

RAND				
memory size	simple loop	blocked	matmul	worstcase
50	Hit rate: 70.7484 Hit count: 7222 Miss count: 2986 Overall evictions: 2936 Clean evictions: 136 Dirty evictions: 2800	Hit rate: 99.6518 Hit count: 2409716 Miss count: 8420 Overall evictions: 8370 Clean evictions: 3085 Dirty evictions: 5285	Hit rate: 65.5417 Hit count: 1892756 Miss count: 995108 Overall evictions: 995058 Clean evictions: 478149 Dirty evictions: 516909	Hit rate: 33.5749 Hit count: 13250 Miss count: 26214 Overall evictions: 26164 Clean evictions: 304 Dirty evictions: 25860
100	Hit rate: 72.9036 Hit count: 7442 Miss count: 2766 Overall evictions: 2666 Clean evictions: 43 Dirty evictions: 2623	Hit rate: 99.7821 Hit count: 2412866 Miss count: 5270 Overall evictions: 5170 Clean evictions: 1842 Dirty evictions: 3328	Hit rate: 88.7799 Hit count: 2563842 Miss count: 324022 Overall evictions: 323922 Clean evictions: 158383 Dirty evictions: 165539	Hit rate: 34.9990 Hit count: 13812 Miss count: 25652 Overall evictions: 25552 Clean evictions: 148 Dirty evictions: 25404
150	Hit rate: 73.4326 Hit count: 7496 Miss count: 2712 Overall evictions: 2562 Clean evictions: 11 Dirty evictions: 2551	Hit rate: 99.8188 Hit count: 2413755 Miss count: 4381 Overall evictions: 4231 Clean evictions: 1532 Dirty evictions: 2699	Hit rate: 96.6502 Hit count: 2791125 Miss count: 96739 Overall evictions: 96589 Clean evictions: 47273 Dirty evictions: 49316	Hit rate: 35.5666 Hit count: 14036 Miss count: 25428 Overall evictions: 25278 Clean evictions: 76 Dirty evictions: 25202
200	Hit rate: 73.4326 Hit count: 7496 Miss count: 2712 Overall evictions: 2512 Clean evictions: 11 Dirty evictions: 2501	Hit rate: 99.8405 Hit count: 2414278 Miss count: 3858 Overall evictions: 3658 Clean evictions: 1317 Dirty evictions: 2341	Hit rate: 98.0466 Hit count: 2831452 Miss count: 56412 Overall evictions: 56212 Clean evictions: 27481 Dirty evictions: 28731	Hit rate: 35.7414 Hit count: 14105 Miss count: 25359 Overall evictions: 25159 Clean evictions: 58 Dirty evictions: 25101

