NBGOS Performance Report

Testers: Meghan Dorian, Shiwei Huang, & Muneeba Syed

Purpose: The purpose of this report is to observe how different parameters affect the performance of the NBGOS operating system and to determine the relationship of quantum size and degree of multiprogramming, which will optimize the performance indicated by CPU utilization.

Assumptions and Definitions: [ranges are inclusive]

We worked with a total of five data sets generated using the C++ rand() function. Each file contained 30 jobs with the same set of start times and job IDs but with uniquely-generated IO probabilities between 1% and 5% and job lengths (see pg 4 for data sets).

The files we tested included:

* One control file containing jobs with a length of 500 milliseconds
* One file containing short jobs between 20 and 500 milliseconds
* One file containing long jobs between 500 and 3600 milliseconds
* Two files containing a mix of jobs lengths between 20 and 3600 milliseconds

Other assumptions included:

* High degree of multiprogramming: 8-10
* Middle degree of multiprogramming: 4-7
* Low degree of multiprogramming: 1-3

Based on the median IO probability (3%) and IO time (15 ms), the approximate IO time during 30 second simulation was 13500ms. Therefore, expected CPU utilization ignoring swap-time would be 16500/30000 or 55%. Our goal was to complete half or more of the incoming jobs in order for our simulation software to perform at an acceptable standard.

Method:

For each data set, we ran the simulation software with a simulation time of 30 seconds.

We tested for the combination of degree (1-10) and quantum time in multiples of ten (10 - 100) for a total of 100 runs per data set. Then, we recorded the number of jobs completed and percentage of CPU utilization.

Interpretation:

We started with Control Jobs (pg 5), which gave us a maximum CPU utilization of 18.55% at degree (of multiprogramming) 10 and quantum 80ms. Degree 10 at quantum of 80, 90, and 100 milliseconds all tied for the highest number of jobs completed during the simulation. Simulations with higher degrees saw little change in performance, in both number of jobs completed and CPU utilization than lower degrees, among the different quantum sizes.

From there, we moved to our Short Jobs (pg 6) where the highest CPU utilization was 13.76% at degree 8 and quantum 70ms. The maximum number of completed jobs was 16, which was at degrees 9 and 10 with 80ms and 60ms respectively. We found this to be the most unstable data set, as there was a higher variance across the results than in any other of the tests. This was most likely due to the CPU having to wait between swapping out jobs as they finished faster than in any of the other data sets.

Our first mixed data set (pg 7) netted interesting results, as higher degrees showed more stable trends in CPU utilization and the lower degrees appeared more erratic. In our highest CPU utilization across all data sets (55.5%), it was surprising that it occurred at degree 10 and quantum of 20ms as most of the highest percentages (and completed jobs)  arose in the lower right hand corner of most tables (ie, high degrees of multiprogramming and mid-to-high quantums).

Mixed Files B (pg 8) set showed the most stable trends overall. Here, variances in CPU utility came in tenths of a percent or even less. The highest number of jobs completed was an outlier of 15 jobs at degree 10 quantum 70ms, but seven different quantums at degree 10 tied for second place with 10 completed jobs.

Finally, our data set with Long Jobs (pg 9) also showed very stable trends. The top CPU utilizations varied by hundredths of a percent around 59.45%, and were all at degree 10. The number of jobs completed stayed identical regardless of changes in quantum with only minor exceptions.

Conclusion:

We found that overall, a quantum of 70ms gave higher CPU utilization rates especially when paired with a degree of multiprogramming of 10. However, the NBGOS operating system still does not perform desirably because, even at its most optimal degree and quantum, it skips well over half of the incoming jobs and does not usually perform at or above 55% of CPU utility.

By testing hundreds of combinations of quantums and degrees of multiprogramming on a variety of test sets, we believe that the number of processes allowed in the system is a much more important factor in determining system performance than increasing quantum size. When looking at a graph like CPU utilization for Mixed Files A, it is easy to see that increasing the degree of multiprogramming yields higher results than increasing the quantum sizes. In every single test, degrees 7 and higher are at the top of the graph, regardless of that test’s CPU utilization range. In the test of Short Jobs, the CPU utilization never went beyond 14%, whereas in Mixed Files A, it hit 55%. Lower degrees were always the lines that hugged the lower ranges for its respective tests, such as in Mixed Files A when degree 3 hit 9.8% of CPU utilization at quantum 80ms or in the test with long jobs when the run with degree 1 with a quantum of 90ms was only at 7.8% of CPU utilization. In the control jobs file, no degree less than 8 ever hit 14% (relatively high for this test) of CPU utilization.

In contrast, quantum sizes are substantially less influential in deciding a test’s results. In Long Jobs, the differences in increasing a quantum size by 10ms are so minimal that the slopes appear to be nearly zero. Differences here were all by tenths or smaller units, and the same could be said for Mixed Files B. Mixed Files A showed some variation across quantum sizes, but the same graph showed that the degree of multiprogramming brought the results closer to our goal. Short Jobs showed the same overall trend of degree playing a stronger role than quantum size, but with a larger range in CPU utilization and number of jobs completed than other tests. Instead of the results differing by tenths or hundredths, the outcomes differed up to 4 percentage points on CPU utility and 4 completed jobs. The same tendency is seen in Control Jobs, where the results differed up to 7% and 4 completed jobs across the fourth degree.

