

# Homework 2: due by 11:59pm on February 14, 2024

(Total: 100 points)

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Commit and push all work to the GitHub repo at <https://classroom.github.com/a/JT-07k0x>. In case of problems committing your files, please contact the teaching staff at [comp322-staff@mailman.rice.edu](mailto:comp322-staff@mailman.rice.edu) before the deadline to get help resolving your issues.

The slip day policy for COMP 322 is similar to that of COMP 321. All students will be given 3 slip days to use throughout the semester. When you use a slip day, you will receive up to 24 additional hours to complete the assignment. You may use these slip days in any way you see fit (3 days on one assignment, 1 day each on 3 assignments, etc.). If you plan to use a slip day, you need to say so in a committed README.md file before the deadline. You should specifically mention how many slip days you plan to use.

Other than slip days, no extensions will be given unless there are exceptional circumstances (such as severe sickness, not because you have too much other work). Such extensions must be requested and approved by the instructor (via e-mail, phone, or in person) before the due date for the assignment. Last minute requests are likely to be denied.

If you see an ambiguity or inconsistency in a question, please seek a clarification on Piazza (remember not to share homework solutions in public posts) or from the teaching staff. If it is not resolved through those channels, you should state the ambiguity/inconsistency that you see, as well as any assumptions that you make to resolve it.

*Honor Code Policy: All submitted homeworks are expected to be the result of your individual effort. You are free to discuss course material and approaches to problems with your other classmates, the teaching assistants and the professor, but you should never misrepresent someone else's work as your own. If you use any material from external sources, you must provide proper attribution.*

## 1 Written Assignments (30 points)

Your solution to the written assignment should be submitted as a PDF file named `hw2_written.pdf` in the `hw2` directory.

### 1.1 Parallelizing the *IsKColorable* Algorithm for Undirected Graphs (25 points)

Consider the pseudo-code of the **IsKColorable** algorithm for undirected graphs shown in Algorithm 1 that you learned in COMP 182. Your assignment is as follows:

- (10 points) Assume that every comparison operator executed in line 4 takes 1 unit of work, and everything else has zero cost. Create a parallel version of this algorithm using `finish` and `async` statements so as to maximize parallelism, while ensuring that the parallel version always computes the same result as the sequential version. You may change data structures (e.g., replace a scalar variable by an array) if needed.
- (5 points) What is the big-O for the total WORK that your algorithm performs?
- (5 points) Assume that every comparison operator executed in line 4 takes 1 unit of work, and everything else has zero cost. Is it possible for your parallel algorithm to have a **larger** value of WORK than the sequential version for a given set of inputs? If so, describe an example when this can happen. If not, explain why not.
- (5 points) Assume that every comparison operator executed in line 4 takes 1 unit of work, and everything else has zero cost. Is it possible for your parallel algorithm to have a **smaller** value of WORK than

the sequential version for a given set of inputs? If so, describe an example when this can happen. If not, explain why not.

5. (5 points) Is it possible for your program to exhibit a data race according to the definition introduced in class? If so, would you consider that data race to be benign?

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### Algorithm 1: IsKColorable

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**Input:** Graph  $g = (V, E)$  and  $k \in \mathbb{N}$ .

**Output:**  $\exists f : V \rightarrow [k], \forall \{u, v\} \in E, f(u) \neq f(v)$ .

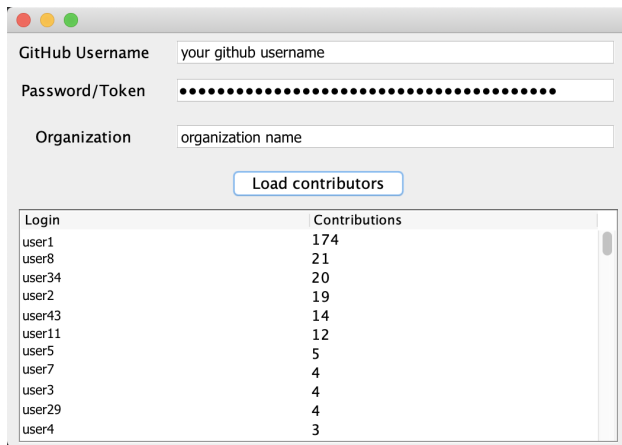
```
1 foreach Assignment  $f$  of a value in  $[k]$  to each node in  $V$  do
2    $colorable \leftarrow True$ ;
3   foreach  $\{u, v\} \in E$  do
4     if  $f(u) = f(v)$  then
5        $colorable \leftarrow False$ ;
6       break;
7   if  $colorable = True$  then
8     return  $True$ ;
9 return  $False$ ;
```

