OS Pthread

Implementation

```
int main(int argc, char** argv) {
    assert(argc == 4);

    int n = atoi(argv[1]);
    std::string input_file_name(argv[2]);
    std::string output_file_name(argv[3]);

    TSQueue<Item*> reader_queue(READER_QUEUE_SIZE);
    TSQueue<Item*> worker_queue(WORKER_QUEUE_SIZE);
    TSQueue<Item*> writer_queue(WRITER_QUEUE_SIZE);
    Transformer transformer;
    // TODO: implements main function
    Reader* reader = new Reader(n, input_file_name, &reader_queue/*,
&reader_finish*/);
    Producer* producer1 = new Producer(&reader_queue, &worker_queue,
&transformer/*, &reader_finish*/);
    Producer* producer2 = new Producer(&reader_queue, &worker_queue,
&transformer/*, &reader_finish*/);
    Producer* producer3 = new Producer(&reader_queue, &worker_queue,
&transformer/*, &reader_finish*/);
    Producer* producer4 = new Producer(&reader_queue, &worker_queue,
&transformer/*, &reader_finish*/);
    Writer* writer = new Writer(n, output_file_name, &writer_queue);
    ConsumerController* consumer_controller = new ConsumerController(
        &worker_queue,
        &writer_queue,
        &transformer,
        CONSUMER_CONTROLLER_LOW_THRESHOLD_PERCENTAGE,
        CONSUMER_CONTROLLER_HIGH_THRESHOLD_PERCENTAGE,
        CONSUMER_CONTROLLER_CHECK_PERIOD
    );
    //std::cout << "define threads" << std::endl;
    reader->start();

    producer1->start();
    producer2->start();
    producer3->start();
    producer4->start();
    consumer_controller->start();
    //./main 200 ./tests/00.in ./tests/00.out

    writer->start();
    //std::cout << "start threads" << std::endl;
    reader->join();
    //std::cout << "reader finish" << std::endl;
    // producer1->join();
```

```
    // std::cout << "producer1 finish" << std::endl;
    // producer2->join();
    // producer3->join();
    // producer4->join();
    // consumer_controller->join();
    //./scripts/verify--output ./tests/00.out--answer ./tests/00.ans
    //std::cout << "consumer_controller finish" << std::endl;
    writer->join();
    //std::cout << "writer finish" << std::endl;
    //std::cout << "threads finish" << std::endl;
    // Clean up resources
    delete reader;
    delete producer1;
    delete producer2;
    delete producer3;
    delete producer4;
    delete consumer_controller;
    delete writer;

    return 0;
}
```

producer

```
void Producer::start() {
    // TODO: starts a Producer thread
    pthread_create(&t, 0, Producer::process, (void*)this);
}

void* Producer::process(void* arg) {
    // TODO: implements the Producer's work
    Producer* producer = (Producer*)arg;

    while(true) {
    Item * item = producer->input_queue->dequeue();
    item->val = producer->transformer->producer_transform(item->opcode, item-
>val);
    producer->worker_queue->enqueue(item);
    }
    return nullptr;
}
```

consumer_controller

```
void ConsumerController::start() {
    // TODO: starts a ConsumerController thread
    pthread_create(&t, 0, ConsumerController::process, (void*)this);
}
```

```
void* ConsumerController::process(void* arg) {
    // Cast the argument to ConsumerController
    ConsumerController* controller = static_cast<ConsumerController*>(arg);
    while (true) {
        // Get the current size of the worker queue
        int worker_queue_size = controller->worker_queue->get_size();
        if (worker_queue_size > controller->worker_queue->buffer_size *
controller->high_threshold / 100){
            // Add a new consumer
            Consumer* new_consumer = new Consumer(
                controller->worker_queue,
                controller->writer_queue,
                controller->transformer
            );

            new_consumer->start(); // Start the consumer thread
            controller->consumers.push_back(new_consumer);

            std::cout << "Scaling up consumers from "<< controller-
>consumers.size() - 1 <<  " to " << controller->consumers.size() << std::endl;
        }
        // Scale down consumers if the worker queue falls below the low threshold
        else if (worker_queue_size < controller->worker_queue->buffer_size *
controller->low_threshold / 100 && controller->consumers.size() > 1) {
            // Remove the most recently added consumer
            Consumer* last_consumer = controller->consumers.back();
            last_consumer->cancel(); // Cancel the consumer thread
            last_consumer->join();   // Wait for the thread to finish
            //delete last_consumer;    // Free memory

            controller->consumers.pop_back();
            std::cout << "Scaling down consumers from "<< controller-
>consumers.size() + 1 <<  " to " << controller->consumers.size() << std::endl;

        }

        // Ensure there is always at least one consumer


        // Sleep for the check period
        usleep(controller->check_period);
    }
    return nullptr;
}
```

consumer

```
void Consumer::start() {
    // TODO: starts a Consumer thread
    pthread_create(&t, 0, Consumer::process, (void*)this);
```

```
}

int Consumer::cancel() {
    is_cancel = true;
    return 0;
}

void* Consumer::process(void* arg) {
    Consumer* consumer = (Consumer*)arg;
    pthread_setcanceltype(PTHREAD_CANCEL_DEFERRED, nullptr);
    while (!consumer->is_cancel) {
        // TODO: implements the Consumer's work
        pthread_setcancelstate(PTHREAD_CANCEL_DISABLE, nullptr);
        Item *item = consumer->worker_queue->dequeue();
        item->val = consumer->transformer->consumer_transform(item->opcode, item-
>val);
        consumer->output_queue->enqueue(item);
        pthread_setcancelstate(PTHREAD_CANCEL_ENABLE, nullptr);
    }
    delete consumer;
    return nullptr;
}
```

writer

```
void Writer::start() {
    // TODO: starts a Writer thread
    pthread_create(&t, 0, Writer::process, (void*)this);
}

void* Writer::process(void* arg) {
    // TODO: implements the Writer's work
    Writer* writer = (Writer*)arg;
    while(writer->expected_lines--){
        Item* item = writer->output_queue->dequeue();
        writer->ofs << *item;
        delete item;
    }
    return nullptr;
}
```

Experiment

Different values of CONSUMER_CONTROLLER_CHECK_PERIOD

Discussion

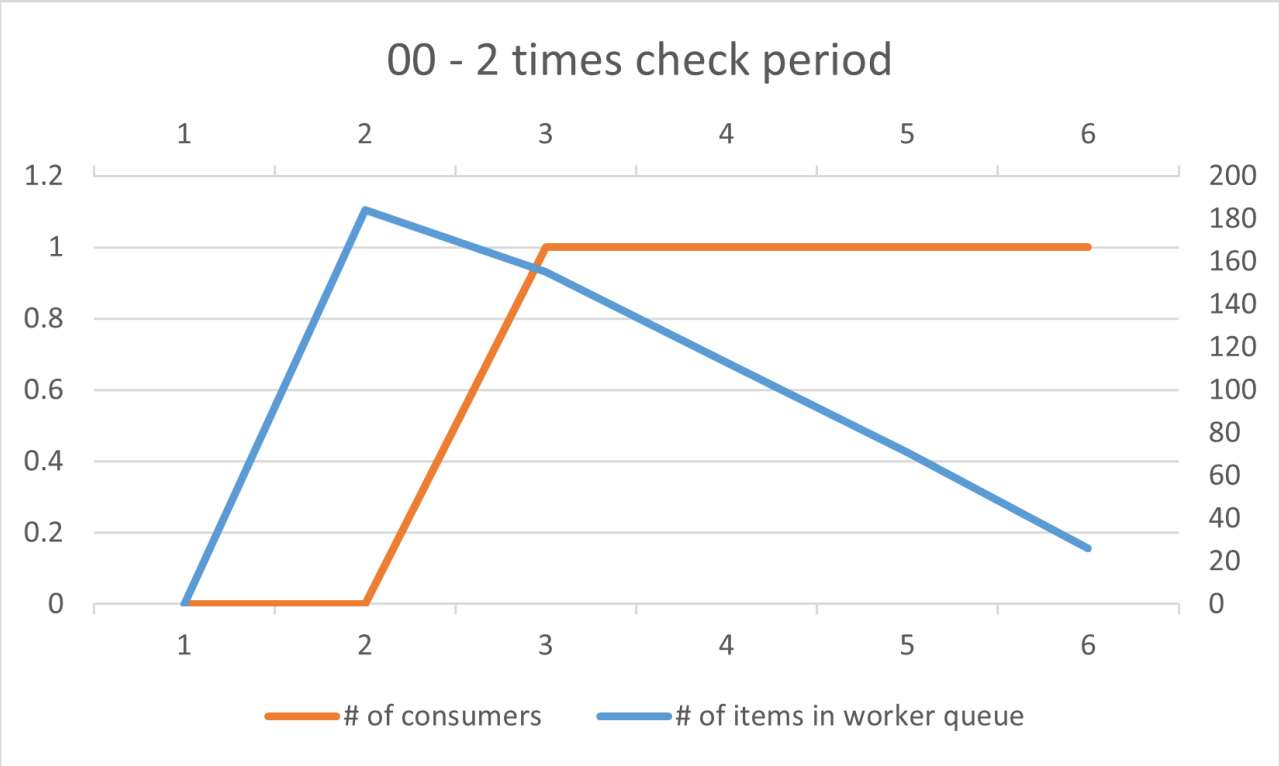
減少 check period time 可以更及時的分配資源，因此可以增快執行速度，但是太過頻繁的檢查並調度也會花費更多的時間，因此可以在 test 01 1/10 times check period 的測試中看到，其執行速度沒有比 1/2 times check

