ThreadPool

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Chapter 1

Data Structure Index

1.1 Data Structures

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2.1 File List

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Chapter 3

Data Structure Documentation

3.1 ThreadPool Class Reference

Manages a pool of worker threads to execute tasks concurrently.

`#include <ThreadPool.hpp>`

Public Member Functions

- ThreadPool ()=delete

  Deleted default constructor.
- ThreadPool (unsigned int num_threads)

  Constructs a ThreadPool with a fixed number of threads.
- template<class Func , class... Args>
  void submit (Func &&f, Args &&... args)

  Submits a task to the thread pool.
- void finish (bool secure=true)

  Stops the thread pool.
- bool status ()

  Returns the current state of the thread pool.
- unsigned int length ()

  Returns the number of process in queue.
- void wait ()

  Waits until the task queue becomes empty.
- ~ThreadPool ()

  Destructor.

Data Fields

- atomic< bool > error =false

Private Attributes

- thread * th
- mutex mtx
- queue< function< void()> > q
- unsigned int num_threads
- atomic< bool > exit_flag
- atomic< bool > * process_flag
- atomic< bool > state
- atomic< bool > waiting
- condition_variable cv
- condition_variable cv2

3.1.1 Detailed Description

Manages a pool of worker threads to execute tasks concurrently.

The ThreadPool maintains a queue of tasks. Worker threads continuously fetch and execute tasks from this queue until the pool is stopped.

Note

Tasks have no return value.

Definition at line 35 of file ThreadPool.hpp.

3.1.2 Constructor & Destructor Documentation

3.1.2.1 ThreadPool() [1/2]

```
ThreadPool::ThreadPool ( )  [delete]
```

Deleted default constructor.

Forces the user to specify the number of threads.

3.1.2.2 ThreadPool() [2/2]

```
ThreadPool::ThreadPool (
            unsigned int num_threads )  [explicit]
```

Constructs a ThreadPool with a fixed number of threads.

Constructs and starts the worker threads.

Parameters

num_threads	Number of worker threads to create.

Each worker thread runs a loop that retrieves tasks from the queue and executes them until termination is requested.
Worker thread function.

Continuously checks the task queue and executes tasks while the pool is active and the exit flag is not set.

Definition at line 15 of file ThreadPool.cpp.

```
00016     :  num_threads(num_threads) {
00017
00018 /**
00019 * @brief Worker thread function.
00020 *
00021 * Continuously checks the task queue and executes tasks
00022 * while the pool is active and the exit flag is not set.
00023 */
00024     function<void(unsigned int)> f = [&](unsigned int process_number) {
00025
00026         function<void()> task;
00027
00028         unique_lock<mutex> lock(this->mtx);
00029
00030         while (!this->exit_flag.load() && this->state.load()) {
00031
00032
00033             cv.wait(lock,[&](){
00034                     return !this->q.empty() || (this->exit_flag.load() || !this->state.load());
00035                 }
00036             );
00037
00038
00039
00040             if(this->exit_flag.load() || !this->state.load()){
00041                 lock.unlock();
00042                 break;
00043             }
00044
00045             task = move(this->q.front());
00046             this->q.pop();
00047
00048             lock.unlock();
00049
00050
00051             this->process_flag[process_number]=true;
00052             try{
00053                 task();
00054             }catch(...){
00055                 this->error=true;
00056             }
00057             this->process_flag[process_number]=false;
00058
00059             lock.lock();
00060             if(this->waiting.load()==true){
00061                 this->cv2.notify_one();
00062             }
00063         }
00064
00065         if(lock.owns_lock()){
00066             lock.unlock();
00067         }
00068     };
00069
00070     this->exit_flag = false;
00071     this->waiting=false;
00072
00073     this->th = new (nothrow) thread[num_threads];
00074     this->process_flag = new (nothrow) atomic<bool>[num_threads];
00075
00076     if (this->th != nullptr && this->process_flag != nullptr) {
00077         this->state = true;
00078
00079         try {
00080             for (unsigned int i = 0; i < this->num_threads; i++) {
00081                 this->th[i] = thread(f,i);
00082                 this->process_flag[i]=false;
00083             }
00084         } catch (exception&) {
00085             this->state = false;
00086             // cout « "The system is unable to start a new thread" « endl;
```

```
00087         }
00088     } else {
00089         this->state = false;
00090     }
00091 }
```

3.1.2.3 ~ThreadPool()

```
ThreadPool::~ThreadPool ( )
```

Destructor.

