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CSCI 4730 (OS)

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## README

**Makefile command:** make all, make clean

**Run command: RUN SERVER FIRST**

**Run server:** ./webserver\_multi [port number] [# of threads]

**Run client:** ./client [host ip (ex. vcf0.cs.uga.edu) [port number] [# of threads]

Example: ./webserver\_multi 2222 10 (create 10 worker threads on port 2222 to handle requests from client)

./client vcf0.cs.uga.edu 2222 20 (send 20 requests to webserver listening on port 2222 through host vcf0)

### Project output - Server:

1. Worker thread: tid and pid
2. Confirmation of listener thread creation
3. Status message (listening on port X)

```
Creating worker thread: [tid #0, pid #3931]
Creating worker thread: [tid #1, pid #3931]
Creating worker thread: [tid #2, pid #3931]
Creating worker thread: [tid #3, pid #3931]
Creating worker thread: [tid #4, pid #3931]
Creating worker thread: [tid #5, pid #3931]
Creating worker thread: [tid #6, pid #3931]
Creating worker thread: [tid #7, pid #3931]
Creating worker thread: [tid #8, pid #3931]
Creating worker thread: [tid #9, pid #3931]
[TEST] Hi listener is created
HTTP server listening on port 2023
```

### Project output – Client:

1. Request thread tid
2. Bytes received
3. Cumulative time taken to process
4. Total number of requests

```

09:58 PM~/csci4730/project2$ ./client vcf0.cs.uga.edu 2023 15
Request: GET vcf0.cs.uga.edu:2023//, # of client: 15
[tid 20411] received 1799 bytes (1.057383 sec).
[tid 20409] received 1799 bytes (1.057758 sec).
[tid 20413] received 1799 bytes (1.056863 sec).
[tid 20414] received 1799 bytes (1.055601 sec).
[tid 20408] received 1799 bytes (1.057901 sec).
[tid 20412] received 1799 bytes (1.057680 sec).
[tid 20407] received 1799 bytes (1.057992 sec).
[tid 20410] received 1799 bytes (1.218623 sec).
[tid 20415] received 1799 bytes (1.215500 sec).
[tid 20416] received 1799 bytes (2.008505 sec).
[tid 20418] received 1799 bytes (2.051494 sec).
[tid 20420] received 1799 bytes (2.050817 sec).
[tid 20419] received 1799 bytes (2.051299 sec).
[tid 20417] received 1799 bytes (2.052270 sec).
[tid 20421] received 1799 bytes (2.050544 sec).
Time to handle 15 requests (0 failed): 2.059505 sec
10:16 PM~/csci4730/project2$ █

```

#### Server output – post client call:

```

[pid 3931, tid 14] Received a request from 128.192.101.135:3177
[pid 3931, tid 14] (from 128.192.101.135:3177) URL: GET / HTTP/1.0
[pid 3931, tid 14] Reply: SUCCEED
[pid 3931, tid 13] Received a request from 128.192.101.135:3179
[pid 3931, tid 13] (from 128.192.101.135:3179) URL: GET / HTTP/1.0
[pid 3931, tid 13] Reply: SUCCEED
[pid 3931, tid 7] Received a request from 128.192.101.135:3181
[pid 3931, tid 7] (from 128.192.101.135:3181) URL: GET / HTTP/1.0
[pid 3931, tid 7] Reply: SUCCEED
[pid 3931, tid 6] Received a request from 128.192.101.135:3183
[pid 3931, tid 6] (from 128.192.101.135:3183) URL: GET / HTTP/1.0
[pid 3931, tid 8] Received a request from 128.192.101.135:3185
[pid 3931, tid 8] (from 128.192.101.135:3185) URL: GET / HTTP/1.0
[pid 3931, tid 11] Received a request from 128.192.101.135:3191
[pid 3931, tid 11] (from 128.192.101.135:3191) URL: GET / HTTP/1.0
[pid 3931, tid 10] Received a request from 128.192.101.135:3189
[pid 3931, tid 10] (from 128.192.101.135:3189) URL: GET / HTTP/1.0
[pid 3931, tid 12] Received a request from 128.192.101.135:3187
[pid 3931, tid 12] (from 128.192.101.135:3187) URL: GET / HTTP/1.0
[pid 3931, tid 8] Reply: SUCCEED
[pid 3931, tid 10] Reply: SUCCEED
[pid 3931, tid 6] Reply: SUCCEED
[pid 3931, tid 11] Reply: SUCCEED
[pid 3931, tid 12] Reply: SUCCEED