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## 2 GitHub Contributions (70 points)

### 2.1 Introduction

In this assignment, you will implement a concurrent version of a program that fetches and displays all contributors and their total contributions across all repositories under a given organization on GitHub.



The code in your GitHub repository implements a sequential version of this program that causes the user-interface to block when the *Load Contributors* button is clicked. For making the GitHub requests, follow the steps below to generate a token for your account. To test your code, you may find it helpful to use the following organizations that contain sample data:

- revelation
- galaxycats
- moneyspyder

- notch8

Other organizations are provided in the unit tests.

## 2.2 Setup

See the Lab 1 handout for instructions on HJlib installation for use in this homework. The provided code for HW 2 can be found in your GitHub repository at <https://classroom.github.com/a/JT-07k0x>.

You can generate a GitHub developer token at <https://github.com/settings/tokens/new>. Select the repo scope and click Generate Token. Copy and save the token in a safe place.

To start up the program open the main class and click the green arrow to start up the user-interface. Specify your github account username, the token generated above, and an organization from the list above. Click the Load Contributors button to load the data.

## 2.3 Abstract Overhead

Thus far, our abstract metrics have assumed an idealized execution in which there is no overhead in creating *async* or *future* tasks. In the real world, asyncs are not actually free: they consume processor cycles and system memory. In this homework, we will simulate that cost using abstract metrics, and try to implement a parallel algorithm in such a way as to obtain the best work value when taking abstract overheads into account.

## 2.4 Parallel GitHub Contributions

The goal of this assignment is to implement a parallel GitHub contributions program. All requests and processing of the results must be performed concurrently. Your parallel solution must use futures, data-driven tasks, and streams. You should not use `finish` or `async`. All aggregation and post-processing of the results must be performed concurrently using streams.

A correct parallel program should generate the same output as the sequential version, and should not exhibit any data races. It should pass the unit tests provided, and other tests that the teaching staff may use while grading. You are free to add any tests or other code you like under the `main/` and `test/` directories, but please do not modify the folder structure of the project. Be sure to change the `loadContributorsSeq` function call in the `ContributorsUI` class to your `loadContributorsPar` implementation.

For testing, change the username field in the `ContributorsTest` class to your GitHub username and the token field to you GitHub token generated above.

## 2.5 Submitting

To submit, you will need to add, commit, and push all work to the GitHub repository. The repository is located at <https://classroom.github.com/a/JT-07k0x>. Please open a browser, navigate to the url, and verify that you successfully committed your homework. Don't forget to add a `README.md` file if you plan to use slip days.

Your submission should include the following in the `hw2` directory:

1. 50 points for your completed parallel solution that loads and processes all the data concurrently.
2. 5 points for coding style and documentation. We have provided the basic checkstyle rules as part of your Maven project. At a minimum, all code should include basic documentation for each method in each class. You are also welcome to add additional unit tests to test corner cases and ensure the correctness of your implementation.
3. 15 points for a report file formatted as a PDF file named `hw2_report.pdf` in the `hw2` directory. The report should contain the following:
  - (a) A summary of your parallel algorithm, and the steps that you had to take to process the results concurrently.

- (b) An explanation as to why you believe that your implementation is correct and data-race-free.
- (c) An explanation of what value of work (as a function of  $N$ ) you expect to see from your implementation, and why.

*Hints based on common errors/omissions from past years:* Be sure to explain what parallel constructs you used, why, and what subcomputations ran in parallel as a result. Also, justify why you believe that your parallel solution will always produce the same output as the sequential version. In addition, you should explain why there are no data races in your solution. Finally remember to explain what value of work (as a function of  $N$ ) you expect to see from your implementation, and why.