

# Concurrent Distributed Dynamic Sized Queue

Yunjia Wang (yunjiaw@andrew.cmu.edu)

Jiaan Dai (jiaand@andrew.cmu.edu)

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Project URL: <https://flowersh0026.github.io/618-final/>

## 1 Summary

## 2 Background

## 3 Approach

## 4 Results

### 4.1 Performance Metric and Experimental Setup

We use Google Benchmark library [2] to do the performance measurement. Since the accurate wall-clock time measurement in Google Benchmark requires disabling the CPU frequency scaling, we use the average CPU time for a single thread as an estimate of the wall-clock time. The metric we use for performance comparison is the push and pop operation throughput, which is defined as the number of items being pushed or popped in a second.

We set up the experiments using a Multiple Producer Multiple Consumer (MPMC) framework. In each experiment, we create equal number of producer and consumer threads to repeatedly do the push and pop operations. The number of producer threads is from 1 to 16, and the number of consumer threads is also from 1 to 16. The number of iterations is determined by the Google benchmark library (i.e., the size of inputs, typically varying from 100,000 to 7,000,000). When the benchmark is running, the producer and consumer threads continuously push and pop items to and from the shared concurrent queue. They counts the number of pushed items and popped items separately. On tear-down, it reports the sum of the number of items pushed and items popped, and we will use these two numbers to calculate the push throughput and pop throughput in this

benchmark case. A typical number of pushed and popped items varies from 50,000 to 3,000,000 in our results.

The problem size of our benchmark is the number of concurrent threads, rather than the number of items being pushed and popped. This is because the number of concurrent threads reflects the level of contentions, which is an important factor when benchmarking the performance of a concurrent data structure. Thus, in all results shown below, we use the number of concurrent threads as the x axis. Since the machines we are targeting (the GHC cluster machines, [ghcX.ghc.andrew.cmu.edu](http://ghcX.ghc.andrew.cmu.edu)) have 16-core CPUs, we will run at most 32 threads (considering Intel’s hyper-threading) in each benchmark case, which means that we run at most 16 producer threads and 16 consumer threads at the same time.

## 4.2 Effects of Optimization Techniques

We first compare the effects of two different optimization techniques in our implemented concurrent queues, including using a better memory allocator (jemalloc [3]) and conducting cache line alignment on variables to avoid false sharing. We mainly focus on the results of RTM-based queue and CAS-based queue here.

### 4.2.1 Push Throughput of RtmQueue

First, we shows the comparison of push throughput on RTM-based queue when applying different combinations of optimizations.

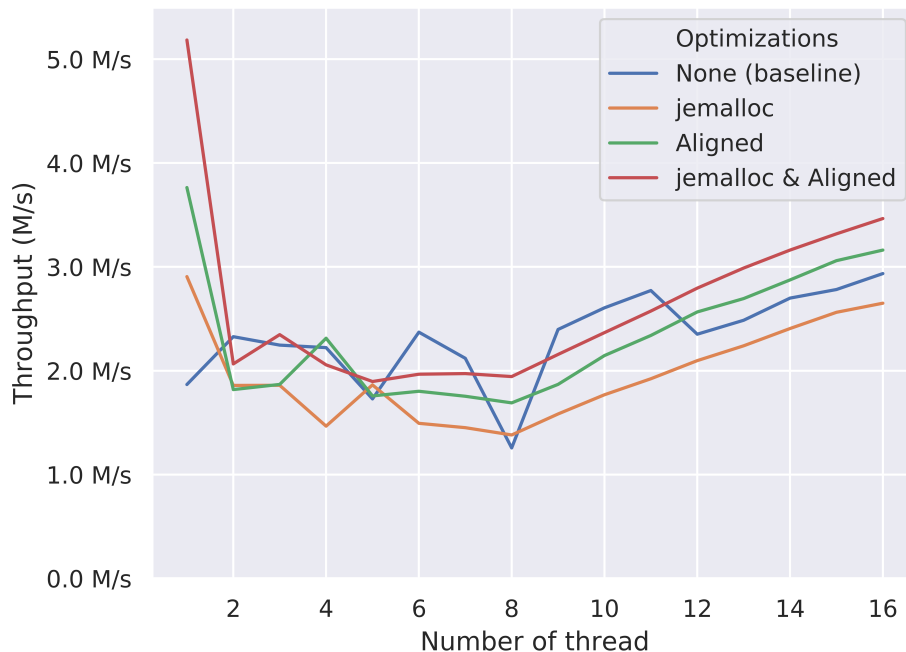


Figure 1: Effects of optimizations (push throughput of RTM-based queue).