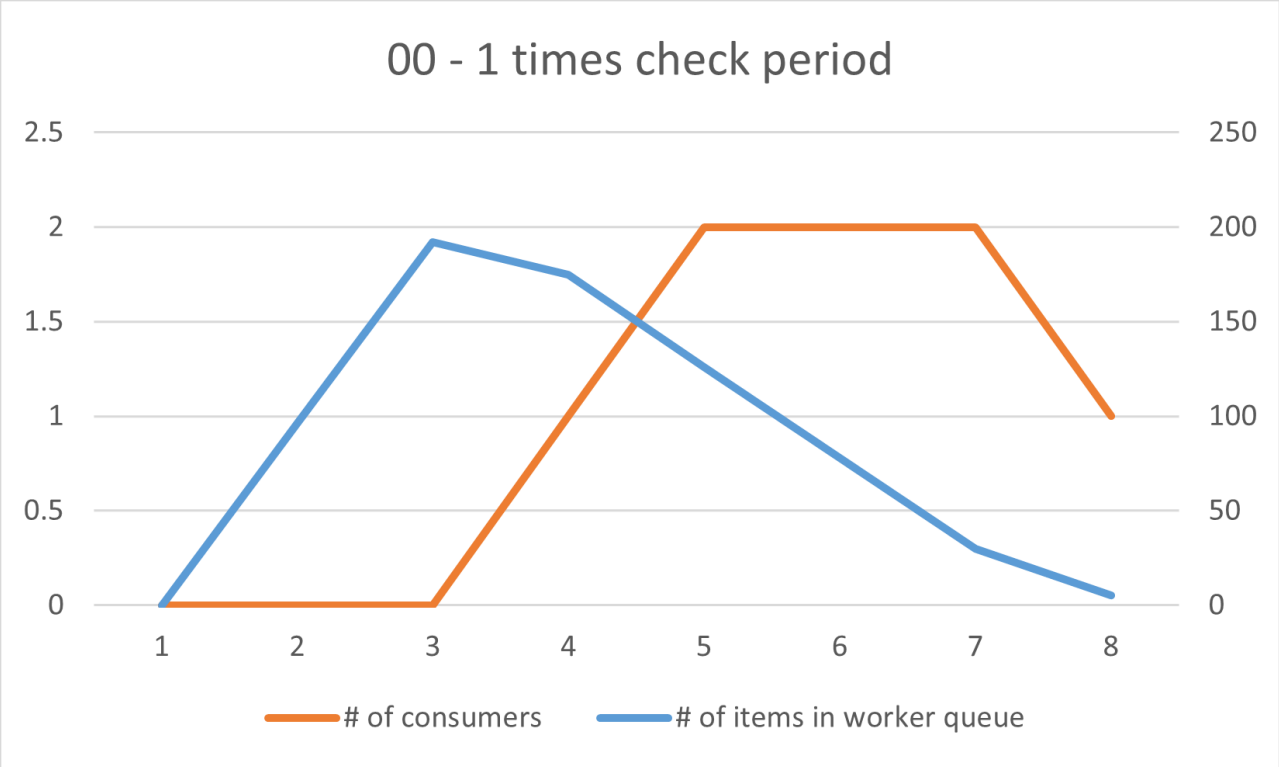
period 的速度更快，因此 check period time 應該是有一個最佳表現區間，太大或太小都會導致執行速度低落。

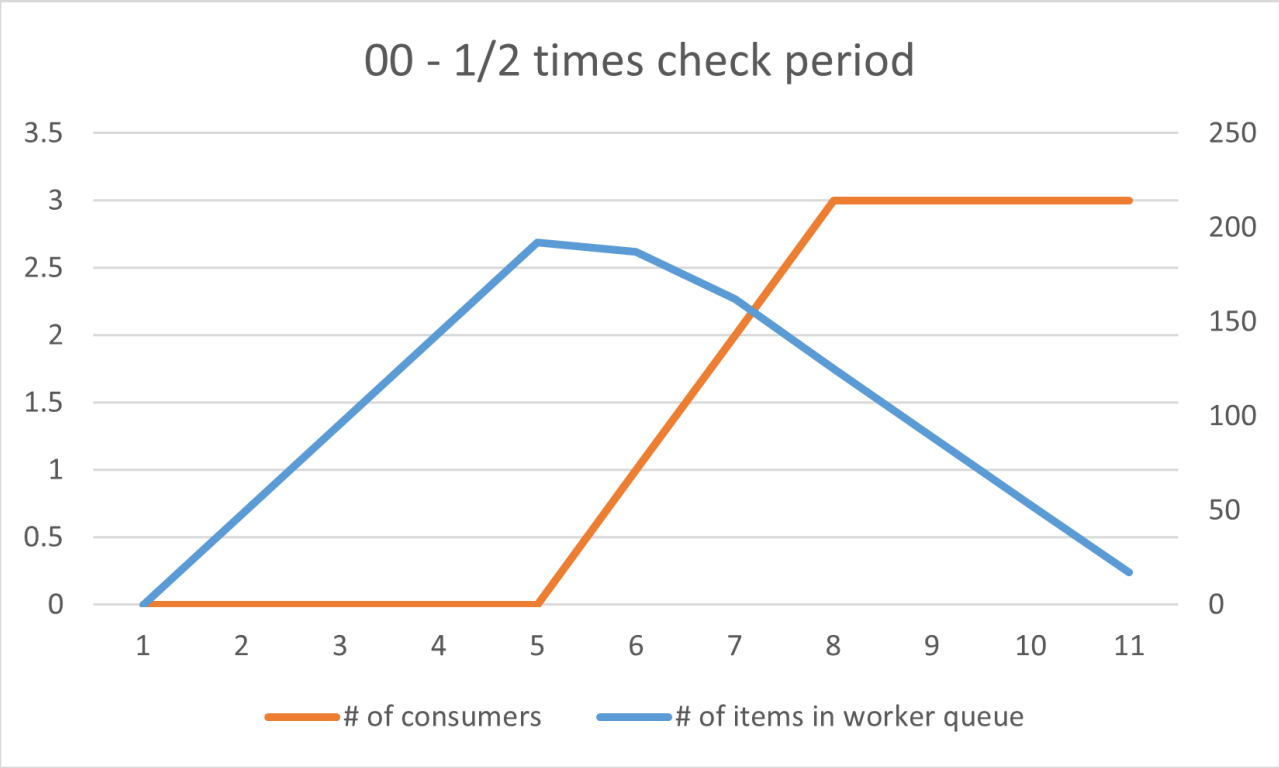
Result

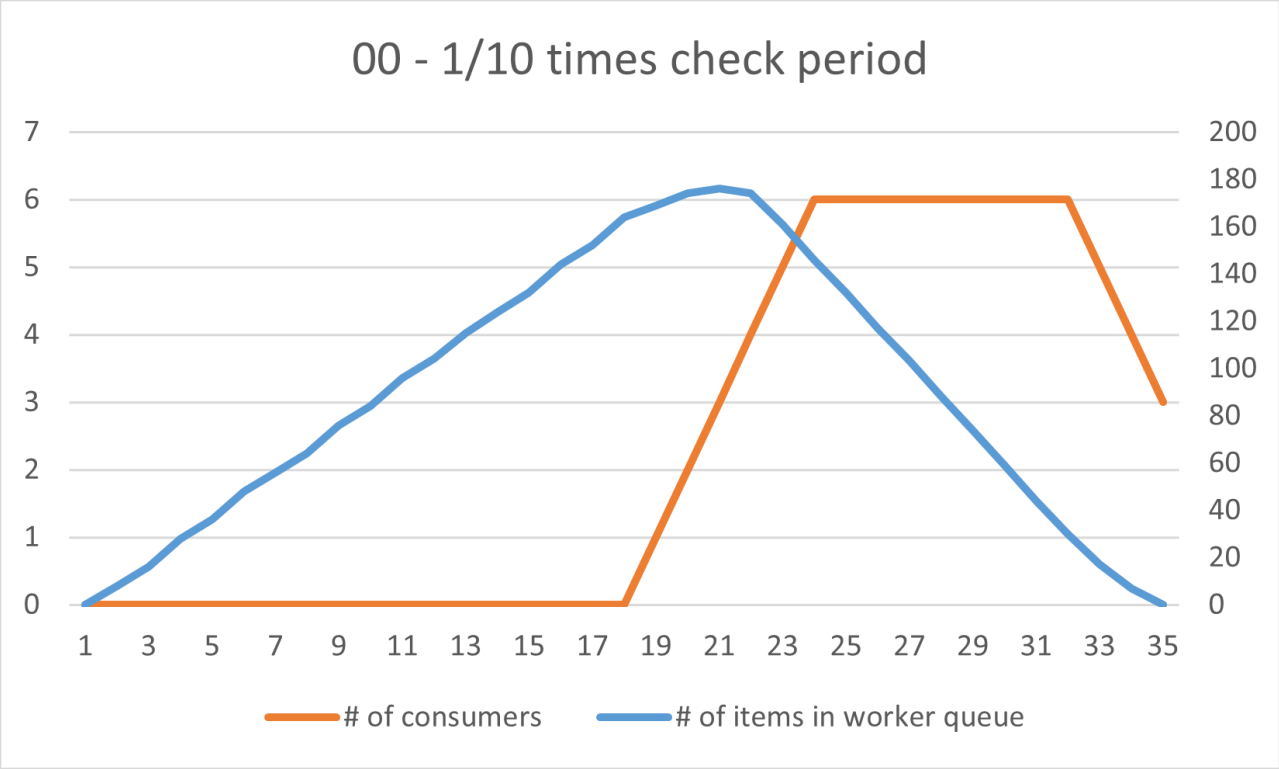
- **test 00**

Check period	Runtime
2 times	11.1133
1 times	7.25883
1/2 times	5.39247
1/10 times	3.46049


00 - 2 times check period
1 2 3 4 5 6
1.2 1 0.8 0.6 0.4 0.2 0
200 180 160 140 120 100 80 60 40 20 0
1 2 3 4 5 6
# of consumers
# of items in worker queue