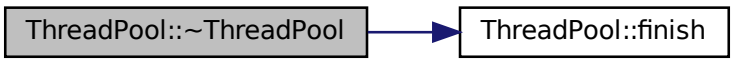
Stops the pool and releases all allocated resources.

Ensures that the pool is stopped and memory is released.

Definition at line 149 of file ThreadPool.cpp.

```
00149                           {
00150     this->finish();
00151     try{
00152         delete[] this->th;
00153         delete[] this->process_flag;
00154     }catch(...){
00155
00156     }
00157 }
```

Here is the call graph for this function:



3.1.3 Member Function Documentation

3.1.3.1 finish()

```
void ThreadPool::finish (
            bool secure = true )
```

Stops the thread pool.

Stops the thread pool and optionally joins threads.

Sets the exit flag and optionally waits for all threads to finish.

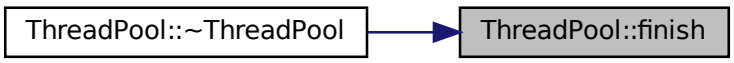
Parameters

secure	If true, joins all worker threads.
secure	If true, waits for all threads to finish execution.

Definition at line 121 of file ThreadPool.cpp.

```
00121                                       {
00122     this->exit_flag = true;
00123
00124
00125     unique_lock<mutex> lock(this->mtx);
00126     this->cv.notify_all();
00127     lock.unlock();
00128
00129     if (secure && this->state.load()) {
00130         for (unsigned int i = 0; i < this->num_threads; i++) {
00131             if (this->th[i].joinable()) {
00132                 try {
00133                     this->th[i].join();
00134                 } catch (...)  {
00135                     // cout « "Error joining thread " « i « endl;
00136                 }
00137             }
00138
00139         }
00140         this->state = false;
00141     }
00142 }
```

Here is the caller graph for this function:



3.1.3.2 length()

```
unsigned int ThreadPool::length ( )
```

Returns the number of process in queue.

Provides the number of process in queue.

Returns

integer with the length of the queue.

Definition at line 110 of file ThreadPool.cpp.

```
00110                                       {
00111     return this->q.size();
00112 }
```

3.1.3.3 status()

```
bool ThreadPool::status ( )
```

Returns the current state of the thread pool.

Checks whether the thread pool is running.

Returns

True if the pool is running, false otherwise.

True if the pool is active, false otherwise.

Definition at line 98 of file ThreadPool.cpp.

```
00098                           {
00099     return this->state;
00100 }
```

3.1.3.4 submit()

```
template<class Func , class...  Args>
void ThreadPool::submit (
             Func && f,
             Args &&...  args )
```

Submits a task to the thread pool.

Adds a new task to the task queue.

The task is stored in the internal queue and will be executed by one of the worker threads.

Template Parameters

Func	Callable object type.
Args	Argument types for the callable.

Parameters

f	Function to execute.
args	Arguments passed to the function.

Locks the mutex, pushes the task into the queue, and then unlocks the mutex.

Definition at line 153 of file ThreadPool.hpp.

```
00153                                                {
00154
00155
00156
00157     lock_guard<mutex> lock(this->mtx);
00158
00159
00160     this->q.push(
00161         move(
```

```
00162             [&]() {
00163                 f(args...);
00164             }
00165         )
00166     );
00167
00168
00169     this->cv.notify_one();
00170 }
```

3.1.3.5 wait()

```
void ThreadPool::wait ( )
```

Waits until the task queue becomes empty.

Waits until all queued tasks have been processed.

Note

This function performs a busy wait.

Definition at line 162 of file ThreadPool.cpp.

```
00162                       {
00163     unique_lock<mutex> lock(this->mtx);
00164
00165     this->waiting=true;
00166
00167     this->cv2.wait(lock,[&](){
00168
00169             bool flag=true;
00170
00171             if(this->q.empty()){
00172
00173                 for(unsigned int i=0;i<this->num_threads;i++){
00174                     if(this->process_flag[i].load()){
00175                         flag=false;
00176                         break;
00177                     }
00178                 }
00179
00180                 return flag?true:false;
00181             }else{
00182                 return false;
00183             }
00184         }
00185     );
00186
00187     this->waiting=false;
00188
00189 }
```

3.1.4 Field Documentation

3.1.4.1 cv

```
condition_variable ThreadPool::cv  [private]
```

Condition variable used to stop the threads until a new process is pushed

Definition at line 64 of file ThreadPool.hpp.

3.1.4.2 cv2

```
condition_variable ThreadPool::cv2  [private]
```

Condition variable used to wait until all the queue finish

Definition at line 67 of file ThreadPool.hpp.