With the sole exception of a few runs in Short Jobs, our simulation only completed around one-third of the given jobs in the 30 seconds rather than the half we were aiming for. However, we were more successful in terms of CPU utilization; in Long Jobs, Mixed Files A, and Mixed Files B, higher degrees of programming consistently brought us over 40% of CPU utilization and therefore closer to our goal of 55%. Our initial expectation was that with our simulation time, half or more of the given jobs would have been completed regardless of the trends in CPU utilization. As is seen here, at our highest CPU utilization (55.5% in Mixed Files A) only 11 jobs were completed; conversely, when 16 jobs were completed in Short Jobs, the CPU utilization was approximately 13.6% in those runs. Therefore, based on these test results, our initial hypothesis was incorrect and the correlation between CPU utilization and number of jobs completed was not as strong as we had thought.

In order to increase performance under the current conditions, we suggest adding a second CPU to the system. This is because the current probability for a process needing IO is small compared to the probability it will need the CPU each clock-tick. A second CPU would help decrease the number of processes in the ready queue at a given clock-tick as well as increase throughput. It will reduce the waiting and turnaround time for all processes, and will likely reduce the number of skipped jobs as well. With two CPUs, the overall CPU utilization percentage and number of completed jobs would be much higher, therefore bringing us closer to our definition of an acceptable system performance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Control Jobs File**  30  5 1 1 500  30 2 4 500  97 3 3 500  104 4 4 500  311 5 1 500  319 6 3 500  575 7 5 500  645 8 3 500  665 9 3 500  1233 10 5 500  1272 11 1 500  1273 12 3 500  1294 13 2 500  1317 14 5 500  1323 15 4 500  1359 16 5 500  1371 17 1 500  1587 18 4 500  1615 19 5 500  1672 20 4 500  1762 21 2 500  1799 22 1 500  1971 23 4 500  2023 24 3 500  2051 25 3 500  2137 26 2 500  2322 27 3 500  2398 28 1 500  2398 29 1 500  2489 30 4 500 | **Short Jobs File**  30  5 1 5 249  30 2 1 67  97 3 3 150  104 4 2 407  311 5 2 456  319 6 3 34  575 7 4 320  645 8 5 195  665 9 1 335  1233 10 2 491  1272 11 4 330  1273 12 3 204  1294 13 4 102  1317 14 2 176  1323 15 5 172  1359 16 2 405  1371 17 5 80  1587 18 1 252  1615 19 3 284  1672 20 2 216  1762 21 5 190  1799 22 5 377  1971 23 4 468  2023 24 3 508  2051 25 5 322  2137 26 2 76  2322 27 4 225  2398 28 1 71  2398 29 1 345  2489 30 5 202 | **Long Jobs File**  30  5 1 4 1695  30 2 5 2067  97 3 5 3747  104 4 3 1059  311 5 4 2018  319 6 4 1303  575 7 5 1663  645 8 2 2764  665 9 5 950  1233 10 3 499  1272 11 1 538  1273 12 5 3596  1294 13 3 3108  1317 14 5 2796  1323 15 1 1009  1359 16 1 2768  1371 17 2 1856  1587 18 4 635  1615 19 5 3030  1672 20 2 3459  1762 21 2 645  1799 22 3 1250  1971 23 4 1205  2023 24 2 1200  2051 25 1 3568  2137 26 5 1138  2322 27 4 2570  2398 28 5 578  2398 29 4 934  2489 30 5 3548 | **Mixed A File**  30  5 1 5 1170  30 2 1 161  97 3 2 1085  104 4 3 793  311 5 1 2951  319 6 4 2933  575 7 4 1889  645 8 3 1651  665 9 3 525  1233 10 4 929  1272 11 5 2253  1273 12 4 1664  1294 13 4 2641  1317 14 3 2522  1323 15 1 1377  1359 16 3 1953  1371 17 2 874  1587 18 2 1123  1615 19 1 1532  1672 20 5 1344  1762 21 2 312  1799 22 1 1360  1971 23 5 743  2023 24 4 682  2051 25 5 256  2137 26 2 2296  2322 27 3 2972  2398 28 1 2632  2398 29 1 1914  2489 30 5 2456 | **Mixed B File**  30  5 1 5 1143  30 2 1 1680  97 3 2 1154  104 4 2 1632  311 5 2 978  319 6 2 2855  575 7 3 222  645 8 3 2510  665 9 4 991  1233 10 4 852  1272 11 2 496  1273 12 5 496  1294 13 4 1685  1317 14 2 1257  1323 15 1 1230  1359 16 4 617  1371 17 4 1838  1587 18 5 1691  1615 19 4 572  1672 20 3 2438  1762 21 2 2137  1799 22 5 307  1971 23 2 343  2023 24 4 375  2051 25 2 1532  2137 26 2 505  2322 27 1 150  2398 28 5 501  2398 29 4 2307  2489 30 5 586 |