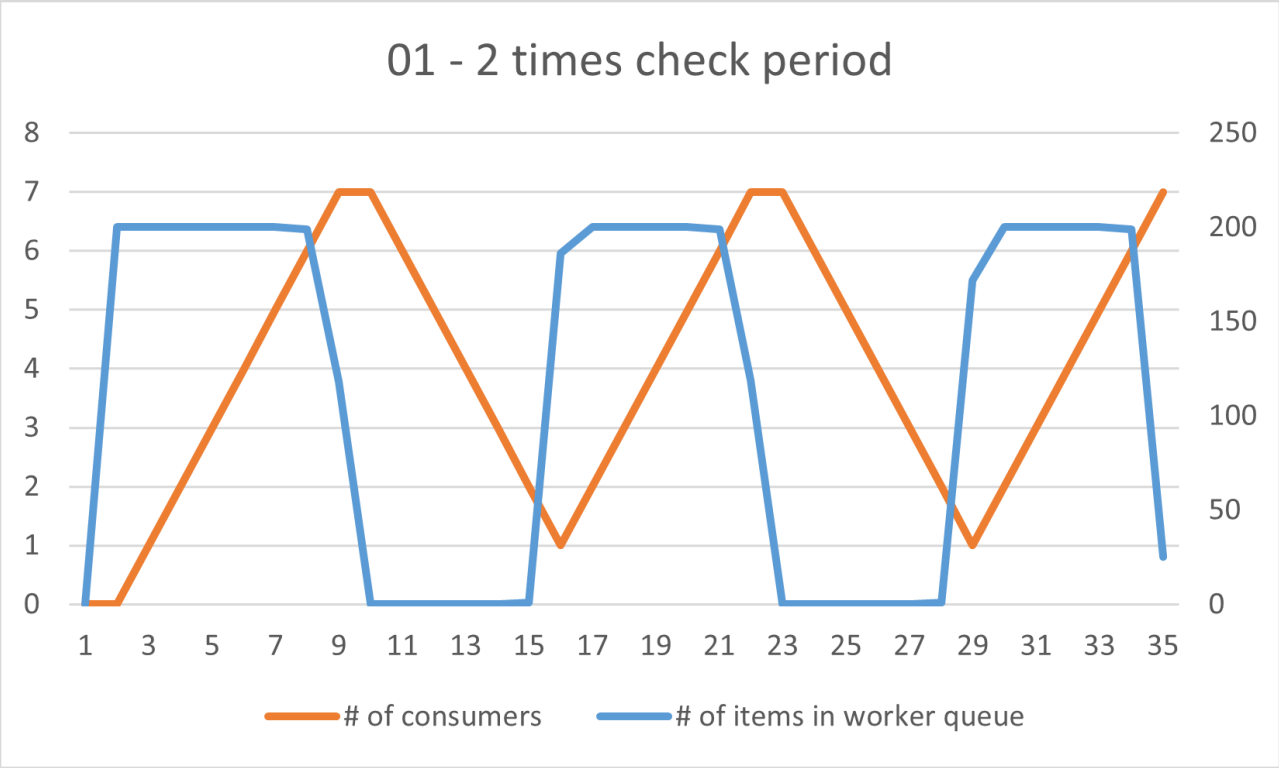

00 - 1 times check period
2.5 2 1.5 1 0.5 0
250 200 150 100 50 0
1 2 3 4 5 6 7 8
# of consumers
# of items in worker queue