FIFO				
memory size	simple loop	blocked	matmul	worstcase
50	Hit rate: 70.8464 Hit count: 7232 Miss count: 2976 Overall evictions: 2926 Clean evictions: 128 Dirty evictions: 2798	Hit rate: 99.7311 Hit count: 2411634 Miss count: 6502 Overall evictions: 6452 Clean evictions: 2116 Dirty evictions: 4336	Hit rate: 60.9653 Hit count: 1760595 Miss count: 1127269 Overall evictions: 1127219 Clean evictions: 541682 Dirty evictions: 585537	Hit rate: 33.6813 Hit count: 13292 Miss count: 26172 Overall evictions: 26122 Clean evictions: 300 Dirty evictions: 25822
100	Hit rate: 73.0016 Hit count: 7452 Miss count: 2756 Overall evictions: 2656 Clean evictions: 32 Dirty evictions: 2624	Hit rate: 99.8206 Hit count: 2413799 Miss count: 4337 Overall evictions: 4237 Clean evictions: 1397 Dirty evictions: 2840	Hit rate: 62.4793 Hit count: 1804318 Miss count: 1083546 Overall evictions: 1083446 Clean evictions: 530670 Dirty evictions: 552776	Hit rate: 35.0851 Hit count: 13846 Miss count: 25618 Overall evictions: 25518 Clean evictions: 132 Dirty evictions: 25386
150	Hit rate: 73.3836 Hit count: 7491 Miss count: 2717 Overall evictions: 2567 Clean evictions: 8 Dirty evictions: 2559	Hit rate: 99.8252 Hit count: 2413910 Miss count: 4226 Overall evictions: 4076 Clean evictions: 1366 Dirty evictions: 2710	Hit rate: 98.8085 Hit count: 2853454 Miss count: 34410 Overall evictions: 34260 Clean evictions: 16665 Dirty evictions: 17595	Hit rate: 35.5108 Hit count: 14014 Miss count: 25450 Overall evictions: 25300 Clean evictions: 83 Dirty evictions: 25217
200	Hit rate: 73.4620 Hit count: 7499 Miss count: 2709 Overall evictions: 2509 Clean evictions: 6 Dirty evictions: 2503	Hit rate: 99.8687 Hit count: 2414962 Miss count: 3174 Overall evictions: 2974 Clean evictions: 1001 Dirty evictions: 1973	Hit rate: 98.8265 Hit count: 2853975 Miss count: 33889 Overall evictions: 33689 Clean evictions: 16250 Dirty evictions: 17439	Hit rate: 35.7338 Hit count: 14102 Miss count: 25362 Overall evictions: 25162 Clean evictions: 61 Dirty evictions: 25101

CLOCK				
memory size	simple loop	blocked	matmul	worstcase
50	Hit rate: 72.6097 Hit count: 7412 Miss count: 2796 Overall evictions: 2746 Clean evictions: 69 Dirty evictions: 2677	Hit rate: 99.7823 Hit count: 2412872 Miss count: 5264 Overall evictions: 5214 Clean evictions: 1467 Dirty evictions: 3747	Hit rate: 63.9439 Hit count: 1846613 Miss count: 1041251 Overall evictions: 1041201 Clean evictions: 520112 Dirty evictions: 521089	Hit rate: 36.1621 Hit count: 14271 Miss count: 25193 Overall evictions: 25143 Clean evictions: 47 Dirty evictions: 25096
100	Hit rate: 73.6579 Hit count: 7519 Miss count: 2689 Overall evictions: 2589 Clean evictions: 4 Dirty evictions: 2585	Hit rate: 99.8340 Hit count: 2414123 Miss count: 4013 Overall evictions: 3913 Clean evictions: 1332 Dirty evictions: 2581	Hit rate: 63.9519 Hit count: 1846843 Miss count: 1041021 Overall evictions: 1040921 Clean evictions: 519985 Dirty evictions: 520936	Hit rate: 36.3420 Hit count: 14342 Miss count: 25122 Overall evictions: 25022 Clean evictions: 4 Dirty evictions: 25018
150	Hit rate: 73.6873 Hit count: 7522 Miss count: 2686 Overall evictions: 2536 Clean evictions: 0 Dirty evictions: 2536	Hit rate: 99.8372 Hit count: 2414200 Miss count: 3936 Overall evictions: 3786 Clean evictions: 1326 Dirty evictions: 2460	Hit rate: 98.8500 Hit count: 2854654 Miss count: 33210 Overall evictions: 33060 Clean evictions: 16131 Dirty evictions: 16929	Hit rate: 36.3496 Hit count: 14345 Miss count: 25119 Overall evictions: 24969 Clean evictions: 0 Dirty evictions: 24969
200	Hit rate: 73.7069 Hit count: 7524 Miss count: 2684 Overall evictions: 2484 Clean evictions: 0 Dirty evictions: 2484	Hit rate: 99.8681 Hit count: 2414947 Miss count: 3189 Overall evictions: 2989 Clean evictions: 1065 Dirty evictions: 1924	Hit rate: 98.8606 Hit count: 2854960 Miss count: 32904 Overall evictions: 32704 Clean evictions: 15988 Dirty evictions: 16716	Hit rate: 36.3547 Hit count: 14347 Miss count: 25117 Overall evictions: 24917 Clean evictions: 0 Dirty evictions: 24917