3.1.4.3 error

```
atomic<bool> ThreadPool::error =false
```

Parameters

Flag	that idicates if any thread has thrown an exception

Definition at line 143 of file ThreadPool.hpp.

3.1.4.4 exit_flag

```
atomic<bool> ThreadPool::exit_flag  [private]
```

Flag indicating when threads should terminate

Definition at line 52 of file ThreadPool.hpp.

3.1.4.5 mtx

```
mutex ThreadPool::mtx  [private]
```

Mutex protecting access to the task queue

Definition at line 43 of file ThreadPool.hpp.

3.1.4.6 num_threads

```
unsigned int ThreadPool::num_threads  [private]
```

Number of threads managed by the pool

Definition at line 49 of file ThreadPool.hpp.

3.1.4.7 process_flag

```
atomic<bool>* ThreadPool::process_flag  [private]
```

Array of flags indicating if a thread is running a process or not

Definition at line 55 of file ThreadPool.hpp.

3.1.4.8 q

```
queue<function<void()> > ThreadPool::q  [private]
```

Queue containing pending tasks

Definition at line 46 of file ThreadPool.hpp.

3.1.4.9 state

```
atomic<bool> ThreadPool::state  [private]
```

Indicates whether the thread pool is active

Definition at line 58 of file ThreadPool.hpp.

3.1.4.10 th

```
thread* ThreadPool::th  [private]
```

Pointer to the array of worker threads

Definition at line 40 of file ThreadPool.hpp.

3.1.4.11 waiting

```
atomic<bool> ThreadPool::waiting  [private]
```

Indicates whether the thread pool is waiting to finish all the tasks or not

Definition at line 61 of file ThreadPool.hpp.

The documentation for this class was generated from the following files:

- ThreadPool.hpp
- ThreadPool.cpp

Chapter 4

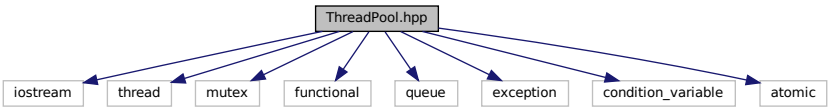
File Documentation

4.1 ThreadPool.hpp File Reference

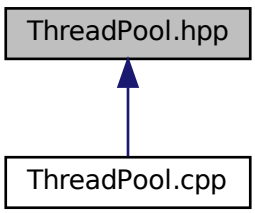
Declaration of a simple ThreadPool class.

```
#include <iostream>
#include <thread>
#include <mutex>
#include <functional>
#include <queue>
#include <exception>
#include <condition_variable>
#include <atomic>
```

Include dependency graph for ThreadPool.hpp:



This graph shows which files directly or indirectly include this file:



Data Structures

- class ThreadPool

  Manages a pool of worker threads to execute tasks concurrently.

4.1.1 Detailed Description

Declaration of a simple ThreadPool class.

Author

qwert-asci

This file contains the declaration of a basic thread pool that executes tasks using a fixed number of worker threads.

Definition in file ThreadPool.hpp.

4.2 ThreadPool.hpp

Go to the documentation of this file.

```
00001
00002 /**
00003 * @file ThreadPool.hpp
00004 * @author qwert-asci
00005 * @brief Declaration of a simple ThreadPool class.
00006 *
00007 * This file contains the declaration of a basic thread pool
00008 * that executes tasks using a fixed number of worker threads.
00009 */
00010
00011 #ifndef THREADPOOL_HPP
00012 #define THREADPOOL_HPP
00013
00014 #include <iostream>
00015 #include <thread>
00016 #include <mutex>
00017 #include <functional>
00018 #include <queue>
00019 #include <exception>
00020 #include <condition_variable>
00021 #include <atomic>
00022
00023
00024 using namespace std;
00025
00026 /**
00027 * @class ThreadPool
00028 * @brief Manages a pool of worker threads to execute tasks concurrently.
00029 *
00030 * The ThreadPool maintains a queue of tasks.  Worker threads continuously
00031 * fetch and execute tasks from this queue until the pool is stopped.
00032 *
00033 * @note Tasks have no return value.
00034 */
00035 class ThreadPool {
00036
00037 private:
00038
00039 /** Pointer to the array of worker threads */
00040     thread* th;
00041
00042 /** Mutex protecting access to the task queue */
00043     mutex mtx;
00044
00045 /** Queue containing pending tasks */
00046     queue<function<void()» q;
00047
00048 /** Number of threads managed by the pool */
00049     unsigned int num_threads;
```

