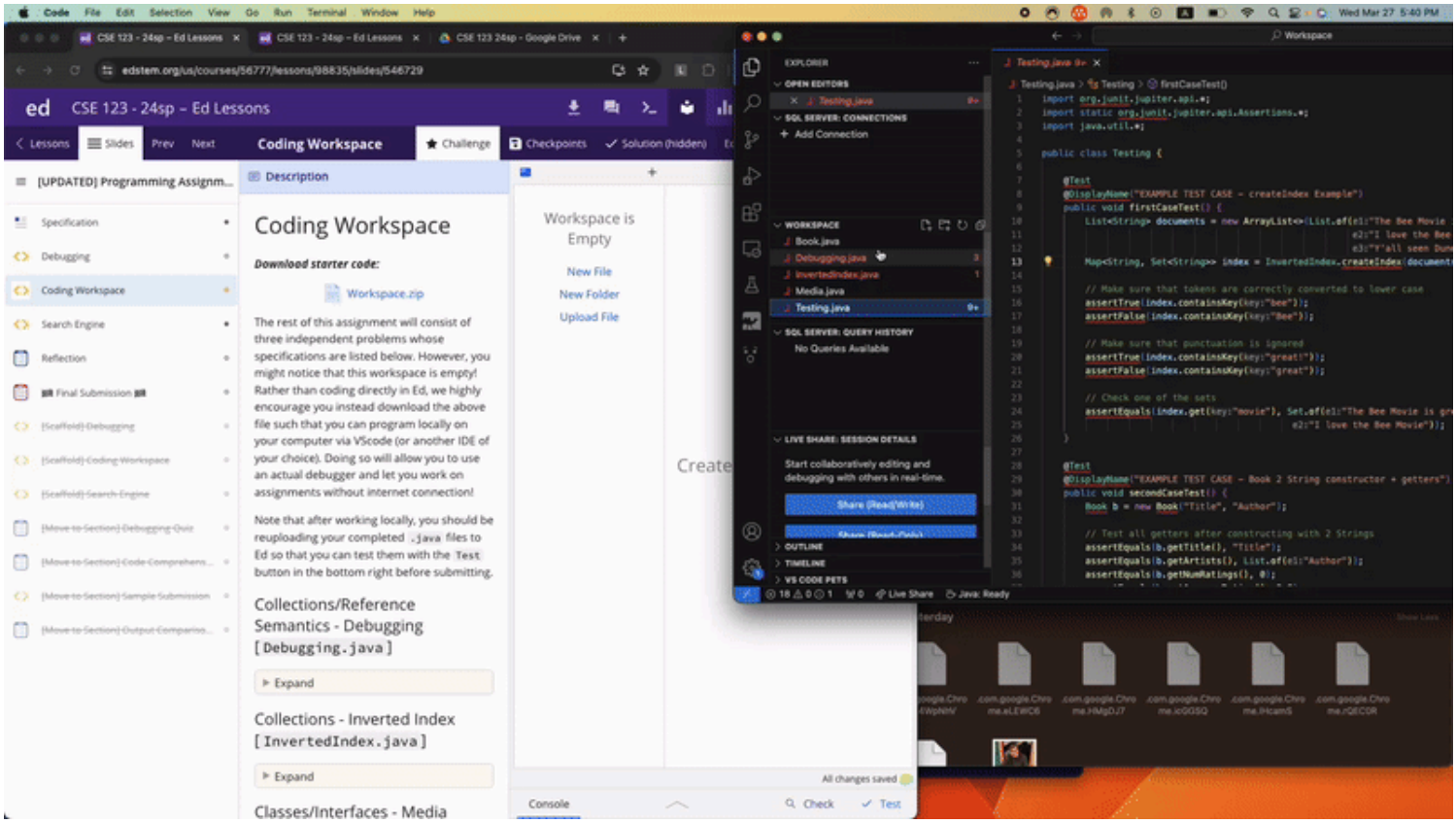
The general process we're expecting you to follow when working on and submitting HW assignments is slightly different from previous courses now that you have an IDE (VSCode)! You should

1. Download the provided `.zip` file
2. Find it in `Finder` / `File Explorer`
3. Unzip it to get the folder with relevant files.
4. In VSCode, click File > Open Folder, and select the recently unzipped folder to open it!

