

Thread Pool Implementation in C

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Abstract—This is a short report on our thread pool performance.

I. INTRODUCTION

THREAD is a basic unit of CPU utilization, it consists of program counter, register set, and its own stack. Compared to processes, threads are much more lightweight since virtual memory space remains the same during a thread switch, which is not true for process switch. However, even threads sometimes pose overhead that will affect the performance of the program. Initializing and cleaning threads can pose a certain amount of overhead. For an parallel application that creates and destroys a large number of threads that each only runs for a short time, the thread management mechanism can create unnecessary resource waste. Thread pool can be useful in this type of scenario as it reduces the complexity of thread management and the overhead involved in thread creation and cleaning. The thread pool in implement in **GNU C**.

II. MOTIVATION

We want to be able to implement a thread pool that is convinient to use. We aim to create a provide an interface that is easy for programmers to use. Thus we minimize the number of functions exposed to the programmers to maintain simplicity. We also want the performance of the thread pool to be reasonably more efficient than normal thread-based version. Thus we create several test cases to compare the performances in different implementations. We mainly focused on testing the performance difference in thread-based implementation and Goroutine-based version for certain types of jobs. Finally, we simply want to learn how to implement a thread pool and explore the drawbacks along with possible improvmetns.

There are several goals we are aiming to achieve in the experiment. First, we want to run both long and short tasks in the threal pool to analyze which type of tests have the most impact on the performance on the program. We've created created various tests for the thread pool to perform and we will show the data collected later in the analysis section. We hope the low overhead of switch between tasks will help us outperform thread-based implementation as well go-based implementation. In addition, we implemented work stealing mechanism to improve the work throughput done by the thread pool. We hope the work stealing function will further improve the efficiency of the thread pool.

III. PROGRAMMING INTERFACE

The programming interface is designed for simplicity, there are three functions users are exposed to.

- **void** thread_pool_init(**int** workers ,
 int mutex_flag);

This function initialize a new thread pool. The **workers** attribute specifies the number of threads that can exist in a thread pool. If 0 is passd in, the number of threads will be initialized to the number of core in the execution environment. The **mutex_flag** argument let user decides whether to use mutex or spinlock as synchronization method. Note if the thread pool is initialized more than once, every invocation of this function will be discarded.

- **bool** thread_pool_add(**task_func** *func ,
 void* aux ,
 enum CallType);

This function adds tasks to the thread pool. The **func** attribute represents the function that is to be executed. The **aux** attribute indicates the parameter **func** takes in. the **CallType** specifies whether to use blocking or non-blocking mechanism for the thread pool. If a task is added without failure, *true* is returned. Otherwise, *false* will be returned.

- **void** thread_pool_wait();

This function signifies all threads in thread pool that no more job will be added and the calling function waits for all tasks in the thread pool to finish.

IV. IMPLEMENTATION

The low overhead of the thread pool is acheived with several design decisions. We will discuss the major implementations. A thread pool is first initialized by the main thread and the corresponding number of threads are initialized with their attributes. Each task is represented as a **struct task**. It is created by the calling function whenever the user sends the function to be executed to the thread pool. It is then distributed to the threads in the thread pool in a round-robin style to ensure even distribution. Each thread owns a privat task queue to store all its assigned tasks. Each queue is protected by either a mutex or a spinlock depending on users' specification. However, it is possible that a thread's task queue is empty when it is first initialized. It will waste CPU resource if such task is kept up and running without executing any tasks. Thus, we use semaphore to improve the efficiency of the thread pool. Thus we let the main thread invoking sema_post on each thread once it finishes adding tasks to the thread's task queue to indicate the availability of tasks. However, the thread's task queue can be empty for other reasons. The most important one is that the thread finishes executing all

assigned tasks. Thus, we implement work stealing algorithm to keep the idle thread busy by letting it trying to steal tasks from other threads by randomly choosing one. Since we don't want tasks stealing to create too much overhead as it tries to grab tasks from other threads, we simply let the idle thread using `pthread_mutex_trylock()` or `pthread_spin_trylock()`. If the stealing succeeds, the tasks is grabbed from the victim's task queue and executed. Otherwise, the steal will fail. If the steal fails too many times, that indicates many threads' task queue is already empty and the thread pool is getting close to running out of tasks. In this case, letting more threads trying to steal tasks will create unnecessary overhead, thus the thread will be blocked to prevent wasting resources. If eventually the threads run out of tasks, it will increase `wait_sema` to let the main thread know it finishes its job. If all threads signify that they've finished their tasks, then thread pool is terminated.

V. ANALYSIS

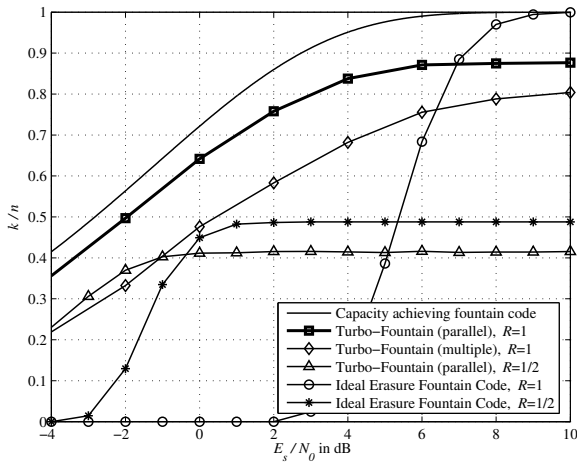


Fig. 1. Simulation results on the AWGN channel. Average throughput k/n vs E_s/N_0 .

VI. FILLING THIS PAGE

Gallia est omnis divisa in partes tres, quarum unam incolunt Belgae, aliam Aquitani, tertiam qui ipsorum lingua Celtae, nostra Galli appellantur. Gallos ab Aquitanis Garumna flumen, a Belgis Matrona et Sequana dividit. Horum omnium fortissimi sunt Belgae, propterea quod a cultu atque humanitate provinciae longissime absunt, minimeque ad eos mercatores saepe commeant atque ea quae ad effeminandos animos pertinent important, proximique sunt Germanis, qui trans Rhenum incolunt, quibuscum continenter bellum gerunt. Qua de causa Helvetii quoque reliquos Gallos virtute praecedunt, quod fere cotidianis proeliis cum Germanis contendunt, cum aut suis finibus eos prohibent aut ipsi in eorum finibus bellum gerunt. Eorum una, pars, quam Gallos obtinere dictum est, initium capit a flumine Rhodano, continetur Garumna flumine, Oceano, finibus Belgarum, attingit etiam ab Sequanis et Helvetiis flumen Rhenum, vergit ad septentriones. Belgae

ab extremis Galliae finibus oriuntur, pertinent ad inferiorem partem fluminis Rheni, spectant in septentrionem et orientem solem.

VII. CONCLUSION

This section summarizes the paper.

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