```

1. Worker thread tid and pid
2. SUCCESS / FAILURE message

### Time explanation:

Each request if processed 1 at a time will take 1 second on average. That means that when run **sequentially**, the webserver **will take 15 seconds to complete 15 requests**.

```
Request: GET vcf0.cs.uga.edu:2223//, # of client: 15
[tid 60368] received 1799 bytes (1.016844 sec).
[tid 60370] received 1799 bytes (2.018176 sec).
[tid 60372] received 1799 bytes (3.019005 sec).
[tid 60373] received 1799 bytes (4.020126 sec).
[tid 60369] received 1799 bytes (5.021420 sec).
[tid 60371] received 1799 bytes (6.022296 sec).
[tid 60374] received 1799 bytes (7.022476 sec).
[tid 60375] received 1799 bytes (8.021408 sec).
[tid 60376] received 1799 bytes (9.020219 sec).
[tid 60379] received 1799 bytes (10.020189 sec).
[tid 60378] received 1799 bytes (11.021228 sec).
[tid 60377] received 1799 bytes (12.022460 sec).
[tid 60380] received 1799 bytes (13.022533 sec).
[tid 60381] received 1799 bytes (14.023374 sec).
[tid 60382] received 1799 bytes (15.024347 sec).
Time to handle 15 requests (0 failed): 15.032269 sec
10:40 PM~/csci4730/project2$
```

Through **parallel** threads, we cut down the time of processing GET requests drastically. Thanks to multithreading, each thread **pool** session takes 1 second.

```
Request: GET vcf0.cs.uga.edu:2223//, # of client: 15
[tid 53591] received 1799 bytes (1.009618 sec).
[tid 53589] received 1799 bytes (1.010013 sec).
[tid 53588] received 1799 bytes (1.010102 sec).
[tid 53592] received 1799 bytes (1.009984 sec).
[tid 53593] received 1799 bytes (1.009925 sec).
[tid 53587] received 1799 bytes (1.010915 sec).
[tid 53590] received 1799 bytes (1.011001 sec).
[tid 53595] received 1799 bytes (1.008433 sec).
[tid 53596] received 1799 bytes (1.007437 sec).
[tid 53597] received 1799 bytes (1.007174 sec).
[tid 53598] received 1799 bytes (1.007255 sec).
[tid 53599] received 1799 bytes (1.007704 sec).
[tid 53601] received 1799 bytes (1.007622 sec).
[tid 53600] received 1799 bytes (1.007871 sec).
[tid 53602] received 1799 bytes (1.008198 sec).
Time to handle 15 requests (0 failed): 1.014219 sec
10:35 PM~/csci4730/project2$
```

