설계과제4
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개요

설계과제 4는 Pthread를 활용한 구현이다. lock, unlock을 사용해서 Pthread에서 임계영역을 잠그고 해제한다. 임계영역을 보장함으로써 공용 변수로 인한 문제 발생을 막을 수 있으며 원자적 실행이 가능하다. 또한 cond의 wait과 signal을 사용해서 신호를 주고 받음으로써 여러 쓰레드가 mutex를 얻기 위해 발생하는 busy waiting 문제를 막을 수 있다. 이러한 기능들을 활용해서 본 과제를 해결한다.

1. Master-Worker Thread Pool 구현

①구현방법

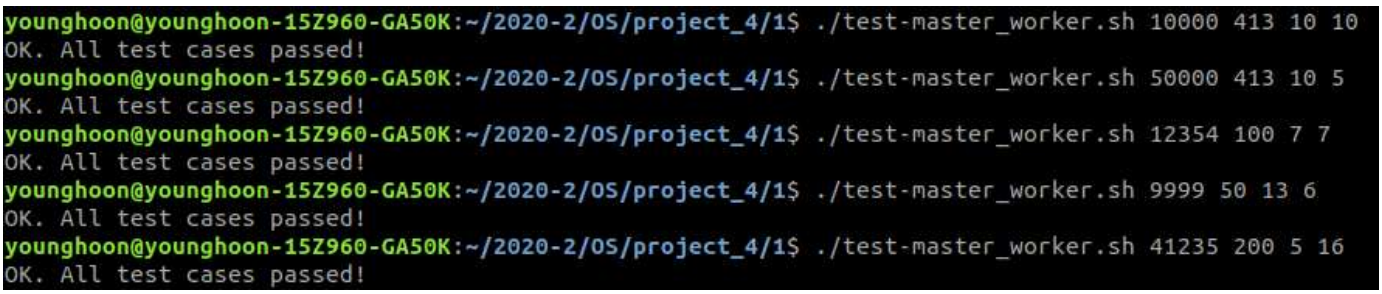
-main thread : 메인 쓰레드 에서는 먼저 마스터 쓰레드와 워커 쓰레드를 pthread_create를 사용해서 생성한다.쓰레드를 생성하고 usleep 함수를 사용해서 약간의 딜레이를 줌으로써 쓰레드가 모두 생성된 후에 작업을 시작하게 한다. 마스터, 워커 쓰레드 생성이 끝나면 한 개의 마스터 쓰레드를 호출함으로써 숫자 생성을 시작한다. 숫자 생성 및 소비가 끝나면 pthread_join으로 마스터, 워커 쓰레드를 종료하며 이때 종료 결과를 출력한다. 마지막으로 mutex와 조건 변수를 destroy하고 버퍼 및 쓰레드 id를 위해 할당된 메모리 공간을 해제한다.

-master thread : 마스터 쓰레드 에서는 0~M-1 까지의 수를 생성해서 버퍼에 저장하지만 버퍼가 가득 찬 경우에는 생성하지 않는다. 이를 위해 void *generate_requests_loop(void *data) 함수를 구현한다. 메인 쓰레드에서 마스터 쓰레드를 생성할 때에 generate_requests_loop 함수를 호출하고, 그 인자로 쓰레드의 번호를 인자로 전달한다. 함수 내부에서는 mutex lock을 얻고 바로 마스터 mutex와 마스터 조건변수를 인자로 wait 한다. 마스터 쓰레드 조건변수 호출이 오면 M-1 까지의 숫자를 생성하였는지 판단 하며 while 문 내에서 숫자 생성을 한다. 만일 버퍼가 가득 차 있는 경우에는 숫자 소비를 위해 워커 쓰레드에 워커 조건변수 신호를 보내고 마스터 mutex와 마스터 조건변수를 인자로 다시 wait을 한다. wait를 하면 mutex unlock이 실행되기 때문에 다른 마스터 쓰레드가 임계구역에 접근할 수 있다. 숫자를 모두 생성한 경우에는 워커 쓰레드에 워커 조건변수 신호를 보내어 버퍼에 남아있는 수들을 소비하고, 마스터 mutex를 unlock하며 나머지 마스터 쓰레드를 종료하기 위해 마스터 조건변수 신호를 보내고 반복문을 종료한다.

-worker thread : 워커 쓰레드 에서는 생성한 0~M-1 까지의 수를 소비하며 버퍼가 비어 있는 경우에는 소비하지 않는다. 이를 위해 void *consume_requests_loop(void *data) 함수를 구현한다. 메인 쓰레드에서 워커 쓰레드를 생성하는 과정은 마스터 쓰레드의 경우와 동일하다. 마스터 쓰레드로부터 워커 조건변수 신호를 받으면 마스터 쓰레드와 비슷하게 while 문 내에서 숫자 소비를 한다. 버퍼가 비어 있는 경우에는 마스터 쓰레드와는 반대로 숫자 생성을 위해 마스터 쓰레드에 마스터 조건변수 신호를 보내고 워커 mutex와 워커 조건변수를 인자로 wait 한다. 숫자를 모두 소비한 경우에는 나머지 워커 쓰레드 종료를 위해 워커 mutex를 unlock 후 워커 조건변수로 신호를 보낸 후 반복문을 종료한다.

②실행결과 : 다양한 입력으로 인한 실행 결과이다.

