Processes v Threads

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Summary

After much experimentation, processes have come out to be slightly more effective then threads. In theory this appears to be a plausable outcome, but is not the one that was expected. Due to the lighter nature of threads in comparison to processes I hypothesised they would likely come out faster. But weight in this hypothesis was in terms of how long it would take to startup the process or thread. Concidering the architecture of most CPU's the results in hinesite appears more obvious then what I had predicted.

In thoery, it would make sense that processes would be more effective, given the timesliced system used by most CPU's. Using threads, the program only gets a single CPU timeslice to execute its threads, which attempt to work in parallel to complete the computations. Processes on the other hand each get a time slice and with the use of multiple cores can aswell work in parallel but over multiple timeslices. This gives the program conciderable more running time vs the idle time incurred by threads having to run within a single timeslice and then having to wait until the process had another turn. Additionaly threads have to maintian synchronization which can drag out a threads execution time or time before a thread can begin.

Calculations & I/O

The calculations used to incure work was the decomposition of the product of two prime numbers. Instead of using loops during the calculation though, the work was split up so that it would create more individual tasks, and thus would test more the efficiency of the parallel functionality of processes and threads. This would reduce the mathematical intensity of a single processes task, but puts more reliance on the thread and process management in terms of speed of completion. Each “task” that a process or thread recieves is a number and then a divisor. The thread or process then calculates if the number is divisible by the divisor, if so then divides the number and produces more tasks for that resulted value so that they can be tested as to whether it can be divided further. If they are divisble and the divisor comes out as 1 and the original number is greater then 1 at this point, it can be safely stated that this number is a prime number.

Note that the logic may appear to give an error in the event the user enters a product not made up of prime numbers. In this case the program will fail and will identify non-prime numbers as the roots of the product. This can then prove that the number given was not a product of primes. This would show though an incorrect use of the program and inaccurate benchmarking of the system, thus making it invalid and out of scope of the programs purpose.

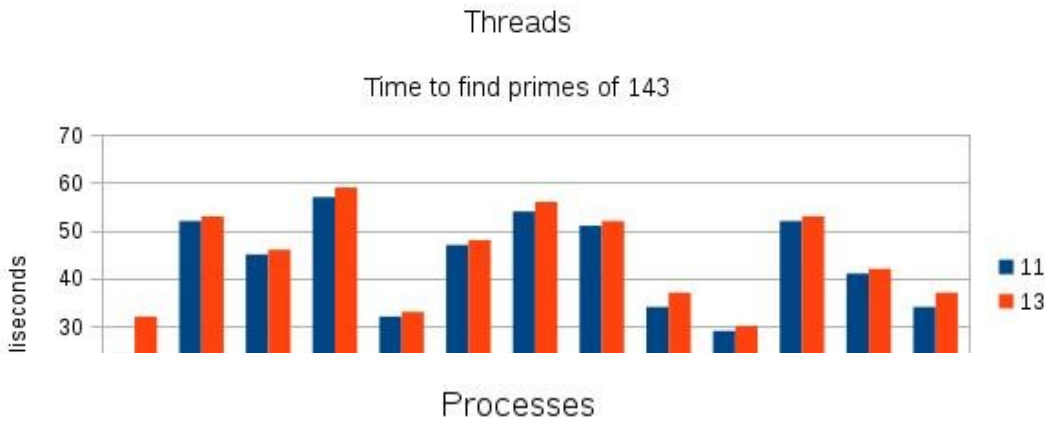
I/O use was simply implemented by the use of aggressive logging. Both console logging and file logging is used on both programs to simulate high I/O. Console logging outputs notes at vaious points and steps of the computation process. I/O to file then outputs only formal information which this analysis is based on. None of the console logging nor file writing is protected with mutexes or semaphores and thus leaves the fight over the I/O resources directly in the hands of the processes and

