Software Security Assignment

n.2

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1 Part B

Approach

The program was developed in a script-like fashion, since it was very simple:

1. Checks for opening the file
2. Gathering data from the file
3. Printing this data to stdout

In order to improve efficiency, the program was designed from the start to make use of two hash tables. These hash tables would generate intermediary data required to extract all required statistics in the fastest way possible.

An extensive use of Rust's collections and format capabilities improved readability a lot. Hash tables were turned into Vectors that could be efficiently parsed and operated with just a few instructions. For example, the sorting of the statistics was only done at the end of the program, since keeping them into a sorted data structure would not have improved performance.

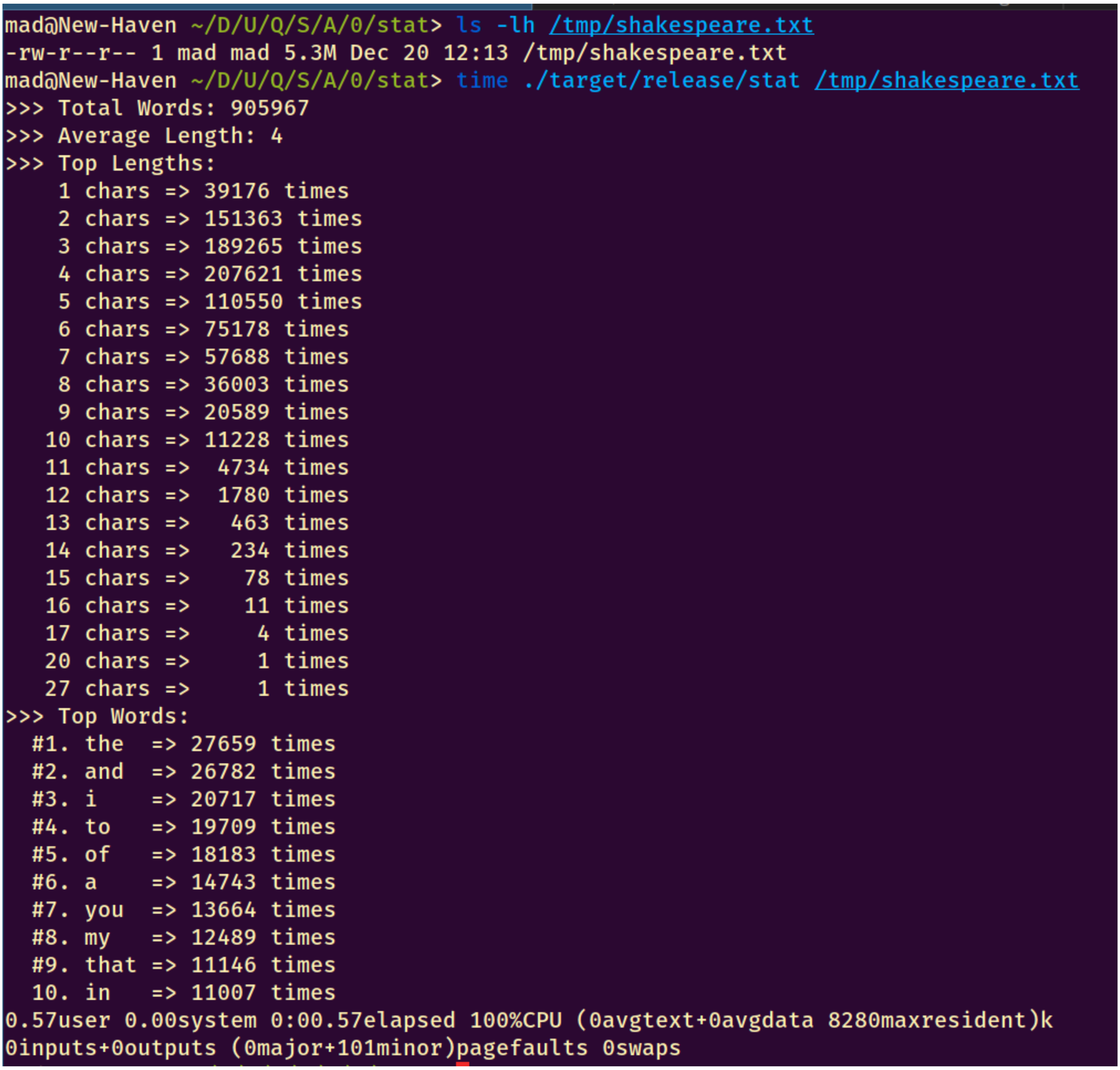
Results

In order to obtained the required data, the following scheme was implemented:

1. obtain dictionary mapping `d_words : word -> #words`
2. obtain dictionary mapping `d_lengths : len -> #words` from `d_words`
3. obtain total number of words from `d_lengths`
4. obtain average word length from `d_lengths`
5. obtain list of word lengths and their quantities from `d_words`
6. obtain 10 most popular words from `d_lengths`

Not only does this approach improve flexibility by allowing to easily display new statistics from the dictionary mappings, but it also improves efficiency by a considerable margin, due to hash table complexity for insertion operations.

To split correctly the sentences into words, and to remove special characters not part of a word, the crate `unicode_segmentation` was used. While this does reduce efficiency compared to `str::split_whitespace()` (the crate uses a tree to index word delimiters), at the same time reliability is gained when dealing with multiple languages or special character stripping. This is because the crate is developed by a Mozilla employee



```
mad@New-Haven ~/D/U/Q/S/A/0/stat> ls -lh /tmp/shakespeare.txt
-rw-r--r-- 1 mad mad 5.3M Dec 20 12:13 /tmp/shakespeare.txt
mad@New-Haven ~/D/U/Q/S/A/0/stat> time ./target/release/stat /tmp/shakespeare.txt
>>> Total Words: 905967
>>> Average Length: 4
>>> Top Lengths:
    1 chars => 39176 times
    2 chars => 151363 times
    3 chars => 189265 times
    4 chars => 207621 times
    5 chars => 110550 times
    6 chars => 75178 times
    7 chars => 57688 times
    8 chars => 36003 times
    9 chars => 20589 times
   10 chars => 11228 times
   11 chars =>  4734 times
   12 chars =>  1780 times
   13 chars =>   463 times
   14 chars =>   234 times
   15 chars =>    78 times
   16 chars =>    11 times
   17 chars =>     4 times
   20 chars =>     1 times
   27 chars =>     1 times
>>> Top Words:
  #1. the   => 27659 times
  #2. and   => 26782 times
  #3. i     => 20717 times
  #4. to    => 19709 times
  #5. of    => 18183 times
  #6. a     => 14743 times
  #7. you   => 13664 times
  #8. my    => 12489 times
  #9. that  => 11146 times
  10. in    => 11007 times
0.57user 0.00system 0:00.57elapsed 100%CPU (0avgtext+0avgdata 8280maxresident)k
0inputs+0outputs (0major+101minor)pagefaults 0swaps
```

Figure 1.1: running stat: the obtained binary was quite efficient

(also the author of all major Unicode packages) and because it implements the official Unicode algorithm mentioned in their annex **UAX29**, so no uncertainty occurs when dealing with words and their boundaries.

It is important to notice that while this Unicode annex does specify word boundaries for many languages, it is unable to do so for the chinese language. This is because not always is it possible to immediatly recognize whether a grapheme is part of a longer word or a word itself. In order to fix this issue, as mentioned by the crate author, some chinese applications implement a separate dictionary containing a chinese dictionary in order to look for words within the text. I feel that this action is out of scope for this assignment, and did not go to such lengths.

Reproducibility Statement

The `Cargo.toml` file contains all required information to normally compile and execute the program using `cargo`.