We first look at the low-contention region (thread = 1). From the figure, we know that using jemalloc is able to significantly improve the performance of both non-aligned and aligned version. In this scenario, the contention only comes from the consumer when checking an empty queue, if variables are aligned to the cache line, since both producer and consumer will access the same dummy node when the queue is empty. Also, because the producer roughly does nothing between two push operations, the memory allocation may takes non-negligible portions of time. Therefore, using a better memory allocator is able to improve the performance in this scenario.

Cache line alignment brings higher improvement in this low-contention region. From this figure, the “Aligned” version is higher than the “jemalloc” version, showing that this optimization technique has a higher speedup compared with using a better memory allocator. By aligning the variables within the data structure to the cache line (basically the head and tail pointer), it greatly reduces the false sharing between the producer and consumer threads, so significantly improves the performance.

In the high-contention region (thread = 16), the effects are roughly the same, except that the “jemalloc” version performs worse than the baseline non-optimized version. We believe that this is due to the performance variance when false sharing exists. The consistent improvement of the “jemalloc & Aligned” version compared with the “Aligned” version in the region from thread = 5 to thread 16 partially illustrates our explanation.

#### 4.2.2 Pop Throughput of RtmQueue

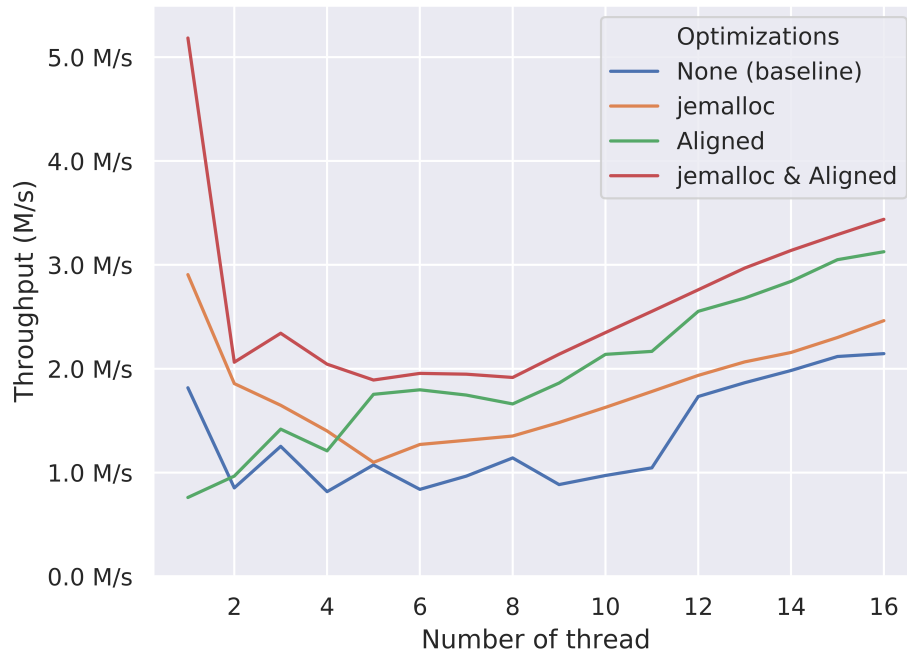


Figure 2: Effects of optimizations (pop throughput of RTM-based queue).

The effects of optimizations on the pop throughput of RTM-based queue are similar. The “jemalloc & Aligned” version uniformly outperforms other poorly optimized versions. However, from the figure, the “Aligned” version performs worse than the baseline version when thread = 1, which is possibly due to the high variance nature of microbenchmark.