LRU				
memory size	simple loop	blocked	matmul	worstcase
50	Hit rate: 72.7763 Hit count: 7429 Miss count: 2779 Overall evictions: 2729 Clean evictions: 65 Dirty evictions: 2664	Hit rate: 99.7844 Hit count: 2412922 Miss count: 5214 Overall evictions: 5164 Clean evictions: 1433 Dirty evictions: 3731	Hit rate: 63.9448 Hit count: 1846638 Miss count: 1041226 Overall evictions: 1041176 Clean evictions: 520102 Dirty evictions: 521074	Hit rate: 36.2102 Hit count: 14290 Miss count: 25174 Overall evictions: 25124 Clean evictions: 43 Dirty evictions: 25081
100	Hit rate: 73.6971 Hit count: 7523 Miss count: 2685 Overall evictions: 2585 Clean evictions: 2 Dirty evictions: 2583	Hit rate: 99.8435 Hit count: 2414351 Miss count: 3785 Overall evictions: 3685 Clean evictions: 1327 Dirty evictions: 2358	Hit rate: 65.1488 Hit count: 1881408 Miss count: 1006456 Overall evictions: 1006356 Clean evictions: 502791 Dirty evictions: 503565	Hit rate: 36.3547 Hit count: 14347 Miss count: 25117 Overall evictions: 25017 Clean evictions: 1 Dirty evictions: 25016
150	Hit rate: 73.7167 Hit count: 7525 Miss count: 2683 Overall evictions: 2533 Clean evictions: 0 Dirty evictions: 2533	Hit rate: 99.8441 Hit count: 2414367 Miss count: 3769 Overall evictions: 3619 Clean evictions: 1318 Dirty evictions: 2301	Hit rate: 98.8612 Hit count: 2854977 Miss count: 32887 Overall evictions: 32737 Clean evictions: 16018 Dirty evictions: 16719	Hit rate: 36.3572 Hit count: 14348 Miss count: 25116 Overall evictions: 24966 Clean evictions: 0 Dirty evictions: 24966
200	Hit rate: 73.7167 Hit count: 7525 Miss count: 2683 Overall evictions: 2483 Clean evictions: 0 Dirty evictions: 2483	Hit rate: 99.8472 Hit count: 2414440 Miss count: 3696 Overall evictions: 3496 Clean evictions: 1281 Dirty evictions: 2215	Hit rate: 98.8616 Hit count: 2854988 Miss count: 32876 Overall evictions: 32676 Clean evictions: 15985 Dirty evictions: 16691	Hit rate: 36.3572 Hit count: 14348 Miss count: 25116 Overall evictions: 24916 Clean evictions: 0 Dirty evictions: 24916

