*Bristol Miller, Shreya Kumar, Corey Vessar*

*bristolnmiller@ksu.edu, shreyak@ksu.edu, coreyvessar@ksu.edu Manhattan, KS 66503*

*PArallelization using three different methods*

Kansas State University: Department of Computer Science

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# Abstract

Implementing programs without parallelization can make even simple solutions quite slow. When reading a larger file and searching it line by line for information, it is necessary to parallelize your program in order to have the most efficient solution. Through our trial of the three different methods of parallelization: OpenMP, MPI, and PThreads, we have found that one method outperforms the others and improves overall timing by an average of (XXX).

# Introduction

A program that we have written reads in a 1.7 GB file, called wiki\_dump.txt, and compares the first two lines, followed by the second and third lines, then the third and fourth lines, and so on, searching for the longest common substring between each pairing and outputting those substrings to a file. The major problem with this program is that it is inefficient.

Initially, we had not implemented any parallelization in order to not complicate the ode. Avoiding parallelization from the start led to our program being very slow. From start to end, accomplishing the tasks of reading in the file and searching for the longest common substrings took (XXX) amount of time. When faced with a heavy task such as reading in a large file and searching through each line of that large file, this can be detrimental if the information is needed quickly. We have solved this problem by parallelizing the program in three different ways, in order to figure out which method provides the quickest way to determine the longest common substrings. These three methods are OpenMP, MPI, and PThreads.

By creating solutions using the OpenMP, MPI, and PThreads methods all separately, we were able to discern which method is the most efficient for this application. Each of the three methods presented a considerable decrease in runtime, and thus a dramatic increase in efficiency. Also, having the comparisons between the three different methods allowed us to make an educated and unbiased decision as to which solution is the best for this specific application. After experimentation with all three methods, we came to the conclusion that the (XXX) method is the best for our program because of (X, Y, and Z).

# Related Work

One could approach this problem in a variety of ways. One such example would be to use a single-threaded implementation. This method would decrease the complexity of such a solution, but the solution would be much slower than our implementations. Usually when you convert a program from single-threaded to multi-threaded, you get a dramatic speedup without too much effort. There is, of course, a balance to strike between the two, though. For some applications, the speed is less important, so it is considered a waste of time to turn the program into a multi-threaded one. On the other hand, there are plenty of scenarios where time is of the essence, and a faster program is valued higher than the effort required to make it so.

Another way to vary the approach of this problem would be to copy the file locally and use that instead of reading it in to memory from a separate location. Approaching with this manner isn’t very spatially effective, but it may produce a speedup as far as timing is concerned. On this note, it also might be more effective to parallelize reading the file in. In our implementation, we simply parallelized the search, rather than our entire program. If we were to read multiple lines into memory at a time, we’re certain that this would be quicker, although it would be more difficult to code.

There are multiple different methods one can use to parallelize their solution. The three that we decided to test were OpenMP, PThreads, and MPI, however, there are more available to programmers. Some of those other methods include OpenACC, OpenCL, and NVIDIA CUDA. For our purposes, we aren’t considering the other methods, although they have their own advantages and drawbacks. CUDA tends to have very high performance, but often requires frequent updates and is expensive. OpenCL may not have as high of performance, but it isn’t very expensive and doesn’t require frequent updates.

# Implementation

MPI is a method that implements message passing, in fact, it’s name is an acronym for Message Passing Interface. In message passing, there are two main functions used: send and receive. Send allows threads communicate with each other. This can be either synchronous or asynchronous. If its synchronous, then it waits for the receive end to send an acknowledgement. On the other hand, if its asynchronous, the message passed from one thread to another can get pushed into a queue, and the thread that sent it can continue about its business. When a thread reaches the receive message, it usually waits, unless there is a message in the queue. When a message is received, we send an acknowledgement.

Our application of MPI found BLAH BLAH BLAH

OpenMP is a different method in which part of your program is single-threaded, while other parts are multi-threaded. The M and P in OpenMP are short for Multi-Processing. This method overall has three different components: a runtime library, environment variables that define the runtime parallel parameters, and directives for the programs. OpenMP is known for its ease of use and portability, while allowing users to standardize and “lean-out” their code.

In our use of OpenMP BLAH BLAH BLAH

PThreads is short for POSIX Threads. It is a method of parallel programming in which the threads are incredibly light-weight and efficient with data exchange. Within this method, there are four main types of functions included in its library. These types are mutexes, condition variables, synchronization between threads using locks and barriers on reads and writes, and thread management techniques including creating and joining threads.

Our use of PThreads More BLAH BLAH BLAH

What we (will do | did): Our Solution

• Another way to look at this section is as a paper, within a paper, describing your implementation. That viewpoint makes this the introduction to the subordinate paper, which should describe the overall structure of your implementation and how it is designed to address the problem effectively.

• Then, describe the structure of the rest of this section, and what each subsection describes.

How our solution (will | does) work

• This is the body of the subordinate paper describing your solution. It may be divided into several subsections as required by the nature of your implementation.

# Evaluation

Our methods for testing involved submitting a variety of jobs to Beocat, Kansas State University’s supercomputer. We chose to run the three different methods, along with our single-threaded implementation as a control, with a combination of (X,Y, and Z) cores with a job size varying from 1000 lines to 1 million lines for comparison. Through these evaluation steps we were able to find that for fewer lines (XXX) performed best, while for more lines (YYY) performed best, and overall the parallelized methods out-performed the single-threaded method.

How we tested our solution

• Performance metrics

• Performance parameters

• Experimental design

How our solution performed, how its performance compared to that of other solutions mentioned in related work, and how these results show that our solution is effective

• Presentation and Interpretation

• Why, how, and to what degree our solution is better

• Why the reader should be impressed with our solution

• Comments

Context and limitations of our solution as required for summation

• What the results do and do not say

# Conclusions & Future Work

We have found that out of the following three methods of parallelization: OpenMP, MPI, and PThreads, (XXX) is the best for our application because of (X, Y, and Z). Thus, when it is necessary to read in a file and search that file for the longest common substrings, we have found one of the most efficient ways to solve the problem.

In the future, one could compare other methods to our findings in this paper. Another way to improve upon our work would be to parallelize the reads, although this would provide only slightly better timing results.

Why the reader should be impressed and/or pleased to have read the paper

• A few sentences about why your solution is valuable, and thus why the reader should be glad to have read the paper and why they should be glad you did this work.

What we will (or could) do next

• Improve our solution

• Apply our solution to harder or more realistic versions of this problem

• Apply our solution or a related solution to a related problem

# Appendix

In this section, we have included copies of our code, along with links to the files on github.

## OpenMP

<https://github.com/shreyakumar1010/cis520-Project4/blob/master/OpenMP/OpenMP.c>

OpenMP Base Code goes here

### OpenMP Shell Script

<https://github.com/shreyakumar1010/cis520-Project4/blob/master/OpenMP/openmp.sh>

Open MP Shell scripts here we can rename the above header to be exactly what it is

## MPI

<https://github.com/shreyakumar1010/cis520-Project4/blob/master/MPI/MPI.c>

Same deal as before

### MPI Shell Script

Same

## PThreads

<https://github.com/shreyakumar1010/cis520-Project4/blob/master/Pthreads/Pthreads.c>

More

### PThreads Shell Script

<https://github.com/shreyakumar1010/cis520-Project4/blob/master/Pthreads/pthread.sh>

And finally more

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