### 4.2.3 Push Throughput of CasQueue

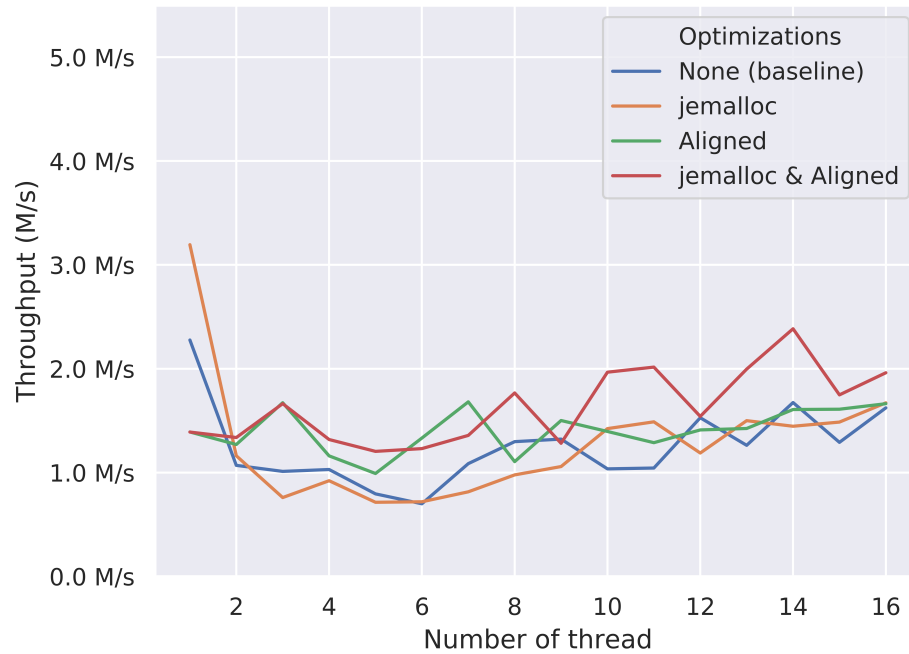


Figure 3: Effects of optimizations (push throughput of CAS-based queue).

#### 4.2.4 Pop Throughput of CasQueue



Figure 4: Effects of optimizations (pop throughput of CAS-based queue).