This process is outlined in the following `.gif` (mac shown, but the process would be the same for windows with File Explorer)



Then, once you've finished, you should re-upload your code by copy-pasting or drag-dropping the files back into Ed! At this point you can run tests via the `Test` button.


CSE 123 - 24sp – Ed Lessons
edstem.org/us/courses/56777/lessons/98835/slides/546729
Lessons
Slides
Prev
Next
Coding Workspace
Challenge
Checkpoints
Solution (hidden)
[UPDATED] Programming Assignm...
Specification
Debugging
Coding Workspace
Search Engine
Reflection
Final Submission
Description
Coding Workspace
Download starter code:
Workspace.zip
The rest of this assignment will consist of three independent problems whose specifications are listed below. However, you might notice that this workspace is empty! Rather than coding directly in Ed, we highly encourage you instead download the above file such that you can program locally on your computer via VScode (or another IDE of your choice). Doing so will allow you to use an actual debugger and let you work on assignments without internet connection!
Note that after working locally, you should be reuploading your completed .java files to Ed so that you can test them with the Test button in the bottom right before submitting.
Collections/Reference Semantics - Debugging [Debugging.java]
Expand
Collections - Inverted Index [InvertedIndex.java]
Expand
Classes/Interfaces - Media
Workspace is Empty
New File
New Folder
Upload File
All changes saved
Console
Check
Test
EXPLORER
OPEN EDITORS
SQL SERVER: CONNECTIONS
Add Connection
WORKSPACE
Book.java
Debugging.java
InvertedIndex.java
Media.java
Testing.java
SQL SERVER: QUERY HISTORY
No Queries Available
LIVE SHARE: SESSION DETAILS
Start collaboratively editing and debugging with others in real-time.
Share (Read/Write)
OUTLINE
TIMELINE
VS CODE PETS
Live Share
Java: Ready
Testing.java
import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;
import java.util.*;
public class Testing {
@Test
@DisplayName("EXAMPLE TEST CASE - createIndex Example")
public void firstCaseTest() {
List<String> documents = new ArrayList<>(List.of(e1:"The Bee Movie
e2:"I love the Bee
e3:"Y'all seen Dun
Map<String, Set<String>> index = InvertedIndex.createIndex(document
// Make sure that tokens are correctly converted to lower case
assertTrue(index.containsKey(key:"bee"));
assertFalse(index.containsKey(key:"Bee"));
// Make sure that punctuation is ignored
assertTrue(index.containsKey(key:"great!"));
assertFalse(index.containsKey(key:"great"));
// Check one of the sets
assertEquals(index.get(key:"movie"), Set.of(e1:"The Bee Movie is gr
e2:"I love the Bee Movie"));
}
@Test
@DisplayName("EXAMPLE TEST CASE - Book 2 String constructor + getters")
public void secondCaseTest() {
Book b = new Book("Title", "Author");
// Test all getters after constructing with 2 Strings
assertEquals(b.getTitle(), "Title");
assertEquals(b.getArtists(), List.of(e1:"Author"));
assertEquals(b.getNumRatings(), 0);

[NOT GRADED] Media

❌ This slide is **NOT** graded.

Download starter code:

C0_Media.zip

This is the first of two slides where you will implement the beginning parts of your assignment. However, you might notice that this workspace is empty! Rather than coding directly in Ed, we highly encourage you to instead download the above file such that you can program locally on your computer via VScode (or another IDE of your choice). Doing so will allow you to use an actual debugger and will let you work on assignments without internet connection!

Note that after working locally, you should be reuploading your completed `.java` files to Ed so that you can test them with the `Test` button in the bottom right before submitting.

📖 Book

First, we'll need to implement a way to represent the media we'll be searching. We've provided you with an interface called `Media` that can be used to represent many different types of media (movies, songs, books, etc.). You will **write a Java class called `Book` that implements the provided `Media` interface and represents a book.** For books, the artists are considered to be the author(s).

Here is the provided `Media` interface for reference:

▶ Expand

🏗 Constructors

Your class should have one constructor:

```
public Book(String title, List<String> authors, Scanner content)
```

- Creates a book with the provided title, list of author(s), and content in the given `Scanner`.