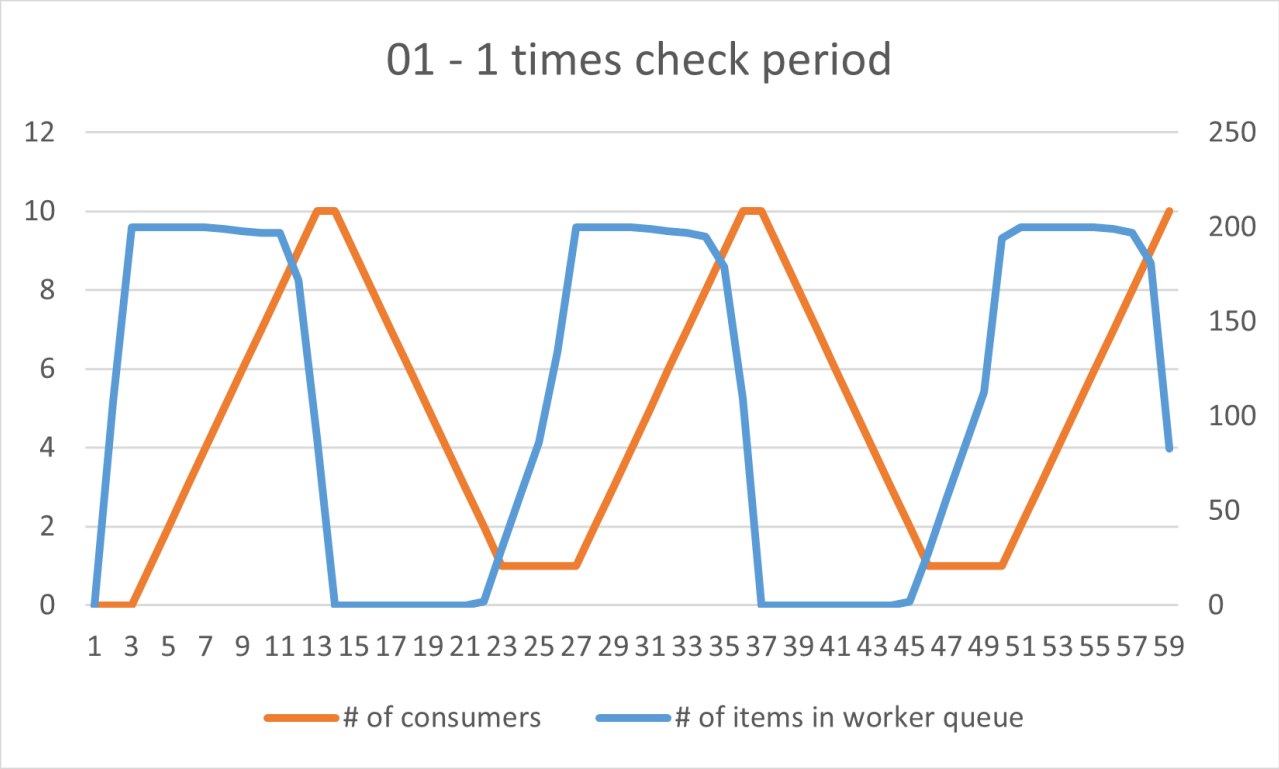


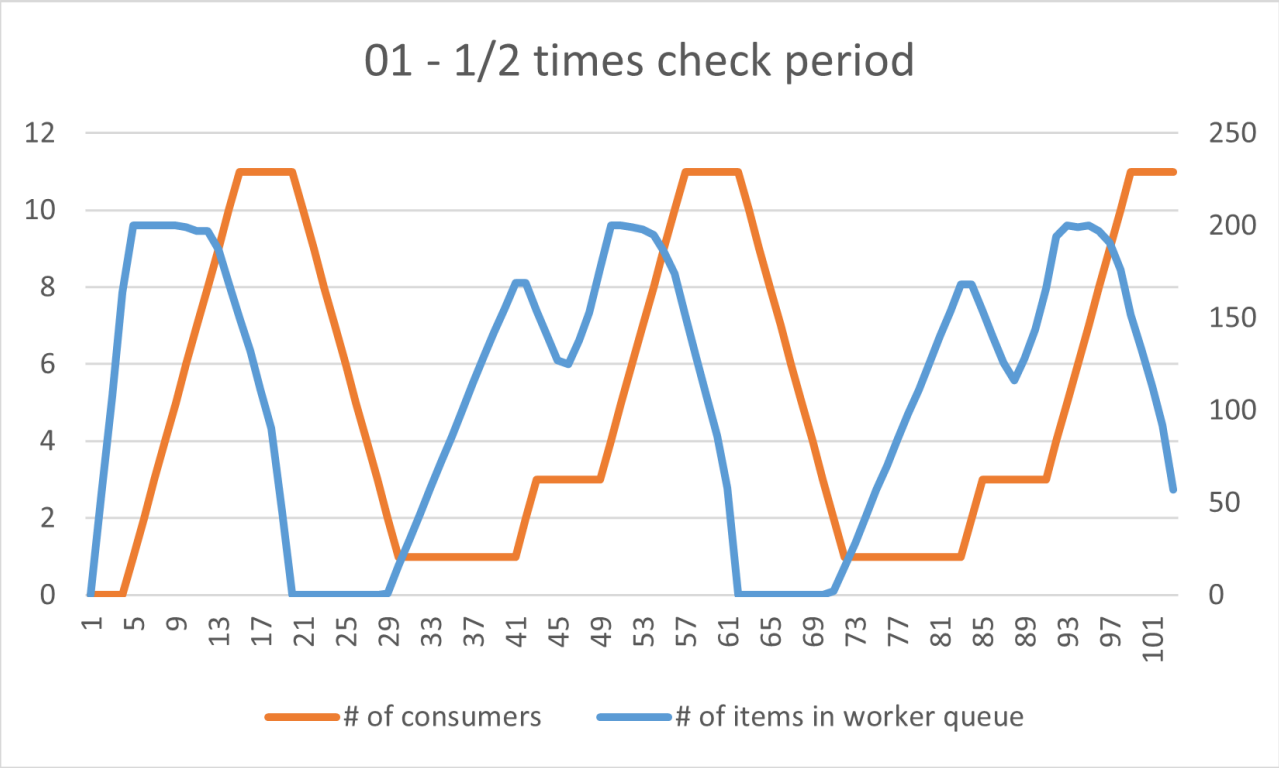


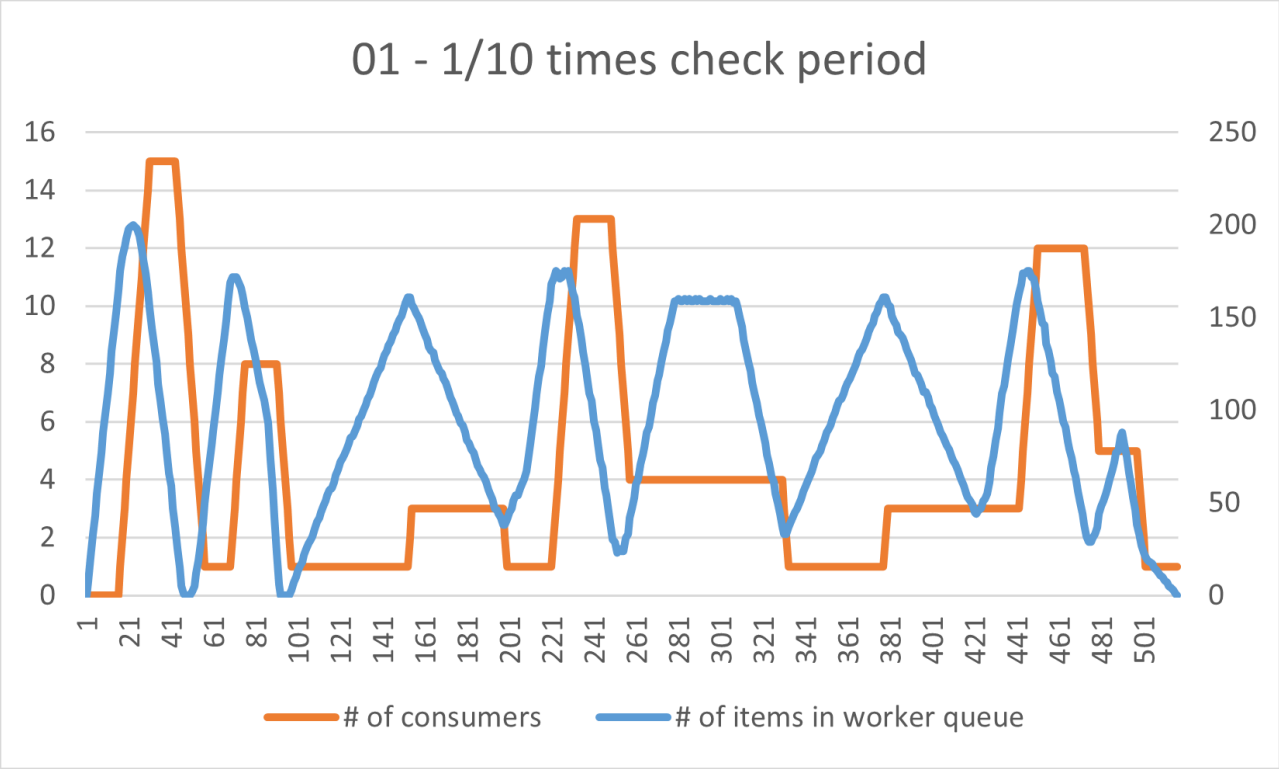
- **test 01**

Check period	Runtime
2 times	68.8665
1 times	59.7507
1/2 times	52.8105
1/10 times	52.8789


01 - 2 times check period
8
7
6
5
4
3
2
1
0
250
200
150
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
# of consumers
# of items in worker queue


01 - 1 times check period
12
10
8
6
4
2
0
250
200
150
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
# of consumers
# of items in worker queue





Different values of CONSUMER_CONTROLLER_LOW_THRESHOLD_PERCENTAGE and CONSUMER_CONTROLLER_HIGH_THRESHOLD_PERCENTAGE

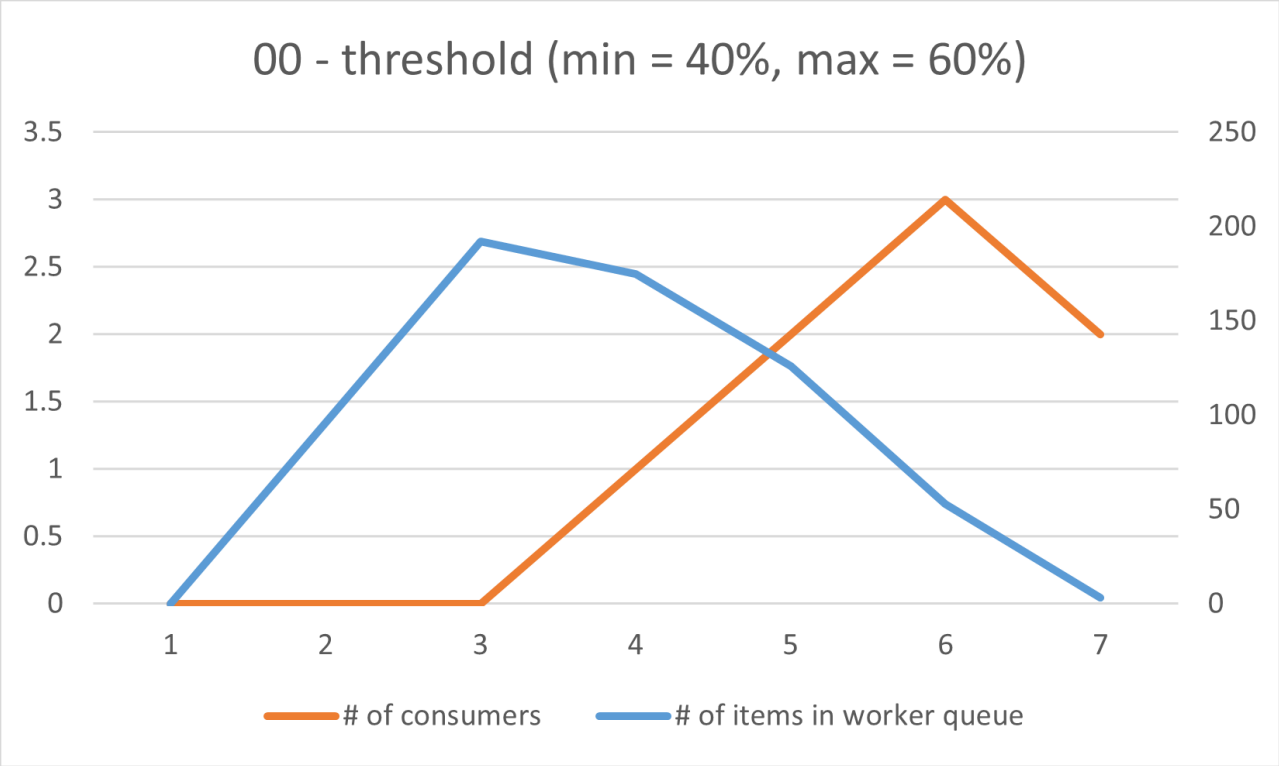
Discussion

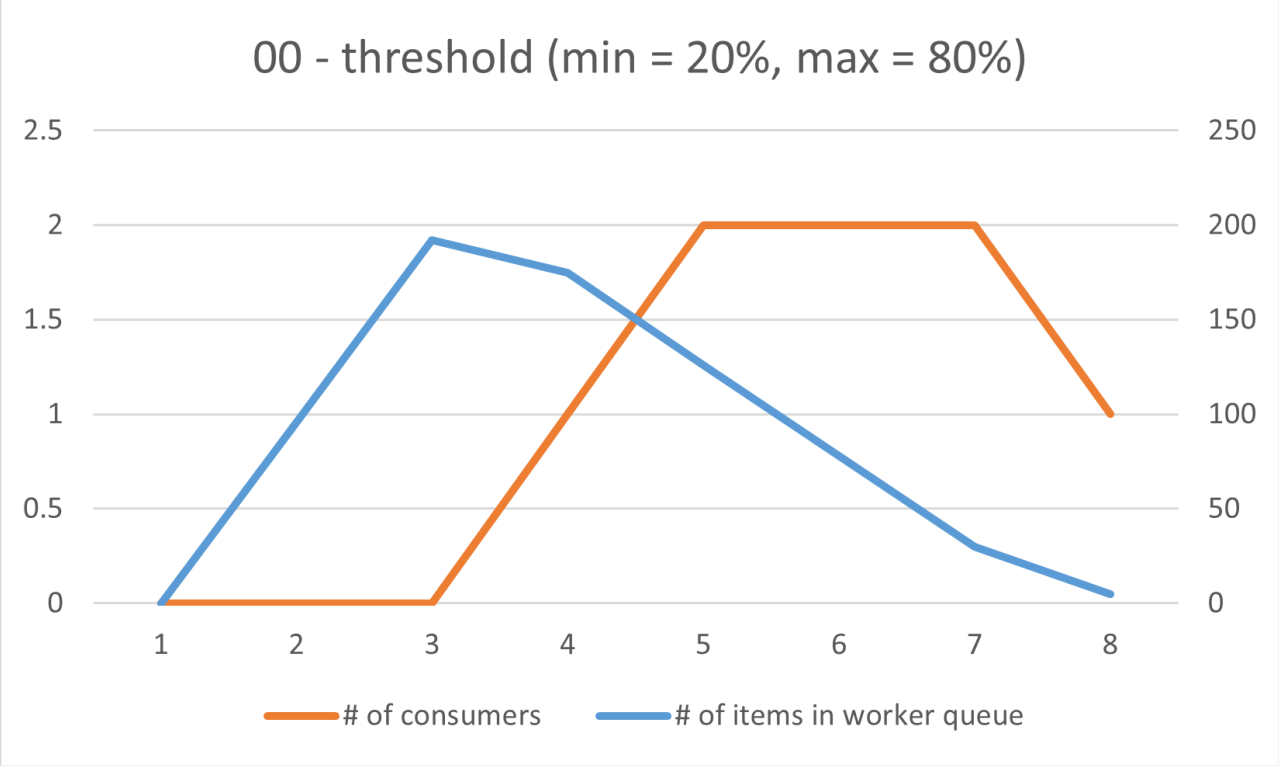
從 test 00 看起來，較小的 min threshold 與較小的 max threshold 執行速度更快，但當數量放大之後，從 test 01 的結果可以看出，這兩個 threshold 的設置對於執行速度上的影響甚微。