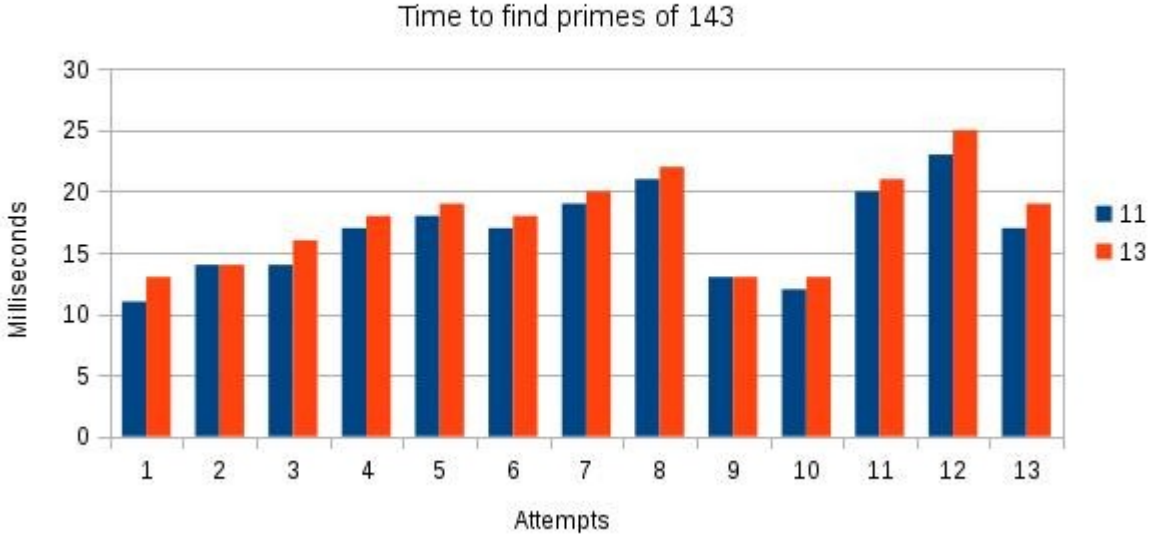
threads. Although file writes are atomic, this puts extra strain specifically on the processes and thread parallism, testing their efficiency.

I/O to the file contains two unique measurements by the program for examination of efficiency. The first and most frequent numbers are the time it takes for a process or thread to complete an evaluation of the number and divisor. On average, both threads and processes in this area act relatively the same. Reasoning of this is likely due to the time here is just how fast the CPU can get through a function. This value could vary depending on system CPU power, caching and resources available at the time of execution. The large difference comes from the second value which calculates the time it took to finaly find a root prime. This measurement is most valuable because it shows how effective the processes vs the threads were in taking as much of the CPU resources as possible, to come to the calculation.

Graph Charts

Below diagrams the time it took to find the prime numbers 11 and 13 that made up the product of 143. The Y-Axis marks how many milliseconds it took to find the prime and the X-Axis marks each execution attempt of the program. Colored in blue and red are each prime number that make up the product. The first diagram is attempts using threading, the second uses processes.





From these charts we can see Threads average finding the prime numbers on average around 40ms. Process though, average finding the prime numbers in 15-20ms. The difference is quite substantial as the average of processess computation time is still better then the Thread's best attempt (attempts number 1) where it finds 11 in roughly 24 ms.