The title and author(s) should *not* be able to be modified by a client after creation. The `Scanner` parameter to the constructor should be used to access the content of the book, which is what should be returned by the `getContent` method of the `Media` interface. You should treat each token you read from the `Scanner` as a single piece of content. (Most likely, this will be the actual words in the book, but you do not need to assume that — just read the tokens from the `Scanner`.)

🔒 `toString`

In addition to the methods required by the interface, your `Book` class should include a `toString()` method to produce a readable string representation. If the book has zero ratings, the string representation should be:

```
<title> by [<authors>]
```

If the book has at least one review, the string representation should be:

```
<title> by [<authors>]: <average rating> (<num ratings> ratings)
```

The average rating should be rounded to at most two decimal places *in the string representation only*. (The `getAverageRating` method should return the actual average without rounding.)

🔒 `Comparable<Book>`

Finally, your `Book` class should implement the `Comparable<Book>` interface, and you should implement *a comparison algorithm of your choice*. **Your comparison must make use of at least one method of the `Media` class**, but can otherwise work in any way you see fit. You may wish to keep in mind that we will ultimately be creating a search engine, so comparing media in a way that the ones most likely to be relevant to a search appear first might be useful, but this is not required (and would be challenging without knowing the search terms).

[NOT GRADED] Inverted Index

This slide is **NOT** graded.

Download starter code:

C0_InvertedIndex.zip

To get started, download the zip file above, and paste in your implementation of `Book.java` from the previous slide.

Similarly to the previous slide, rather than coding directly in Ed, we highly encourage you to instead download the above file such that you can program locally on your computer via VScode (or another IDE of your choice). Doing so will allow you to use an actual debugger and will let you work on assignments without internet connection!

Note that after working locally, you should be reuploading your completed `.java` files to Ed so that you can test them with the `Test` button in the bottom right before submitting.

NOTE: The tests for your `createIndex` implementation are tied to a working `Book` implementation. This means that you should be passing all `Book` tests before moving on to implementing `createIndex`!

WARNING: We've noticed that sometimes VSCode will automatically include an import for `javax.print.attribute.standard.Media;`. Please delete this if you notice it present within your `SearchClient.java` file!

Inverted Index

Next, we will to create an index for our search engine to use. In particular, we will use an approach called an *inverted index* that maps content to locations where that content can be found. In this case, we will map the content obtained from the `getContent` method of the `Media` interface to each `Media` object that contains that content.

Write a method in the `InvertedIndex class` called `createIndex` (note: this will eventually go in the `SearchClient.java` file in the graded slide) that creates an inverted index for a list of documents. Your method should take one parameter, a list of `Media` objects. Your method should return a map where the keys are individual tokens that appear within each of the `Media` objects (as returned by the `getContent` method) and the values are sets of `Media` objects in which those tokens appear.

Suppose we have a list of `Media` objects `docs` that, when printed out, produce the output:

```
docs = [One by [a1], Two by [a2], Three by [a3]]
```

and where each element contained the following tokens:

```
docs.get(0).getContent() = [Raiders, of, the, Lost, Ark]
docs.get(1).getContent() = [The, Temple, of, Doom]
docs.get(2).getContent() = [The, Last, Crusade]
```

In this case, an inverted index would return the following map:

```
{ark=[One by [a1]], crusade=[Three by [a3]], doom=[Two by [a2]], last=[Three by [a3]],
 lost=[One by [a1]], of=[Two by [a2], One by [a1]], raiders=[One by [a1]],
 temple=[Two by [a2]], the=[Two by [a2], Three by [a3], One by [a1]]}
```

The keys of the returned map should be case-insensitive (i.e. treat "The" and "the" as the same word). The keys of the returned map should be in sorted order, while the sets in the values should prefer fast lookup speed.

Search Engine

This slide **IS** GRADED.

Download starter code:

C0_SearchEngine.zip

You might notice that this workspace is empty! Rather than coding directly in Ed, we highly encourage you to instead download the above file such that you can program locally on your computer via VScode (or another IDE of your choice). Doing so will allow you to use an actual debugger and will let you work on assignments without internet connection!