The above example used a 15 threadpool – So, for 15 requests, we only need **1 pool session** to run process all requests – resulting in a 1 second handling time



```
Request: GET vcf0.cs.uga.edu:2223//, # of client: 30
[tid 69605] received 1799 bytes (1.021779 sec).
[tid 69603] received 1799 bytes (1.022010 sec).
[tid 69608] received 1799 bytes (1.020375 sec).
[tid 69601] received 1799 bytes (1.022050 sec).
[tid 69602] received 1799 bytes (1.022545 sec).
[tid 69604] received 1799 bytes (1.022628 sec).
[tid 69606] received 1799 bytes (1.022155 sec).
[tid 69607] received 1799 bytes (1.022825 sec).
[tid 69609] received 1799 bytes (1.019897 sec).
[tid 69610] received 1799 bytes (1.018387 sec).
[tid 69611] received 1799 bytes (1.017586 sec).
[tid 69613] received 1799 bytes (1.016256 sec).
[tid 69612] received 1799 bytes (1.017622 sec).
[tid 69614] received 1799 bytes (1.016142 sec).
[tid 69617] received 1799 bytes (1.016496 sec).
[tid 69616] received 1799 bytes (2.012748 sec).
[tid 69615] received 1799 bytes (2.012971 sec).
[tid 69618] received 1799 bytes (2.011737 sec).
[tid 69619] received 1799 bytes (2.011369 sec).
[tid 69621] received 1799 bytes (2.010366 sec).
[tid 69622] received 1799 bytes (2.010090 sec).
[tid 69620] received 1799 bytes (2.011313 sec).
[tid 69623] received 1799 bytes (2.010241 sec).
[tid 69624] received 1799 bytes (2.009598 sec).
[tid 69625] received 1799 bytes (2.010007 sec).
[tid 69626] received 1799 bytes (2.010135 sec).
[tid 69627] received 1799 bytes (2.010156 sec).
[tid 69628] received 1799 bytes (2.010295 sec).
[tid 69629] received 1799 bytes (2.008841 sec).
[tid 69630] received 1799 bytes (2.007982 sec).
time to handle 30 requests (0 failed): 2.027256 sec
```

The above picture uses the same **15 thread pool** to handle **30 GET requests**. The process will take 2 pool sessions to complete. Thus, it takes **2 seconds through parallel processing**. If we had run everything sequentially, the **process would have taken 30 seconds**.

#### Logic Explanation:

The server utilizes 2 threads to process requests – the listenerthread and the workerthread. The workerthread is initialized as a threadpool set by the user. When the client sends a request, the listener stores the request in an array **buffer**. The threadpool traverses through the buffer and takes out the socket value sent by the client, then sends them through the process.

The project utilizes 2 semaphores (empty, full), and a semaphore functioning as a lock (mutex). The mutex lock prevents race conditions and deadlock by preventing items in the buffer from being changed at the same time process is called.

```
sem_wait(&semEmpty); //empty buffer count -1
sem_wait(&semMutex);

buffer[buffermarker] = s;
buffermarker = buffermarker+1;

sem_post(&semMutex);
sem_post(&semFull); //full buffer count +1;
```

We use two separate integers to mark our places in the buffer- 'buffermarker' for the listener, and 'bufferat' for the worker string. The two work independently of each other to ensure a parallel process.

### Crash handling:

Crash handling should be able to be called via ./webserver\_multi [port number] [thread pool number] [crash rate].