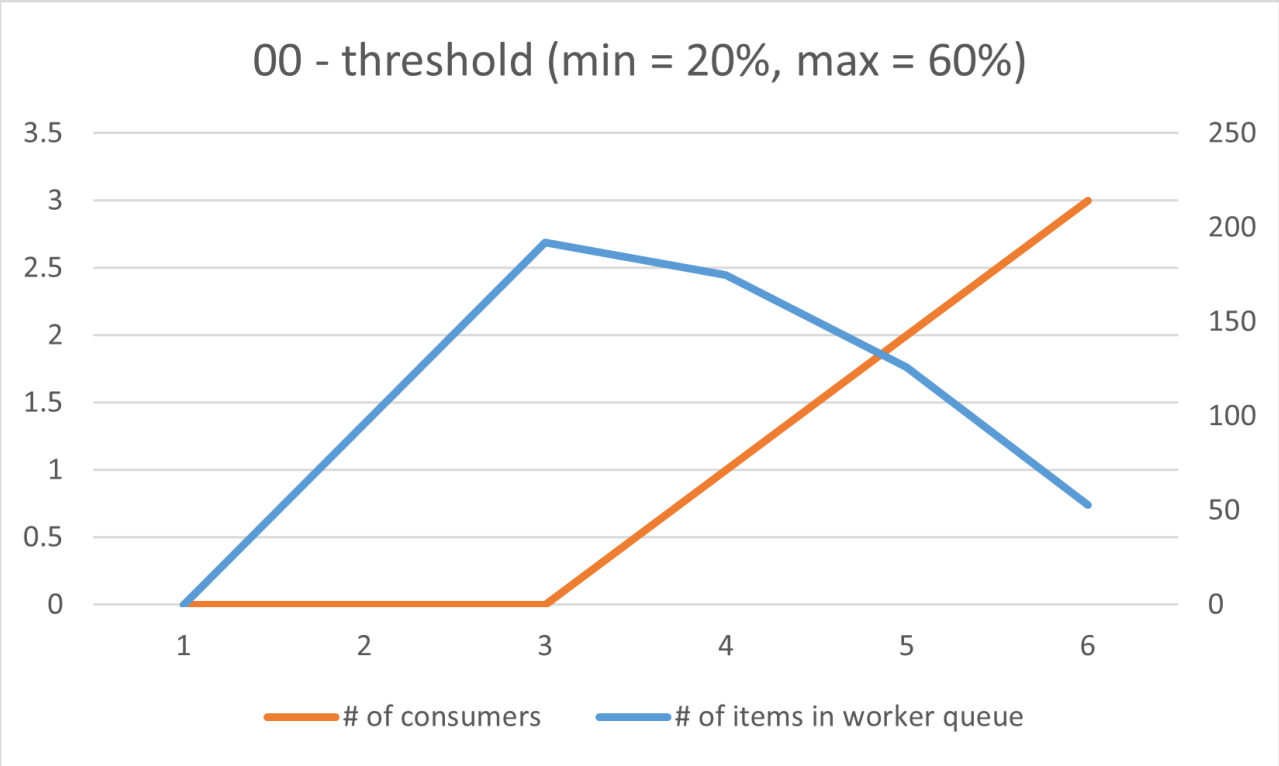
Result

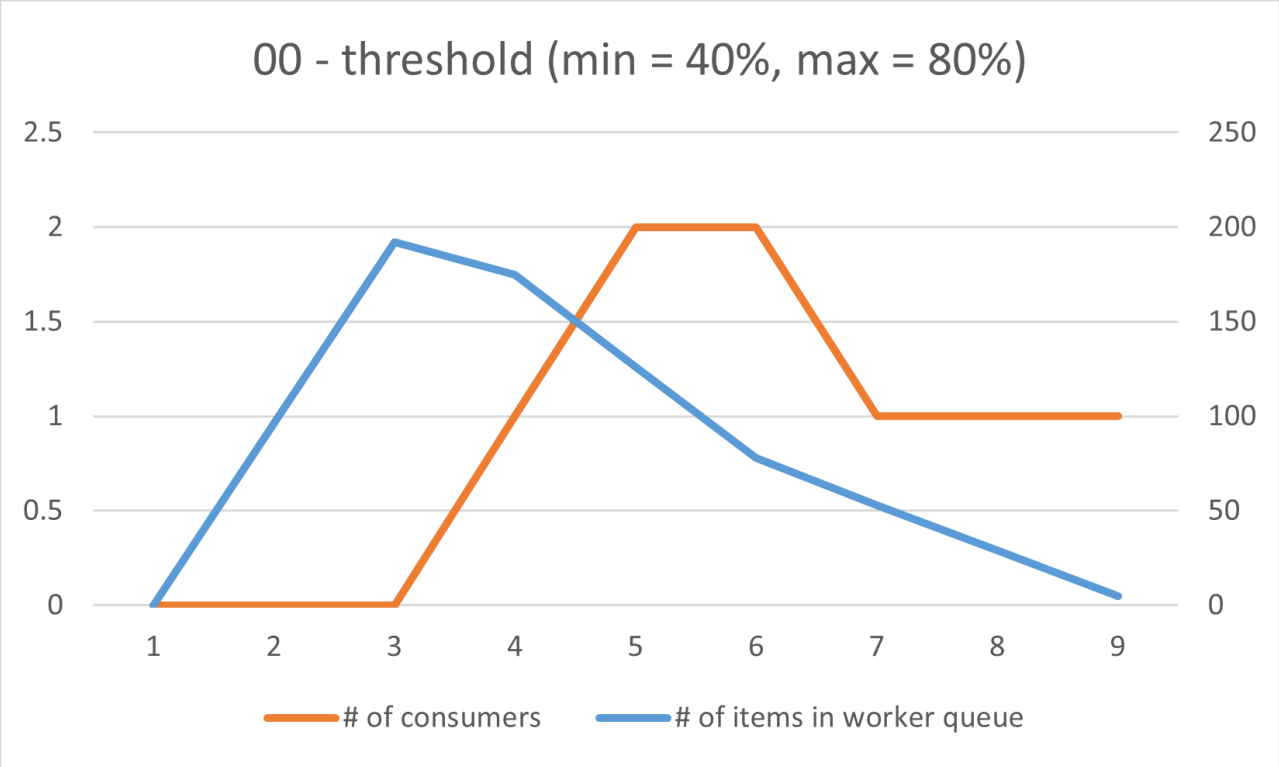
- **test 00**

Threshold (min, max)	Runtime
(40%, 60%)	6.17829
(20%, 80%)	7.25883
(20%, 60%)	5.77848
(40%, 80%)	8.25213