Note that after working locally, you should be reuploading your completed `.java` files to Ed so that you can test them with the `Test` button in the bottom right before submitting.

WARNING: We've noticed that sometimes VSCode will automatically include an import for `javax.print.attribute.standard.Media;`. Please delete this if you notice it present within your `SearchClient.java` file!

NOTE: You don't need to worry about reuploading the books directory as it's already included in the scaffold!

Search Queries

Finally, we'll put the pieces together into our simplified search engine by implementing a way to get only the documents that are relevant to a user's search.

Most of the work has been done for you here, but you'll have to integrate your implementations from the helper slides. This will involve 3 main steps:

1. Paste your implementation of `Book` within `Book.java`
2. Paste your implementation of `createIndex` @ line 44

Then, fill in the method in the `SearchClient` class called `search` (located at line 48) that takes two parameters: an index in the format created by your `createIndex` method and a String representing the query for the search.

Your method should return a set consisting of the media in the index that are relevant to the search query based on *any criteria of your choice*. **Your search criteria must make use of the index somehow**, but can otherwise work in any way you see fit. The set returned from the `search` method should be ordered based on the implementation of the `Comparable` interface in the media classes (e.g. your `Book` class).

NOTE: the line numbers might change after pasting in your `createIndex` implementation, but is marked with a "TODO" comment so you can search for within the file

Testing Requirements

We have provided an incomplete `Testing.java` file that you should update lines according to the guiding comments within. You should only have to change 12 lines of code within this file so that it compiles and accurately tests your implementations.

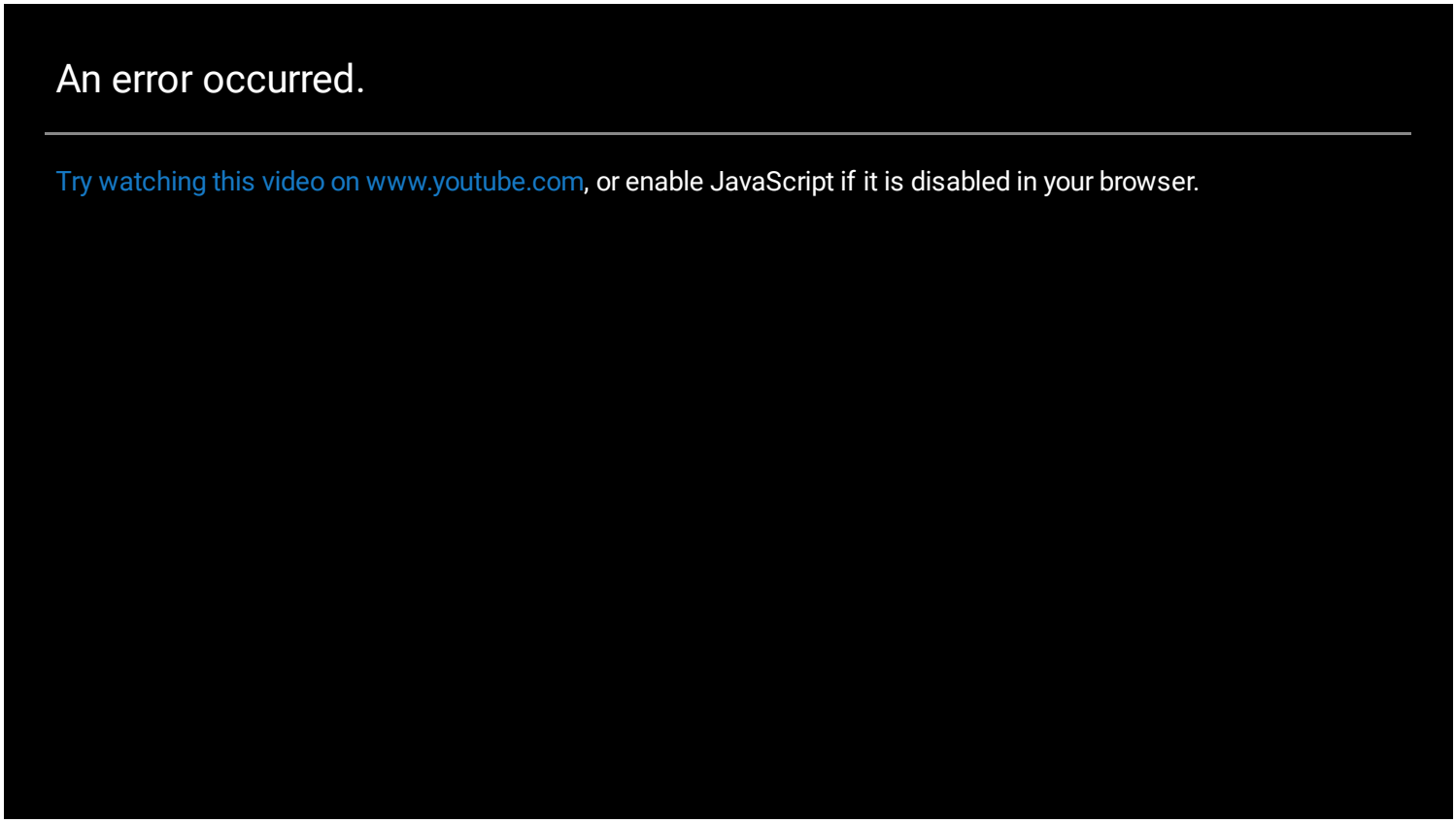
WARNING: We've provided you a test that checks if your `Testing.java` file compiles and no tests fail. It does not check that the appropriate updates were made according to the comments within the file. It is your responsibility to make sure that you're updating the file correctly.