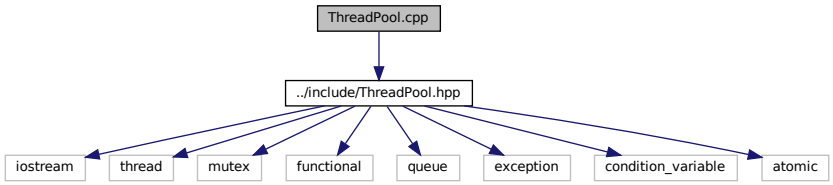
```
00050
00051 /** Flag indicating when threads should terminate */
00052     atomic<bool> exit_flag;
00053
00054 /** Array of flags indicating if a thread is running a process or not */
00055     atomic<bool> * process_flag;
00056
00057 /** Indicates whether the thread pool is active */
00058     atomic<bool> state;
00059
00060 /** Indicates whether the thread pool is waiting to finish all the tasks or not*/
00061     atomic<bool> waiting;
00062
00063 /** Condition variable used to stop the threads until a new process is pushed */
00064     condition_variable cv;
00065
00066 /** Condition variable used to wait until all the queue finish */
00067     condition_variable cv2;
00068
00069 public:
00070
00071 /**
00072 * @brief Deleted default constructor.
00073 *
00074 * Forces the user to specify the number of threads.
00075 */
00076     ThreadPool() = delete;
00077
00078 /**
00079 * @brief Constructs a ThreadPool with a fixed number of threads.
00080 *
00081 * @param num_threads Number of worker threads to create.
00082 */
00083     explicit ThreadPool(unsigned int num_threads);
00084
00085 /**
00086 * @brief Submits a task to the thread pool.
00087 *
00088 * The task is stored in the internal queue and will be executed
00089 * by one of the worker threads.
00090 *
00091 * @tparam Func Callable object type.
00092 * @tparam Args Argument types for the callable.
00093 * @param f Function to execute.
00094 * @param args Arguments passed to the function.
00095 *
00096 */
00097     template <class Func, class...  Args>
00098     void submit(Func&& f, Args&&...  args);
00099
00100 /**
00101 * @brief Stops the thread pool.
00102 *
00103 * Sets the exit flag and optionally waits for all threads to finish.
00104 *
00105 * @param secure If true, joins all worker threads.
00106 */
00107     void finish(bool secure = true);
00108
00109 /**
00110 * @brief Returns the current state of the thread pool.
00111 *
00112 * @return True if the pool is running, false otherwise.
00113 */
00114     bool status();
00115
00116
00117 /**
00118 * @brief Returns the number of process in queue.
00119 *
00120 * @return integer with the length of the queue.
00121 */
00122     unsigned int length();
00123
00124 /**
00125 * @brief Waits until the task queue becomes empty.
00126 *
00127 * @note This function performs a busy wait.
00128 */
00129     void wait();
00130
00131 /**
00132 * @brief Destructor.
00133 *
00134 * Stops the pool and releases all allocated resources.
00135 */
00136     ~ThreadPool();
```

```
00137
00138
00139 /**
00140 * @param Flag that idicates if any thread has thrown an exception
00141 *
00142 */
00143     atomic<bool> error=false;
00144 };
00145
00146 /**
00147 * @brief Adds a new task to the task queue.
00148 *
00149 * Locks the mutex, pushes the task into the queue,
00150 * and then unlocks the mutex.
00151 */
00152 template <class Func, class...  Args>
00153 void ThreadPool::submit(Func&& f, Args&&...  args) {
00154
00155
00156
00157     lock_guard<mutex> lock(this->mtx);
00158
00159
00160     this->q.push(
00161         move(
00162             [&]() {
00163                 f(args...);
00164             }
00165         )
00166     );
00167
00168
00169     this->cv.notify_one();
00170 }
00171
00172 #endif
```

4.3 ThreadPool.cpp File Reference

Implementation of the ThreadPool class.

`#include "../include/ThreadPool.hpp"`
Include dependency graph for ThreadPool.cpp:



4.3.1 Detailed Description

Implementation of the ThreadPool class.

Definition in file ThreadPool.cpp.