Valgrind

Memcheck

Processess

```
==7326==
==7326== HEAP SUMMARY:
==7326==     in use at exit: 72,704 bytes in 1 blocks
==7326==   total heap usage: 3,487 allocs, 3,486 frees, 407,836 bytes allocated
==7326==
==7324==
==7324== HEAP SUMMARY:
==7324==     in use at exit: 72,704 bytes in 1 blocks
==7324==   total heap usage: 3,664 allocs, 3,663 frees, 638,888 bytes allocated
==7324==
==7326== LEAK SUMMARY:
==7326==    definitely lost: 0 bytes in 0 blocks
==7326==    indirectly lost: 0 bytes in 0 blocks
==7326==      possibly lost: 0 bytes in 0 blocks
==7326==    still reachable: 72,704 bytes in 1 blocks
==7326==         suppressed: 0 bytes in 0 blocks
==7326== Reachable blocks (those to which a pointer was found) are not shown.
==7326== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==7326==
==7326== For counts of detected and suppressed errors, rerun with: -v
==7326== Use --track-origins=yes to see where uninitialised values come from
==7326== ERROR SUMMARY: 52 errors from 3 contexts (suppressed: 0 from 0)
==7324== LEAK SUMMARY:
==7324==    definitely lost: 0 bytes in 0 blocks
==7324==    indirectly lost: 0 bytes in 0 blocks
==7324==      possibly lost: 0 bytes in 0 blocks
==7324==    still reachable: 72,704 bytes in 1 blocks
==7324==         suppressed: 0 bytes in 0 blocks
==7324== Reachable blocks (those to which a pointer was found) are not shown.
==7324== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==7324==
==7324== For counts of detected and suppressed errors, rerun with: -v
==7324== Use --track-origins=yes to see where uninitialised values come from
==7324== ERROR SUMMARY: 104 errors from 3 contexts (suppressed: 0 from 0)
==7327==
==7327== HEAP SUMMARY:
==7327==     in use at exit: 72,704 bytes in 1 blocks
==7327==   total heap usage: 3,421 allocs, 3,420 frees, 500,925 bytes allocated
==7327==
==7325==
==7325== HEAP SUMMARY:
==7325==     in use at exit: 72,704 bytes in 1 blocks
==7325==   total heap usage: 3,647 allocs, 3,646 frees, 482,953 bytes allocated
==7325==
==7327== LEAK SUMMARY:
==7327==    definitely lost: 0 bytes in 0 blocks
==7327==    indirectly lost: 0 bytes in 0 blocks
==7327==      possibly lost: 0 bytes in 0 blocks
==7327==    still reachable: 72,704 bytes in 1 blocks
==7327==         suppressed: 0 bytes in 0 blocks
==7327== Reachable blocks (those to which a pointer was found) are not shown.
==7327== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==7327==
```

```
==7327==         suppressed: 0 bytes in 0 blocks
==7327== Reachable blocks (those to which a pointer was found) are not shown.
==7327== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==7327==
==7327== For counts of detected and suppressed errors, rerun with: -v
==7327== Use --track-origins=yes to see where uninitialised values come from
==7327== ERROR SUMMARY: 74 errors from 3 contexts (suppressed: 0 from 0)
==7325== LEAK SUMMARY:
==7325==    definitely lost: 0 bytes in 0 blocks
==7325==    indirectly lost: 0 bytes in 0 blocks
==7325==      possibly lost: 0 bytes in 0 blocks
==7325==    still reachable: 72,704 bytes in 1 blocks
==7325==         suppressed: 0 bytes in 0 blocks
==7325== Reachable blocks (those to which a pointer was found) are not shown.
==7325== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==7325==
==7325== For counts of detected and suppressed errors, rerun with: -v
==7325== Use --track-origins=yes to see where uninitialised values come from
==7325== ERROR SUMMARY: 62 errors from 3 contexts (suppressed: 0 from 0)
==7323==
==7323== HEAP SUMMARY:
==7323==     in use at exit: 72,704 bytes in 1 blocks
==7323==   total heap usage: 3,243 allocs, 3,242 frees, 399,754 bytes allocated
==7323==
==7323== LEAK SUMMARY:
==7323==    definitely lost: 0 bytes in 0 blocks
==7323==    indirectly lost: 0 bytes in 0 blocks
==7323==      possibly lost: 0 bytes in 0 blocks
==7323==    still reachable: 72,704 bytes in 1 blocks
==7323==         suppressed: 0 bytes in 0 blocks
==7323== Reachable blocks (those to which a pointer was found) are not shown.
==7323== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==7323==
==7323== For counts of detected and suppressed errors, rerun with: -v
==7323== Use --track-origins=yes to see where uninitialised values come from
==7323== ERROR SUMMARY: 52 errors from 3 contexts (suppressed: 0 from 0)
About To Return in Parent
==7322==
==7322== HEAP SUMMARY:
==7322==     in use at exit: 72,704 bytes in 1 blocks
==7322==   total heap usage: 2,875 allocs, 2,874 frees, 197,318 bytes allocated
==7322==
==7322== LEAK SUMMARY:
==7322==    definitely lost: 0 bytes in 0 blocks
==7322==    indirectly lost: 0 bytes in 0 blocks
==7322==      possibly lost: 0 bytes in 0 blocks
==7322==    still reachable: 72,704 bytes in 1 blocks
==7322==         suppressed: 0 bytes in 0 blocks
==7322== Reachable blocks (those to which a pointer was found) are not shown.
==7322== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==7322==
==7322== For counts of detected and suppressed errors, rerun with: -v
==7322== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
```