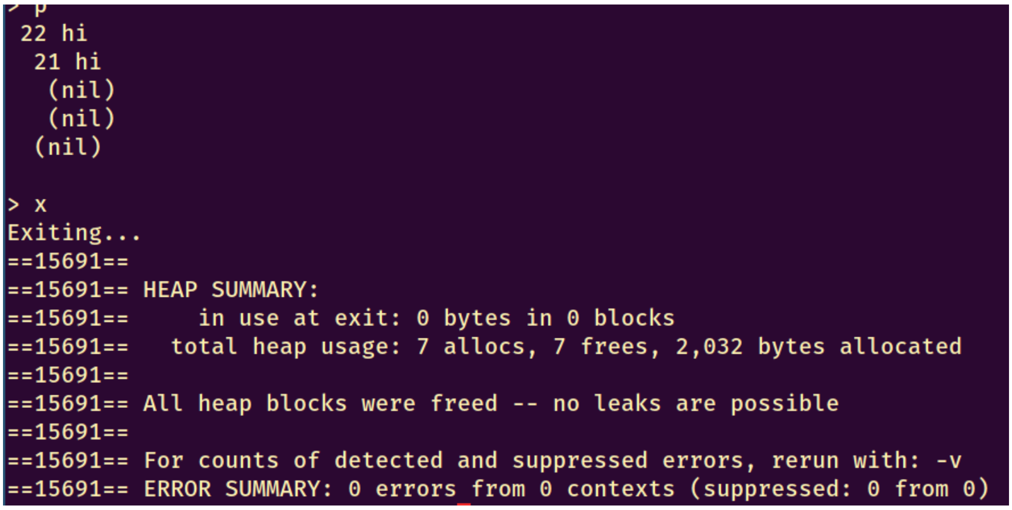
2 Part C

Approach

Due to lack of previous experience using Rust, the program was initially developed within the `main.rs` file and then split into a separate module for the sorted container library. The unit tests for the library were placed inside that file, as is norm in binary crates.

I started by making sure that the main structure of the program was correct, and then proceeded to implement the `struct`s for the sorted container and its nodes. I implemented the traits needed to easily develop some methods, and then moved onto the more difficult and recursive ones: `insert()`, `contains()`, and `erase()`.

Valgrind



```
> p
 22 hi
  21 hi
   (nil)
   (nil)
  (nil)

> x
Exiting...
==15691==
==15691== HEAP SUMMARY:
==15691==     in use at exit: 0 bytes in 0 blocks
==15691==   total heap usage: 7 allocs, 7 frees, 2,032 bytes allocated
==15691==
==15691== All heap blocks were freed -- no leaks are possible
==15691==
==15691== For counts of detected and suppressed errors, rerun with: -v
==15691== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
```

Figure 2.1: valgrind in action: the program does not contain any issues

As can be seen, Rust provides strong safe guarantees after successful compilation and testing. Were the program to execute some careless methods, even then the program would panic at runtime and exploits such as buffer or integer overflows would not be possible!

Results

Inside the main program, some fixes needed to be made to the existing code base and the `unimplemented` macro had to be replaced. The fixes were as follows:

1. The first item of the whitespace-split `input` was accessed directly. In rust, this results in a runtime panic when `input` is an empty string. In order to fix the issue, the existence of that item was checked before using it.
2. Age was not discarded for negative numbers, this was a specification that recently changed for the previous assignment using C.

As for the `sortedcontainer` module, the following steps were taken: 1. Derive *Debug* and ordering traits for the node and tree structures, in order to ease development. 2. Implement *Display* traits for the strcutures, in order to ease development. For the recursive structure, a helper function `fmt_rec()` was used. 3. Implement `new()` methods to ease development. 4. Implement `shallow_cmp()` in order to implement the `insert`, `contains`, and `erase`methods without using the deep comparison `cmp()` which was derived earlier. 5. Implement the main recursive functions, and add unit tests to each of them.

Recursion was used where possible, as suggested be done by the professor in the assignment document.

Checks using `cargo` resulted in code free of errors and successful tests.

Reproducibility Statement

The `Cargo.toml` file contains all required information to normally compile, test, and execute the program using `cargo`. Furthermore, valgrind was tested on the compiled executable using the flags `--leak-check=full --show-leak-kinds=all`.