### 4.3 Performance comparison

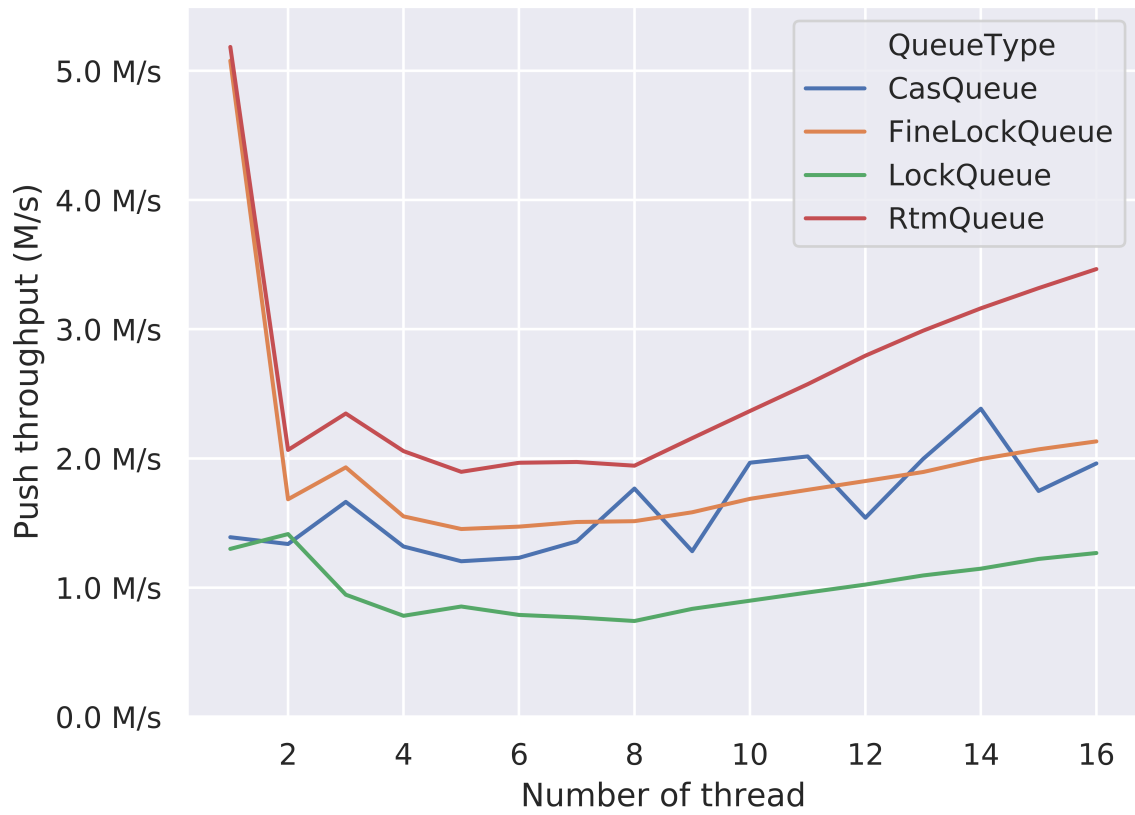


Figure 5: Performance comparison on push operations.

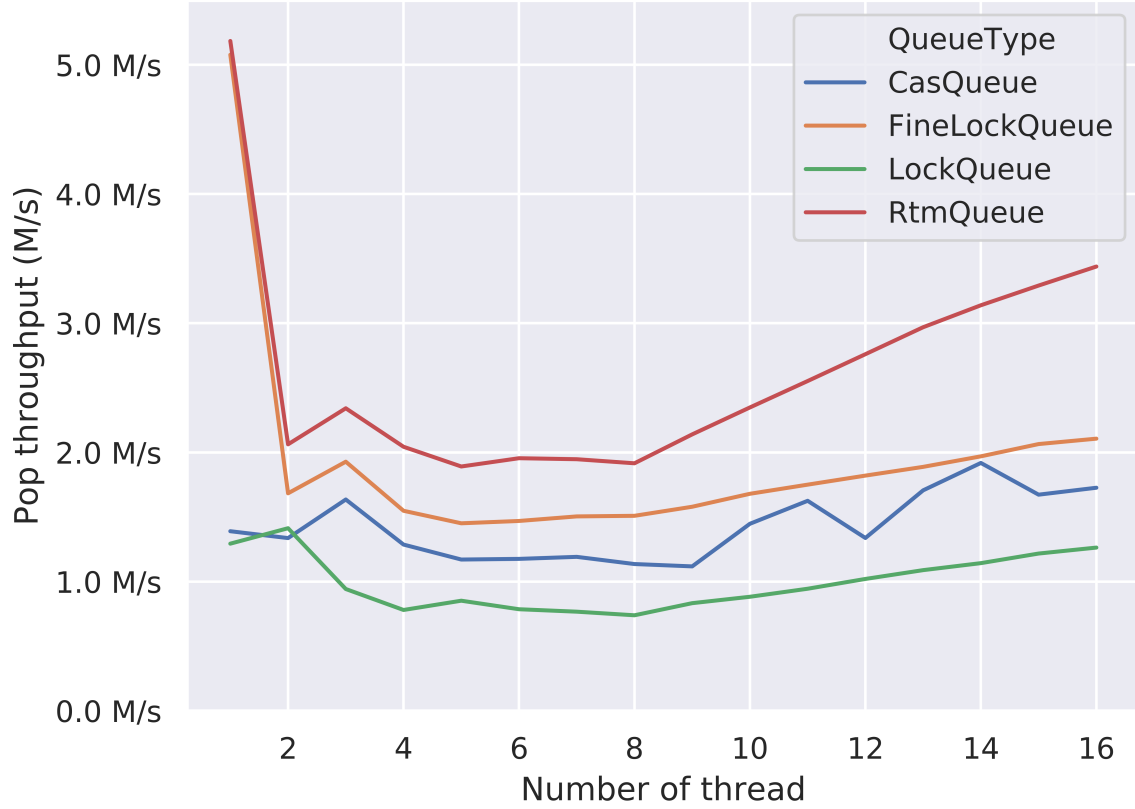


Figure 6: Performance comparison on pop operations.

## 5 References

- [1] Maged M. Michael and Michael L. Scott. 1996. Simple, fast, and practical non-blocking and blocking concurrent queue algorithms. In Proceedings of the fifteenth annual ACM symposium on Principles of distributed computing (PODC '96). ACM, New York, NY, USA, 267-275.
- [2] Google Benchmark library. <https://github.com/google/benchmark/>
- [3] jemalloc. <http://jemalloc.net/>