As you can see each processes has no leaks other then some being still reachable. After some research this was found to be caused by the GMP library and how it handles releasing memory space.

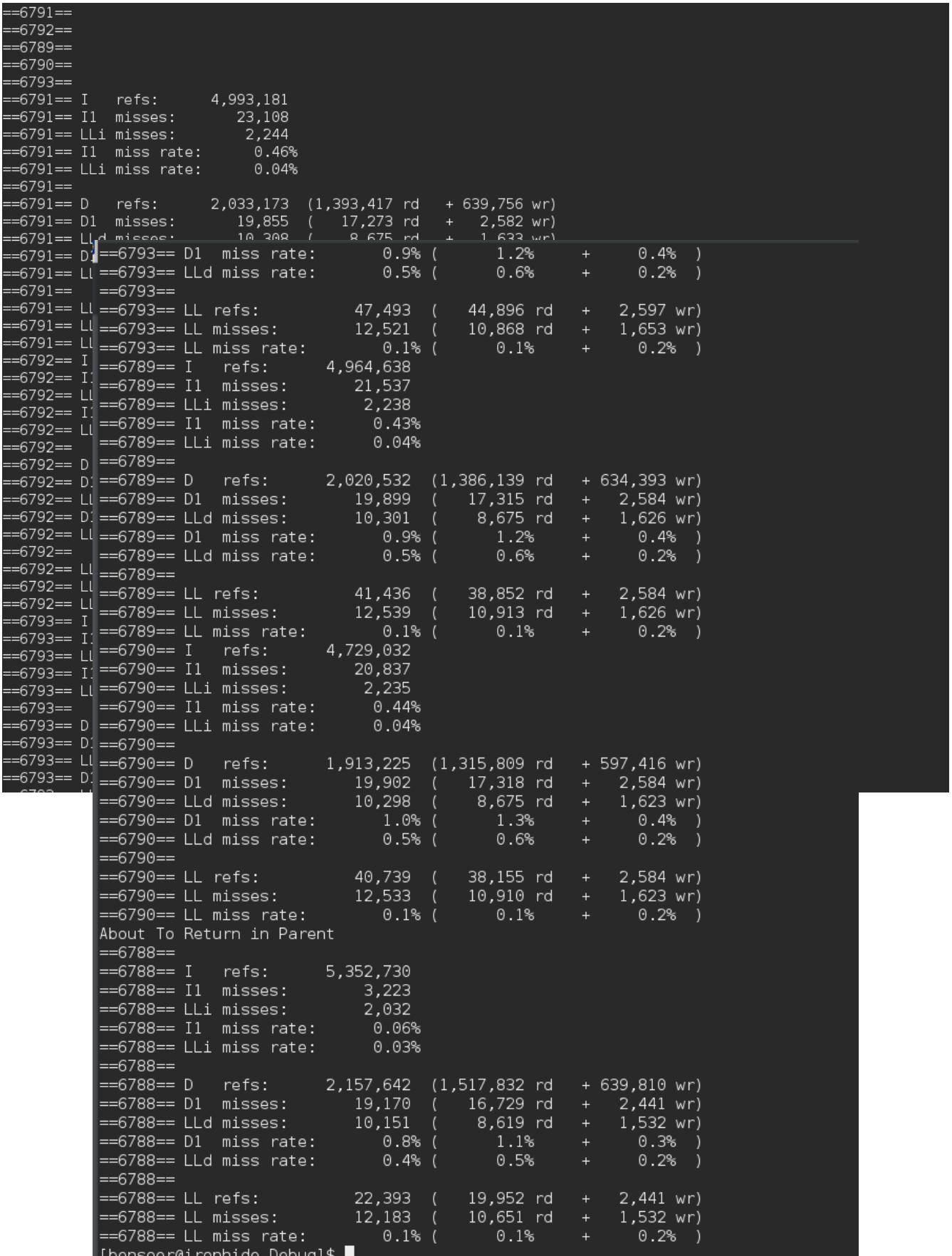
Threads

```
==7693==
==7693== HEAP SUMMARY:
==7693==     in use at exit: 76,496 bytes in 379 blocks
==7693==   total heap usage: 19,001 allocs, 36,438 frees, 1,782,516 bytes allocated
==7693==
==7693== LEAK SUMMARY:
==7693==    definitely lost: 3,792 bytes in 378 blocks
==7693==    indirectly lost: 0 bytes in 0 blocks
==7693==      possibly lost: 0 bytes in 0 blocks
==7693==    still reachable: 72,704 bytes in 1 blocks
==7693==         suppressed: 0 bytes in 0 blocks
==7693== Rerun with --leak-check=full to see details of leaked memory
==7693==
==7693== For counts of detected and suppressed errors, rerun with: -v
==7693== ERROR SUMMARY: 18162 errors from 25 contexts (suppressed: 0 from 0)
```