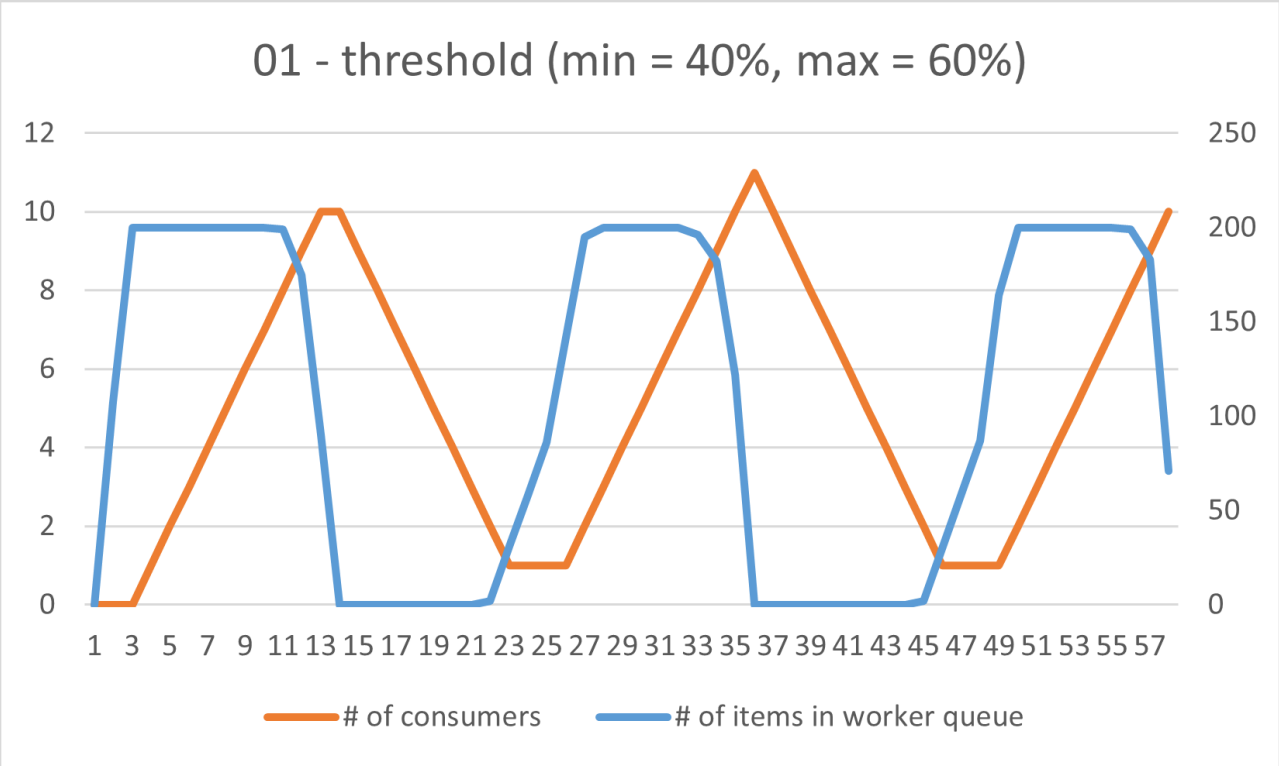


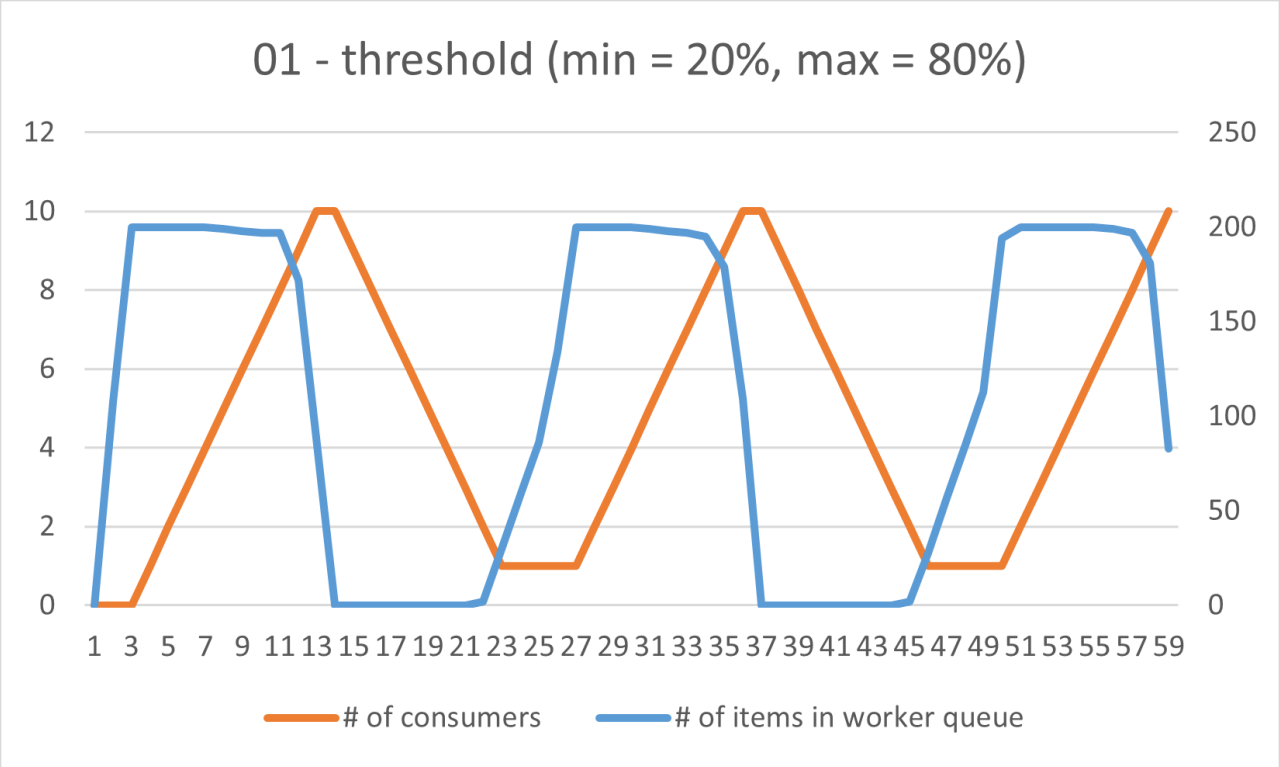


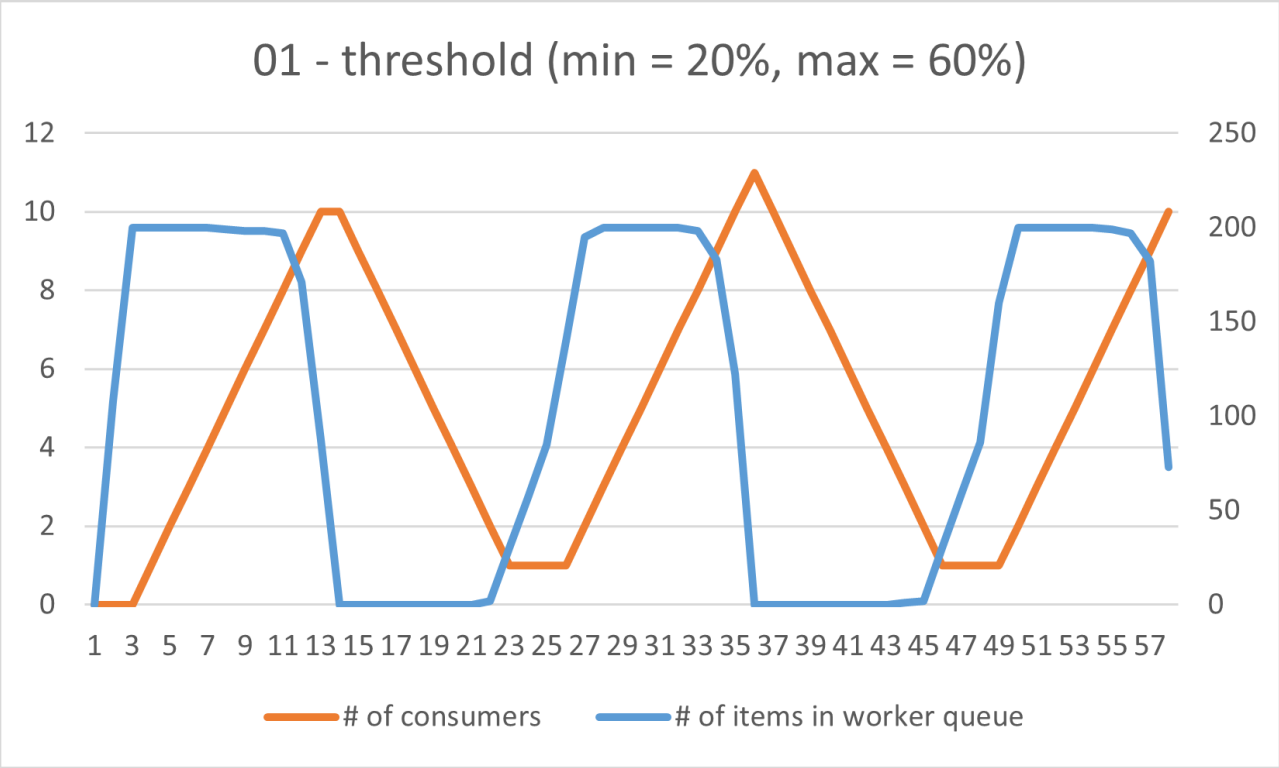


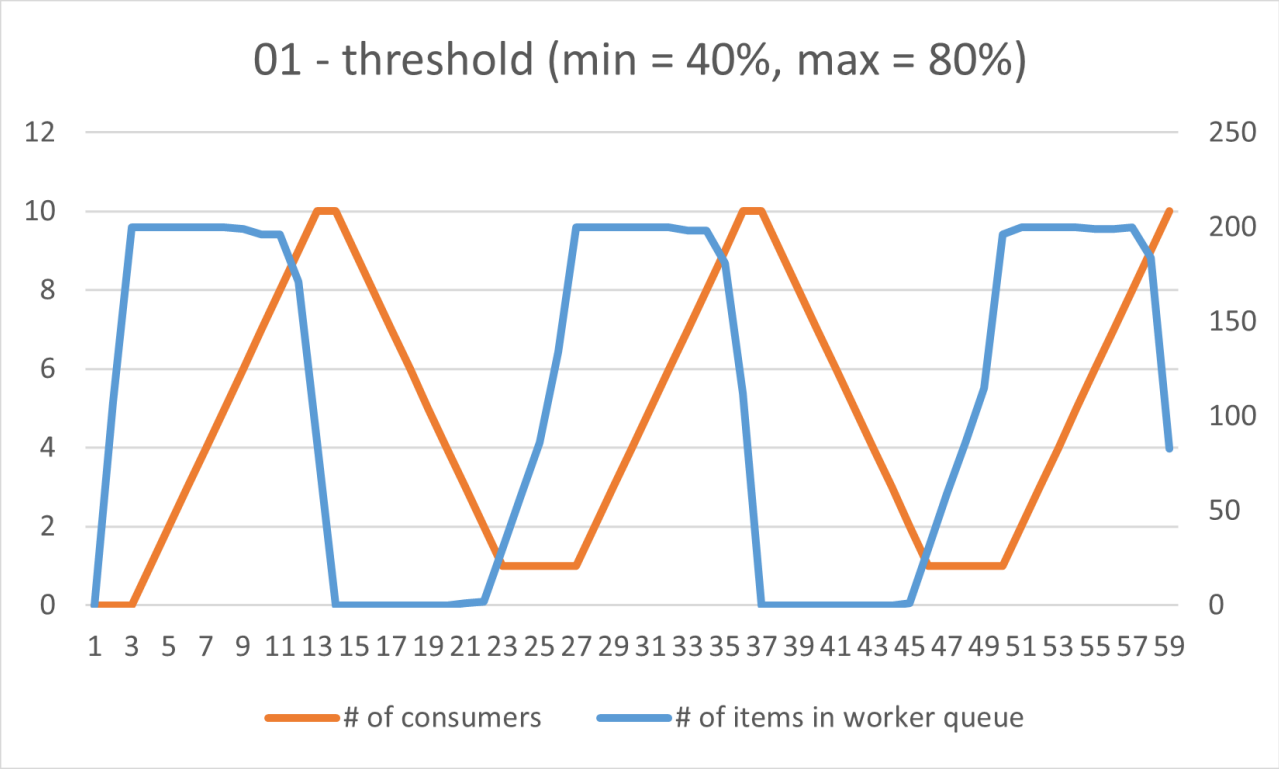
- **test 01**

Threshold (min, max)	Runtime
(40%, 60%)	58.9171
(20%, 80%)	59.7507
(20%, 60%)	58.7007
(40%, 80%)	59.7340


01 - threshold (min = 40%, max = 60%)
12
10
8
6
4
2
0
250
200
150
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57
# of consumers
# of items in worker queue


01 - threshold (min = 20%, max = 80%)
12
10
8
6
4
2
0
250
200
150
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
# of consumers
# of items in worker queue