4.4 ThreadPool.cpp

Go to the documentation of this file.

```
00001 /**
00002 * @file ThreadPool.cpp
00003 * @brief Implementation of the ThreadPool class.
00004 */
00005
00006 #include "../include/ThreadPool.hpp"
00007
00008 /**
00009 * @brief Constructs and starts the worker threads.
00010 *
00011 * Each worker thread runs a loop that retrieves tasks
00012 * from the queue and executes them until termination
00013 * is requested.
00014 */
00015 ThreadPool::ThreadPool(unsigned int num_threads)
00016     :  num_threads(num_threads) {
00017
00018 /**
00019 * @brief Worker thread function.
00020 *
00021 * Continuously checks the task queue and executes tasks
00022 * while the pool is active and the exit flag is not set.
00023 */
00024     function<void(unsigned int)> f = [&](unsigned int process_number) {
00025
00026         function<void()> task;
00027
00028         unique_lock<mutex> lock(this->mtx);
00029
00030         while (!this->exit_flag.load() && this->state.load()) {
00031
00032
00033             cv.wait(lock,[&](){
00034                     return !this->q.empty() || (this->exit_flag.load() || !this->state.load());
00035                 }
00036             );
00037
00038
00039
00040             if(this->exit_flag.load() || !this->state.load()){
00041                 lock.unlock();
00042                 break;
00043             }
00044
00045             task = move(this->q.front());
00046             this->q.pop();
00047
00048             lock.unlock();
00049
00050
00051             this->process_flag[process_number]=true;
00052             try{
00053                 task();
00054             }catch(...){
00055                 this->error=true;
00056             }
00057             this->process_flag[process_number]=false;
00058
00059             lock.lock();
00060             if(this->waiting.load()==true){
00061                 this->cv2.notify_one();
00062             }
00063         }
00064
00065         if(lock.owns_lock()){
00066             lock.unlock();
00067         }
00068     };
00069
00070     this->exit_flag = false;
00071     this->waiting=false;
00072
00073     this->th = new (nothrow) thread[num_threads];
00074     this->process_flag = new (nothrow) atomic<bool>[num_threads];
00075
00076     if (this->th != nullptr && this->process_flag != nullptr) {
00077         this->state = true;
00078
00079         try {
00080             for (unsigned int i = 0; i < this->num_threads; i++) {
00081                 this->th[i] = thread(f,i);
00082                 this->process_flag[i]=false;
```

```
00083             }
00084         } catch (exception&) {
00085             this->state = false;
00086             // cout « "The system is unable to start a new thread" « endl;
00087         }
00088     } else {
00089         this->state = false;
00090     }
00091 }
00092
00093 /**
00094 * @brief Checks whether the thread pool is running.
00095 *
00096 * @return True if the pool is active, false otherwise.
00097 */
00098 bool ThreadPool::status() {
00099     return this->state;
00100 }
00101
00102
00103
00104
00105 /**
00106 * @brief Provides the number of process in queue.
00107 *
00108 * @return integer with the length of the queue.
00109 */
00110 unsigned int ThreadPool::length() {
00111     return this->q.size();
00112 }
00113
00114
00115
00116 /**
00117 * @brief Stops the thread pool and optionally joins threads.
00118 *
00119 * @param secure If true, waits for all threads to finish execution.
00120 */
00121 void ThreadPool::finish(bool secure) {
00122     this->exit_flag = true;
00123
00124
00125     unique_lock<mutex> lock(this->mtx);
00126     this->cv.notify_all();
00127     lock.unlock();
00128
00129     if (secure && this->state.load()) {
00130         for (unsigned int i = 0; i < this->num_threads; i++) {
00131             if (this->th[i].joinable()) {
00132                 try {
00133                     this->th[i].join();
00134                 } catch (...)  {
00135                     // cout « "Error joining thread " « i « endl;
00136                 }
00137             }
00138
00139         }
00140         this->state = false;
00141     }
00142 }
00143
00144 /**
00145 * @brief Destructor.
00146 *
00147 * Ensures that the pool is stopped and memory is released.
00148 */
00149 ThreadPool::~ThreadPool() {
00150     this->finish();
00151     try{
00152         delete[] this->th;
00153         delete[] this->process_flag;
00154     }catch(...){
00155
00156     }
00157 }
00158
00159 /**
00160 * @brief Waits until all queued tasks have been processed.
00161 */
00162 void ThreadPool::wait() {
00163     unique_lock<mutex> lock(this->mtx);
00164
00165     this->waiting=true;
00166
00167     this->cv2.wait(lock,[&](){
00168
00169             bool flag=true;
```

```
00170
00171             if(this->q.empty()){
00172
00173                 for(unsigned int i=0;i<this->num_threads;i++){
00174                     if(this->process_flag[i].load()){
00175                         flag=false;
00176                         break;
00177                     }
00178                 }
00179
00180                 return flag?true:false;
00181             }else{
00182                 return false;
00183             }
00184         }
00185     );
00186
00187     this->waiting=false;
00188
00189 }
```

Index