OPT				
memory size	simple loop	blocked	matmul	worstcase
50	Hit rate: 73.8734 Hit count: 7541 Miss count: 2667 Overall evictions: 2617 Clean evictions: 17 Dirty evictions: 2600	Hit rate: 99.8467 Hit count: 2414429 Miss count: 3707 Overall evictions: 3657 Clean evictions: 1319 Dirty evictions: 2338	Hit rate: 79.6578 Hit count: 2300409 Miss count: 587455 Overall evictions: 587405 Clean evictions: 293413 Dirty evictions: 293992	Hit rate: 36.3268 Hit count: 14336 Miss count: 25128 Overall evictions: 25078 Clean evictions: 11 Dirty evictions: 25067
100	Hit rate: 74.1085 Hit count: 7565 Miss count: 2643 Overall evictions: 2543 Clean evictions: 0 Dirty evictions: 2543	Hit rate: 99.8755 Hit count: 2415126 Miss count: 3010 Overall evictions: 2910 Clean evictions: 1043 Dirty evictions: 1867	Hit rate: 96.7866 Hit count: 2795066 Miss count: 92798 Overall evictions: 92698 Clean evictions: 46006 Dirty evictions: 46692	Hit rate: 36.3572 Hit count: 14348 Miss count: 25116 Overall evictions: 25016 Clean evictions: 0 Dirty evictions: 25016
150	Hit rate: 74.1085 Hit count: 7565 Miss count: 2643 Overall evictions: 2493 Clean evictions: 0 Dirty evictions: 2493	Hit rate: 99.8955 Hit count: 2415609 Miss count: 2527 Overall evictions: 2377 Clean evictions: 827 Dirty evictions: 1550	Hit rate: 99.0784 Hit count: 2861249 Miss count: 26615 Overall evictions: 26465 Clean evictions: 12927 Dirty evictions: 13538	Hit rate: 36.3572 Hit count: 14348 Miss count: 25116 Overall evictions: 24966 Clean evictions: 0 Dirty evictions: 24966
200	Hit rate: 74.1085 Hit count: 7565 Miss count: 2643 Overall evictions: 2443 Clean evictions: 0 Dirty evictions: 2443	Hit rate: 99.9058 Hit count: 2415859 Miss count: 2277 Overall evictions: 2077 Clean evictions: 655 Dirty evictions: 1422	Hit rate: 99.3329 Hit count: 2868599 Miss count: 19265 Overall evictions: 19065 Clean evictions: 9238 Dirty evictions: 9827	Hit rate: 36.3572 Hit count: 14348 Miss count: 25116 Overall evictions: 24916 Clean evictions: 0 Dirty evictions: 24916

Why do I found the forth program interesting?

This program I wrote does very simple things. It just iterates over all the pages, for each page this program will write an integer at an address within this page. However, what makes this program interesting is that it has a very large range of page numbers, which means that the pages we want to reference are very unlikely to be in physical memory, so the hit rates are consistently low, regardless of what algorithm we choose.

One paragraph comparing various algorithms

Hit rate is positively related to memory size. In overall, all algorithm's hit rates increase as memory sizes increase. Among these algorithms, OPT has the highest hit rate under any memory size or choice of trace program, since it uses future reference to decide page to evict. RAND algorithm sometimes performs pretty well under small memory sizes. Using RAND on "matmul" program will give us a second highest hit rate among all the five algorithms, only a bit less than OPT, but in overall, RAND has the lowest hit rate in most cases. FIFO performs slightly better than RAND, but not as good as LRU and CLOCK. It does not work well on "matmul", because FIFO always prefers to replace the oldest page in memory while matrix multiplication need to have access to old pages. LRU and CLOCK algorithms have close performances,

because they both take recent reference into consideration. Pages that are recently been used are less likely to be replaced. Their hit rates are similar, but in general LRU is higher. Lastly, under extreme cases, (the forth program) hit rates for all algorithms are low, so the hit rate also depends a lot on ratio of physical memory size and total address space needed.

Data obtained for LRU as memory size increases

Hit rate of LRU increases with the increment of memory size. LRU keep a record of recently used page. Frequently used pages are more likely to stay in frame for a long time while less used pages can be evicted easily. A larger memory size means more pages are consider least recent used to LRU, so the hit rate will increase. Other than the property of increasing hit rate, a huge gap of hit rate between memory size 100 and 150 when running the “matmul” program is also noteworthy. The reason why this happened is probably because there is a critical value of memory size between 100 and 150, specifically for the “matmul”. When the memory size is below the critical value, there exists some pages that are used frequently by “matmul” moving in and out between memory and swap files, and thus the hit rate is relatively low, but if we increase the memory size until it outstrips the critical value, the memory becomes large enough to put in all the pages that are frequently in use. So, all the active pages are in the physical memory simultaneously and there will be less page moving. Hit rate is therefore increased by a big step.