Different values of WORKER_QUEUE_SIZE

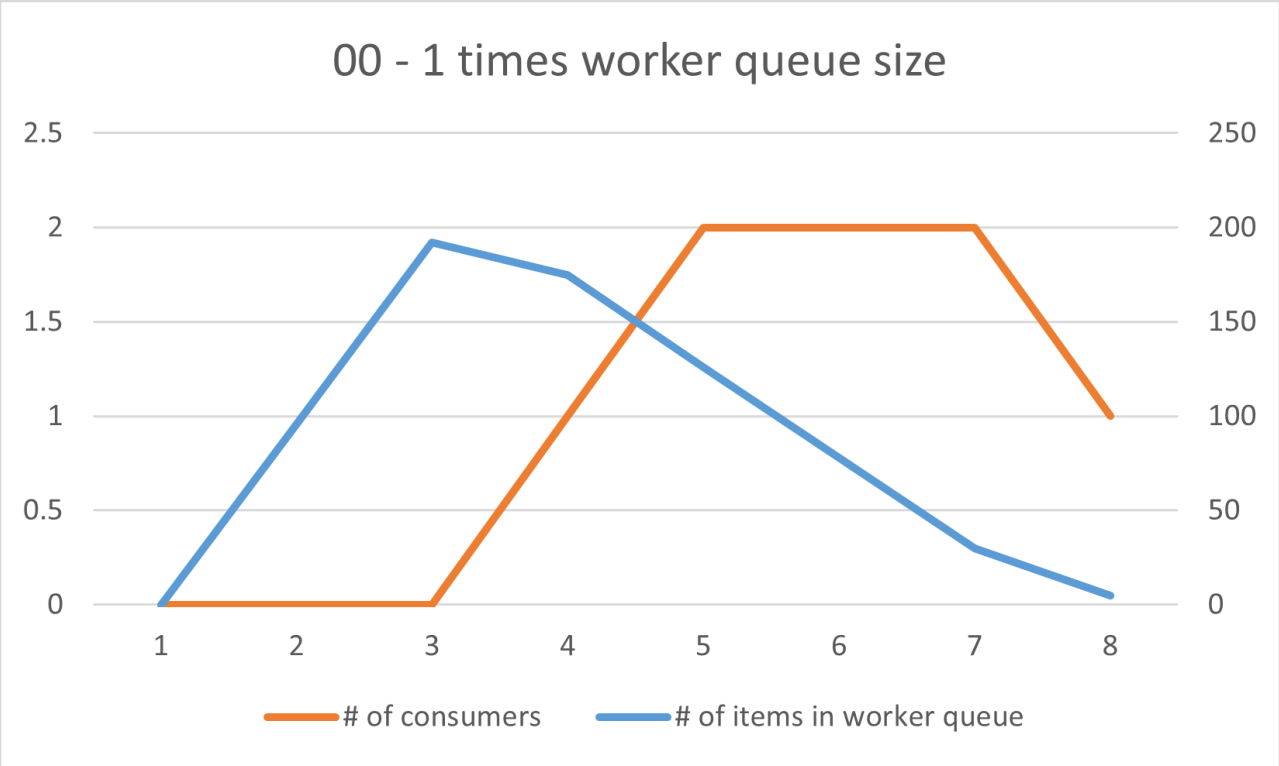
Discussion

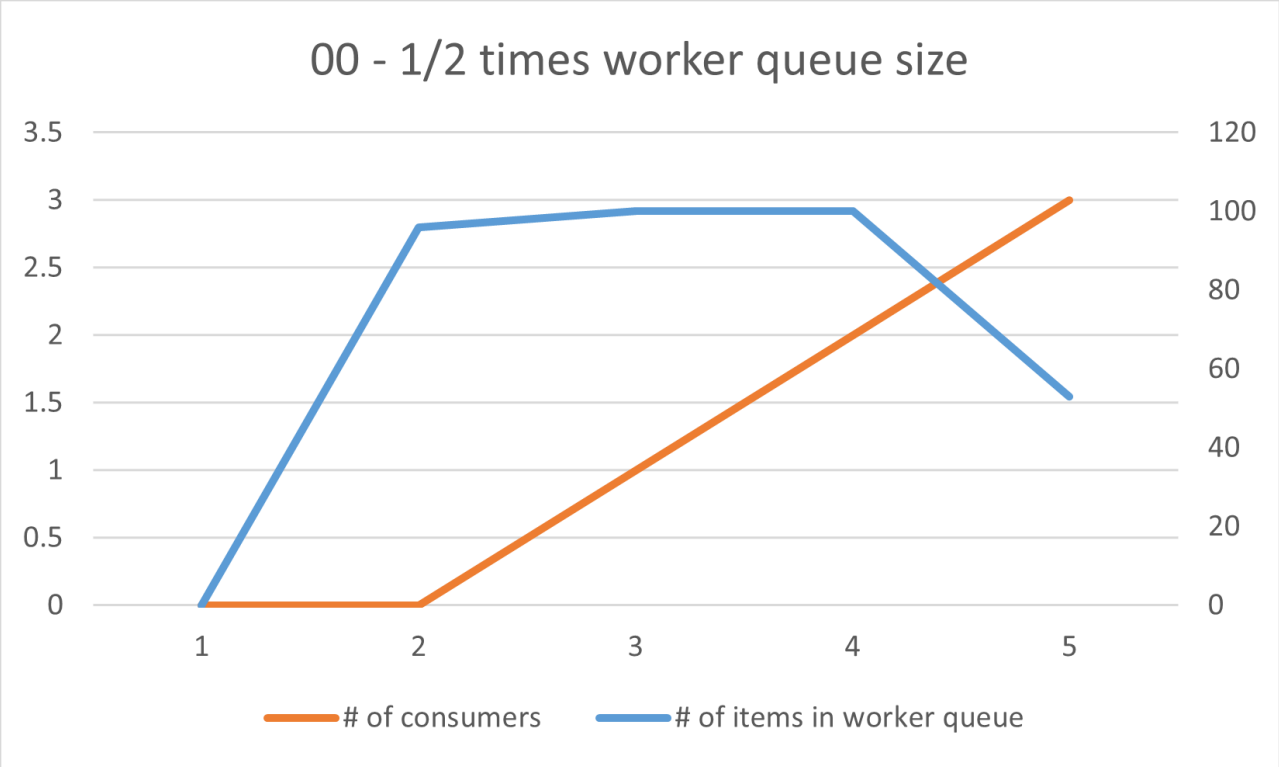
Worker queue size 設定的大一點，雖然能增加處理更多 items 的能力，但當 work queue size 太大的時候會導致 consumer controler 沒有創建 consumer 或是 consumer 數量增長延遲的情況。

Result

- **test 00**

Work queue size	Runtime
2 times	Infinity (never end)
1 times	7.25883
1/2 times	4.77562