We recommend reading over this file to better understand how to write JUnit tests. As the quarter progresses, we will be providing you with less testing guidance, so if you have any questions or confusion, it's best to ask them now!

Reflection

For this week's reflection, we would like everyone to watch and engage with the following video.

Step 1: Watch The moral bias behind your search results | Andreas Ekström (9m 19s)



Question 1

Step 2: Write your own comment below, responding to one of the following prompts in its entirety:

Prompt 1: At Google, who's responsibility do you think it is to come up with moral rules and judgements surrounding search engine ranking results as described in the video? (Executives, managers, software engineers, other). Do you think that they should have that power / responsibility and why? If not, who do you think should have this responsibility?

Prompt 2: Do you think search engine providers (Google, Bing, etc.) have an obligation to remind their users that "unbiased, clean search results" can't truly exist as mentioned within the video? Why? If you do think so, are they currently acting on that obligation? Why might that be the case?

Prompt 3: How do you feel about the video's claim that software reflects the biases of the programmer? Do you agree / disagree? Why? Give an example of a biased program / application in your day-to-day life.

For full credit, all questions within a prompt must be clearly answered. In particular, we

suggest using the ACE (answer, cite, and explain) format. For a meaningful response, it may be helpful to pose some counterexamples, connect in terms of your own experience, add additional support from course materials, and be as specific as possible in your own reasoning

No response

Question 2

Step 3: The following questions will ask that you practice **metacognition** to reflect on the topics covered on this assignment and your experience completing it. For each question, focus on your plan and/or process for working through the assignment along with the CS concepts. Think about things like how you organized your working time, what sorts of things tended to go wrong, and how you dealt with those errors or mistakes.

What skills did you learn and/or practice with working on this assignment?

No response

Question 3

What did you struggle with most on this assignment?

No response

Question 4

What questions do you still have about the concepts and skills you used in this assignment?

No response

Question 5

About how long (in hours) did you spend on this assignment? (Feel free to estimate, but try to be close.)

No response

Question 6

Was any part of the specification or requirements unclear? If so, which part(s), how was it unclear, and how could it have been made more clear?

No response

Question 7

[OPTIONAL] Do you have any other feedback, questions, or comments about this assignment?

(Note that we may not be able to respond to questions here, so please post on the message board if you would like a response!)

No response

□ Final Submission □

□ Final Submission□

Fill out the box below and click "Submit" in the upper-right corner of the window to submit your work.

Question

I attest that the work I am about to submit is my own and was completed according to the course Academic Honesty and Collaboration policy. If I collaborated with any other students or utilized any outside resources, they are allowed and have been properly cited. If I have any concerns about this policy, I will reach out to the course staff to discuss *before* submitting.

(Type "yes" as your response.)

No response