-테스트 프로그램 실행 결과



-0~13의 숫자, 크기 3의 버퍼, 워커 4, 마스터 7개의 쓰레드

```
younghoon@younghoon-15Z960-GA50K:~/2020-2/OS/project_4/1$ ./a.out 14 3 4 7
Produced 0 by master 1
Produced 1 by master 1
Produced 2 by master 1
Consumed 0 by worker 0
Consumed 1 by worker 0
Consumed 2 by worker 0
Produced 3 by master 0
Produced 4 by master 0
Produced 5 by master 0
Consumed 3 by worker 1
Consumed 4 by worker 1
Consumed 5 by worker 1
Produced 6 by master 2
Produced 7 by master 2
Produced 8 by master 2
Consumed 6 by worker 2
Consumed 7 by worker 2
Consumed 8 by worker 2
Produced 9 by master 3
Produced 10 by master 3
Produced 11 by master 3
Consumed 9 by worker 3
Consumed 10 by worker 3
Consumed 11 by worker 3
Produced 12 by master 5
Produced 13 by master 5
Consumed 12 by worker 0
Consumed 13 by worker 0
worker 0 joined
worker 1 joined
worker 2 joined
worker 3 joined
master 0 joined
master 1 joined
master 2 joined
master 3 joined
master 4 joined
master 5 joined
master 6 joined
```

-0~13의 숫자, 크기 3의 버퍼, 워커 9, 마스터 4개의 쓰레드

```
younghoon@younghoon-15Z960-GA50K:~/2020-2/OS/project_4/1$ ./a.out 14 3 9 4
Produced 0 by master 0
Produced 1 by master 0
Produced 2 by master 0
Consumed 0 by worker 1
Consumed 1 by worker 1
Consumed 2 by worker 1
Produced 3 by master 1
Produced 4 by master 1
Produced 5 by master 1
Consumed 3 by worker 0
Consumed 4 by worker 0
Consumed 5 by worker 0
Produced 6 by master 2
Produced 7 by master 2
Produced 8 by master 2
Consumed 6 by worker 2
Consumed 7 by worker 2
Consumed 8 by worker 2
Produced 9 by master 3
Produced 10 by master 3
Produced 11 by master 3
Consumed 9 by worker 7
Consumed 10 by worker 7
Consumed 11 by worker 7
Produced 12 by master 0
Produced 13 by master 0
Consumed 12 by worker 6
Consumed 13 by worker 6
worker 0 joined
worker 1 joined
worker 2 joined
worker 3 joined
worker 4 joined
worker 5 joined
worker 6 joined
worker 7 joined
worker 8 joined
master 0 joined
master 1 joined
master 2 joined
master 3 joined
```

-0~18의 숫자, 크기 5의 버퍼, 워커 9, 마스터 7개의 쓰레드

```
younghoon@younghoon-15Z960-GA50K:~/2020-2/OS/project_4/1$ ./a.out 19 5 9 7
Produced 0 by master 0
Produced 1 by master 0
Produced 2 by master 0
Produced 3 by master 0
Produced 4 by master 0
Consumed 0 by worker 2
Consumed 1 by worker 2
Consumed 2 by worker 2
Consumed 3 by worker 2
Consumed 4 by worker 2
Produced 5 by master 1
Produced 6 by master 1
Produced 7 by master 1
Produced 8 by master 1
Produced 9 by master 1
Consumed 5 by worker 0
Consumed 6 by worker 0
Consumed 7 by worker 0
Consumed 8 by worker 0
Consumed 9 by worker 0
Produced 10 by master 2
Produced 11 by master 2
Produced 12 by master 2
Produced 13 by master 2
Produced 14 by master 2
Consumed 10 by worker 3
Consumed 11 by worker 3
Consumed 12 by worker 3
Consumed 13 by worker 3
Consumed 14 by worker 3
Produced 15 by master 3
Produced 16 by master 3
Produced 17 by master 3
Produced 18 by master 3
Consumed 15 by worker 1
Consumed 16 by worker 1
Consumed 17 by worker 1
Consumed 18 by worker 1
worker 0 joined
worker 1 joined
worker 2 joined
worker 3 joined
worker 4 joined
worker 5 joined
worker 6 joined
worker 7 joined
worker 8 joined
master 0 joined
master 1 joined
master 2 joined
master 3 joined
master 4 joined
master 5 joined
master 6 joined
```

-0~19의 숫자, 크기 5의 버퍼, 워커 10, 마스터 5개의 쓰레드

```
younghoon@younghoon-15Z960-GA50K:~/2020-2/OS/project_4/1$ ./a.out 20 5 10 5
Produced 0 by master 0
Produced 1 by master 0
Produced 2 by master 0
Produced 3 by master 0
Produced 4 by master 0
Consumed 0 by worker 3
Consumed 1 by worker 3
Consumed 2 by worker 3
Consumed 3 by worker 3
Consumed 4 by worker 3
Produced 5 by master 1
Produced 6 by master 1
Produced 7 by master 1
Produced 8 by master 1
Produced 9 by master 1
Consumed 5 by worker 1
Consumed 6 by worker 1
Consumed 7 by worker 1
Consumed 8 by worker 1
Consumed 9 by worker 1
Produced 10 by master 2
Produced 11 by master 2
Produced 12 by master 2
Produced 13 by master 2
Produced 14 by master 2
Consumed 10 by worker 0
Consumed 11 by worker 0
Consumed 12 by worker 0
Consumed 13 by worker 0
Consumed 14 by worker 0
Produced 15 by master 3
Produced 16 by master 3
Produced 17 by master 3
Produced 18 by master 3
Produced 19 by master 3
Consumed 15 by worker 4
Consumed 16 by worker 4
Consumed 17 by worker 4
Consumed 18 by worker 4
Consumed 19 by worker 4
worker 0 joined
worker 1 joined
worker 2 joined
worker 3 joined
worker 4 joined
worker 5 joined
worker 6 joined
worker 7 joined
worker 8 joined
worker 9 joined
master 0 joined
master 1 joined
master 2 joined
master 3 joined
master 4 joined
```