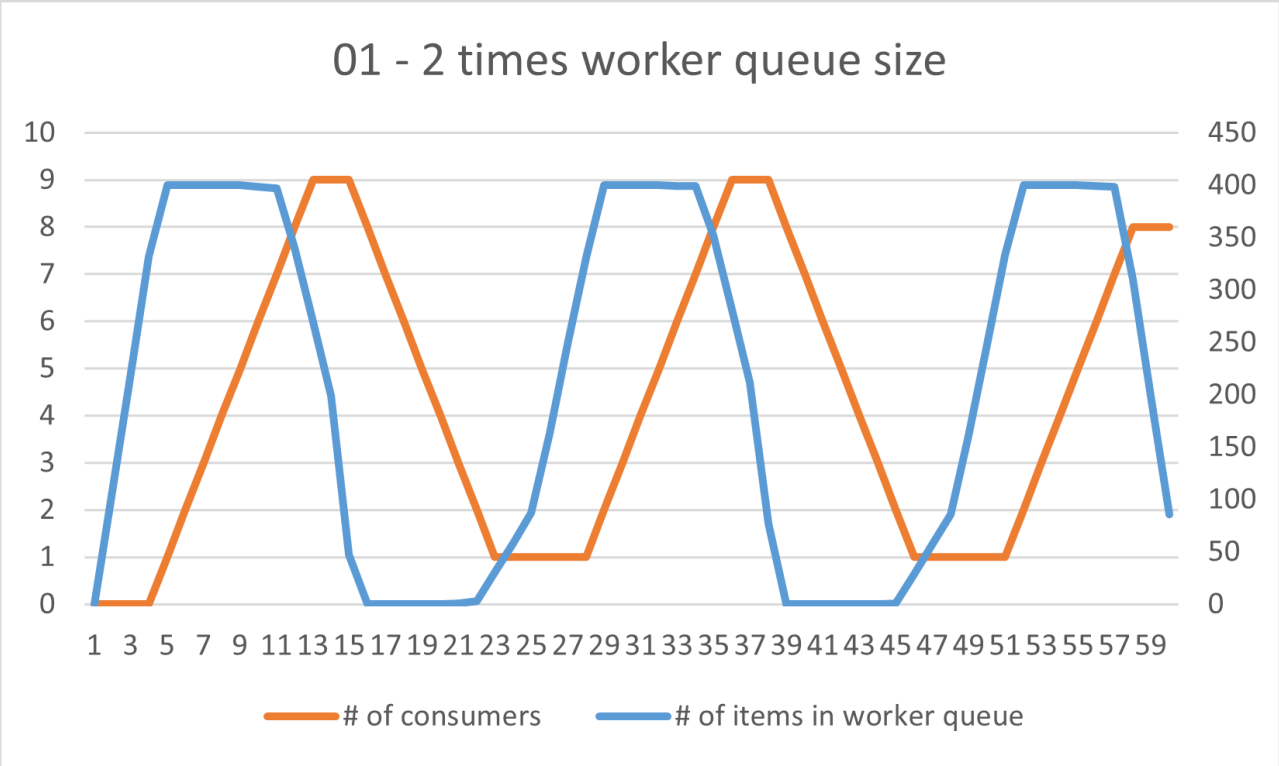


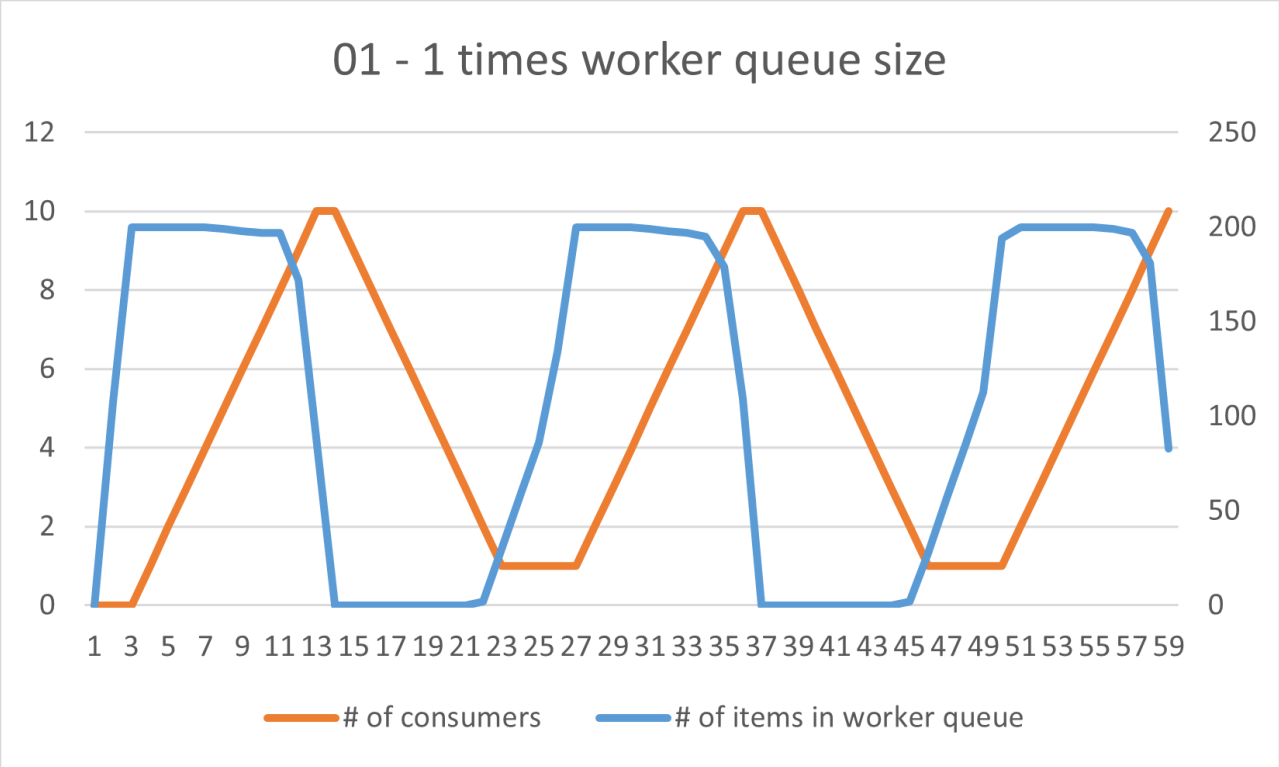


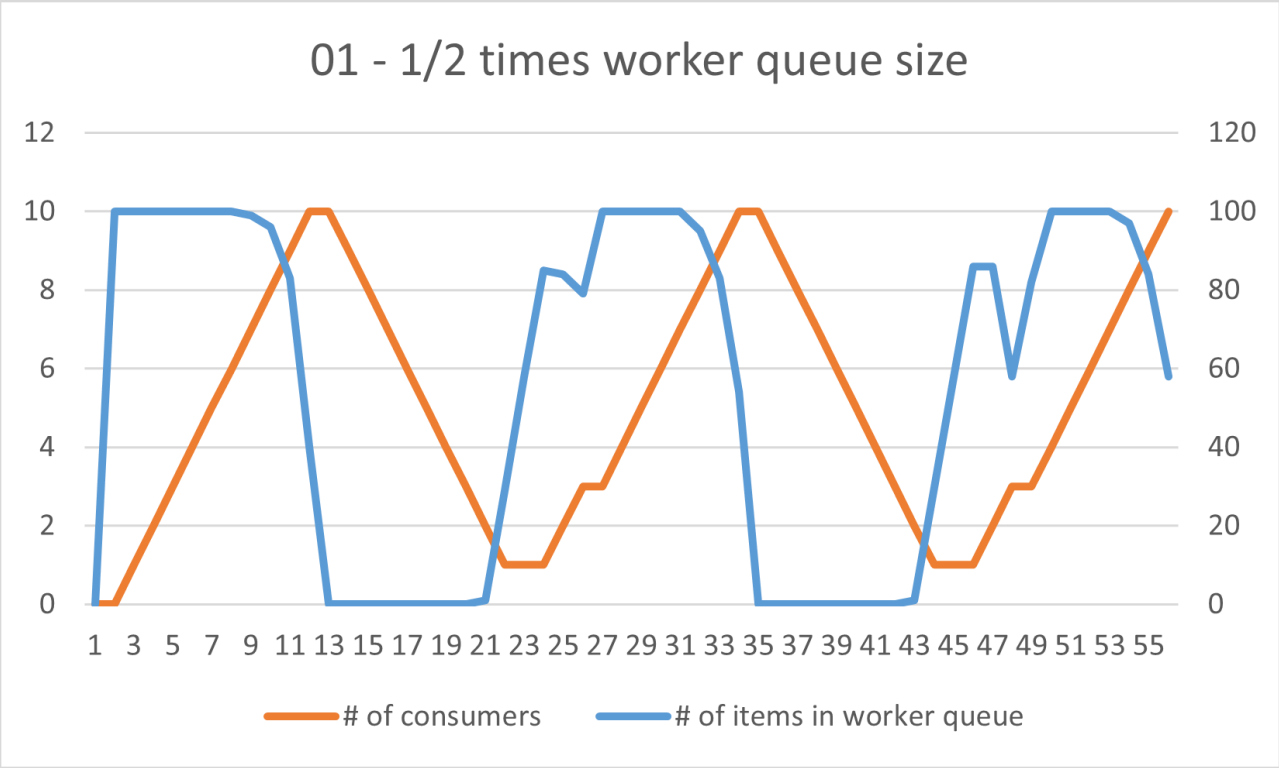
- **test 01**

Work queue size	Runtime

Work queue size	Runtime
2 times	60.4075
1 times	59.7507
1/2 times	56.7949





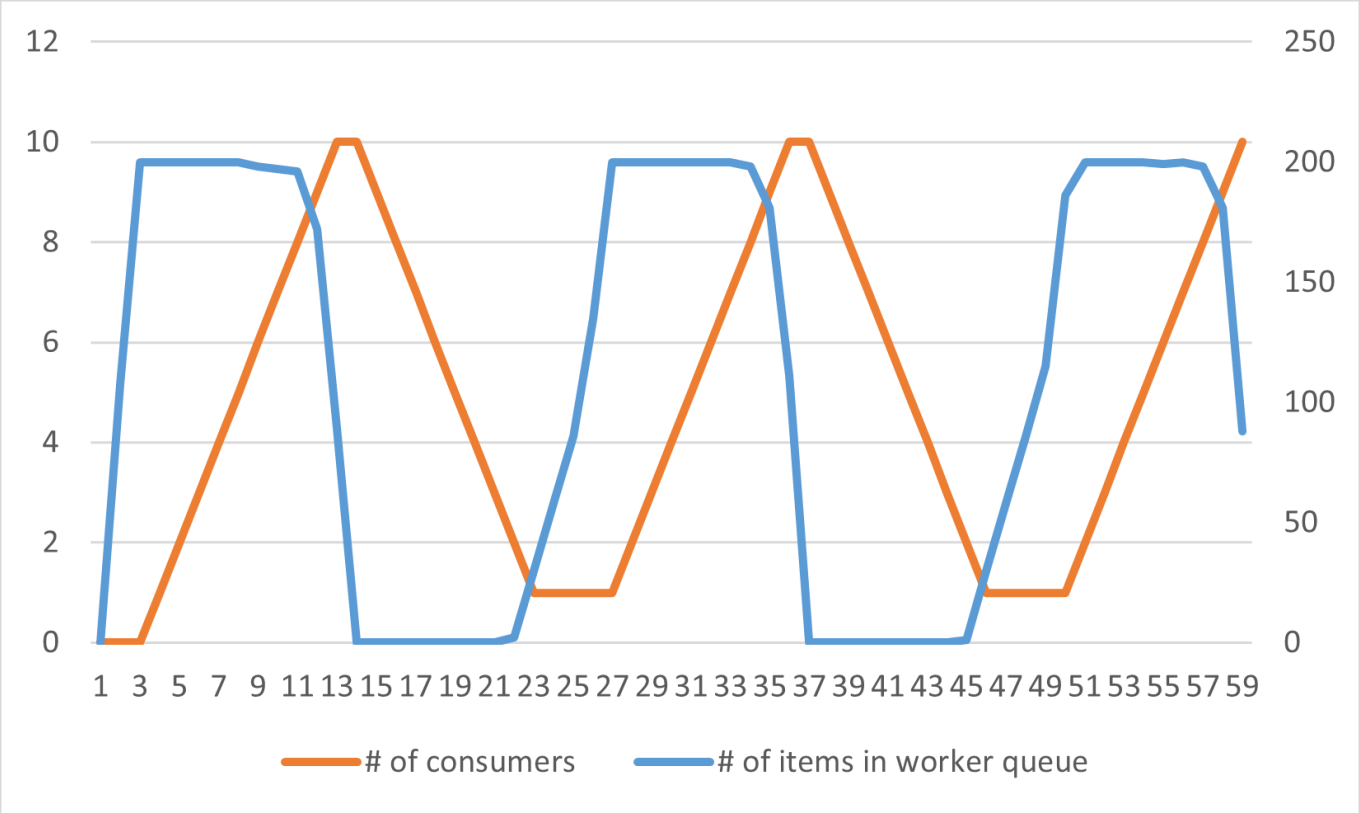


What happens if WRITER_QUEUE_SIZE is very small?

Discussion

好像不會怎樣？

Result



What happens if READER_QUEUE_SIZE is very small?

Discussion

好像不會怎樣？

Result