The thread implementation interestingly had more issues with the GMP library in releasing data. 3792 bytes are lost during each execution of the program. This could have some effect on performance, although it is not large as the thread program has relatively consistent runtimes, making the conclusion that a memory shortage is not interfereing with its performance

Cachegrind

Processess



From here we can see the cache usage in processes is moderatly effective, with a couple of the processes having cache misses over 0.50%. The majority of the processes though had cache miss rates under 0.50% and some below 0.1%. We can see eventhough processess involve context switching by the OS, because of the similarities of purpose in the processes, the program was able to use the cache to its benefit.

Threads

```
==6747==
==6747== I   refs:      70,444,436
==6747== I1  misses:        90,366
==6747== LLi misses:         2,406
==6747== I1  miss rate:       0.12%
==6747== LLi miss rate:       0.00%
==6747==
==6747== D   refs:      29,146,366  (19,538,457 rd   + 9,607,909 wr)
==6747== D1  misses:        55,542  (    23,403 rd   +    32,139 wr)
==6747== LLd misses:        35,926  (     8,688 rd   +    27,238 wr)
==6747== D1  miss rate:        0.1% (       0.1%     +       0.3%  )
==6747== LLd miss rate:        0.1% (       0.0%     +       0.2%  )
==6747==
==6747== LL refs:          145,908  (   113,769 rd   +    32,139 wr)
==6747== LL misses:         38,332  (    11,094 rd   +    27,238 wr)
==6747== LL miss rate:         0.0% (       0.0%     +       0.2%  )
[bensoer@ironhide Debug]$
```

Using threads interestingly enough has a highly effective use of cache. This is likely because of the shared memory used throughout the program causing consistent requests for the same pieces of data in the same locations. This shows that eventhough there were some memory leaks imposed by GMP, the effect was marginal, and the threads obviously had the advantage of a good cache while they were executing.