However, even when using the parameter crash rate, I was unable to trigger a crash. The client reported all bytes received satisfactorily.

```
11:13 PM-/csci4730/project2$ ./webserver_multi 2224 15 50
reating worker thread: [tid #0, pid #17836]
reating worker thread: [tid #1, pid #17836]
reating worker thread: [tid #2, pid #17836]
reating worker thread: [tid #3, pid #17836]
reating worker thread: [tid #4, pid #17836]
reating worker thread: [tid #5, pid #17836]
reating worker thread: [tid #6, pid #17836]
reating worker thread: [tid #7, pid #17836]
reating worker thread: [tid #8, pid #17836]
reating worker thread: [tid #9, pid #17836]
reating worker thread: [tid #10, pid #17836]
reating worker thread: [tid #11, pid #17836]
reating worker thread: [tid #12, pid #17836]
reating worker thread: [tid #13, pid #17836]
reating worker thread: [tid #14, pid #17836]
TEST) Hi listener is created
HTTP server listening on port 2224
pid 17836, tid 1] Received a request from 128.192.101.135:4140
pid 17836, tid 1] (from 128.192.101.135:4140) URL: GET / HTTP/1.0
pid 17836, tid 2] Received a request from 128.192.101.135:4142
pid 17836, tid 2] (from 128.192.101.135:4142) URL: GET / HTTP/1.0
pid 17836, tid 3] Received a request from 128.192.101.135:4144
pid 17836, tid 3] (from 128.192.101.135:4144) URL: GET / HTTP/1.0
pid 17836, tid 4] Received a request from 128.192.101.135:4146
pid 17836, tid 4] (from 128.192.101.135:4146) URL: GET / HTTP/1.0
pid 17836, tid 5] Received a request from 128.192.101.135:4148
pid 17836, tid 5] (from 128.192.101.135:4148) URL: GET / HTTP/1.0
pid 17836, tid 4] Reply: SUCCEED
pid 17836, tid 1] Reply: SUCCEED
pid 17836, tid 6] Received a request from 128.192.101.135:4150
pid 17836, tid 6] (from 128.192.101.135:4150) URL: GET / HTTP/1.0
pid 17836, tid 3] Reply: SUCCEED
pid 17836, tid 7] Received a request from 128.192.101.135:4152
pid 17836, tid 7] (from 128.192.101.135:4152) URL: GET / HTTP/1.0
pid 17836, tid 6] Reply: SUCCEED
pid 17836, tid 8] Received a request from 128.192.101.135:4154
pid 17836, tid 8] (from 128.192.101.135:4154) URL: GET / HTTP/1.0
pid 17836, tid 5] Reply: SUCCEED
pid 17836, tid 9] Received a request from 128.192.101.135:4156
pid 17836, tid 9] (from 128.192.101.135:4156) URL: GET / HTTP/1.0
pid 17836, tid 8] Reply: SUCCEED
pid 17836, tid 10] Received a request from 128.192.101.135:4158
pid 17836, tid 10] (from 128.192.101.135:4158) URL: GET / HTTP/1.0
[pid 8636] received 242 bytes (2.007415 sec).
[pid 8637] received 242 bytes (2.007793 sec).
[pid 8639] received 242 bytes (2.007915 sec).
[pid 8638] received 242 bytes (2.008240 sec).
[pid 8640] received 242 bytes (2.007355 sec).
Time to handle 30 requests (0 failed): 2.021305 sec
11:01 PM-/csci4730/project2$ ^C
11:01 PM-/csci4730/project2$ ./client vcf0.cs.uga.edu 2224
Request: GET vcf0.cs.uga.edu:2223/, # of client: 30
Could not connect: Connection refused
11:14 PM-/csci4730/project2$ ./client vcf0.cs.uga.edu 2224
Request: GET vcf0.cs.uga.edu:2224/, # of client: 30
[pid 26534] received 1799 bytes (1.002684 sec).
[pid 26506] received 1799 bytes (1.016453 sec).
[pid 26508] received 1799 bytes (1.016824 sec).
[pid 26511] received 1799 bytes (1.016834 sec).
[pid 26512] received 1799 bytes (1.016600 sec).
[pid 26509] received 1799 bytes (1.017954 sec).
[pid 26514] received 1799 bytes (1.013844 sec).
[pid 26513] received 1799 bytes (1.015897 sec).
[pid 26507] received 1799 bytes (1.018550 sec).
[pid 26515] received 1799 bytes (1.012916 sec).
[pid 26516] received 1799 bytes (1.012026 sec).
[pid 26517] received 1799 bytes (1.012231 sec).
[pid 26518] received 1799 bytes (1.012483 sec).
[pid 26519] received 1799 bytes (1.012481 sec).
[pid 26520] received 1799 bytes (1.012611 sec).
[pid 26521] received 1799 bytes (2.009148 sec).
[pid 26523] received 1799 bytes (2.008143 sec).
[pid 26522] received 1799 bytes (2.008689 sec).
[pid 26524] received 1799 bytes (2.008378 sec).
[pid 26525] received 1799 bytes (2.008328 sec).
[pid 26526] received 1799 bytes (2.007760 sec).
[pid 26527] received 1799 bytes (2.007995 sec).
[pid 26528] received 1799 bytes (2.007687 sec).
[pid 26529] received 1799 bytes (2.007628 sec).
[pid 26531] received 1799 bytes (2.006561 sec).
[pid 26530] received 1799 bytes (2.007883 sec).
[pid 26532] received 1799 bytes (2.007119 sec).
[pid 26533] received 1799 bytes (2.007209 sec).
[pid 26535] received 1799 bytes (2.007637 sec).
[pid 26510] received 1799 bytes (2.021417 sec).
Time to handle 30 requests (0 failed): 2.022231 sec
11:14 PM-/csci4730/project2$
```

Even at crash rate 50, the server navigated all requests successfully.