

ECE318 Operating Systems



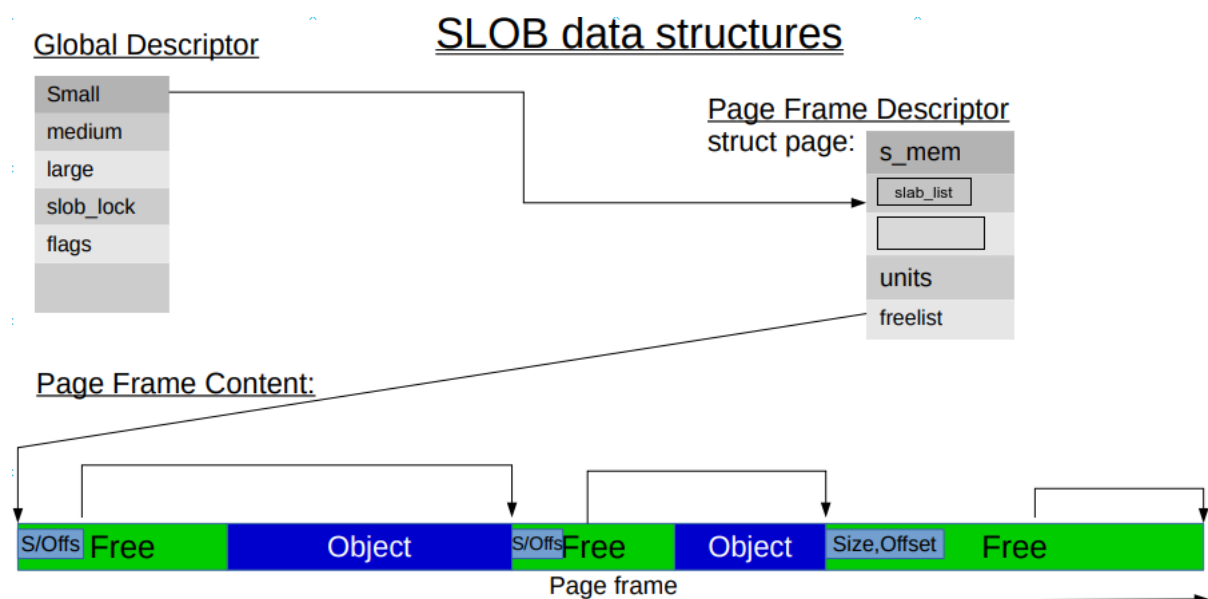
Assignment 3

SLOB Memory allocation: First Fit VS Best Fit

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Project Description

For this project we had to experiment on the SLOB memory allocator of the Linux kernel. Our task was to switch the internal policies of the SLOB allocator and create a version that uses the Best Fit algorithm

The SLOB allocator uses internally a First Fit (??) algorithm, to both find the page in which the allocation and to decide which block it will allocate.

By default, Linux uses the SLUB memory allocator as it is more optimized for use in real systems with a lot of memory since it aims to minimize memory hashing. The SLOB allocator on the other hand, is targeted at systems with limited resources, and therefore is designed to be efficient for these systems, at the cost of external memory hashing.

Part A

For part A we swapped the default SLUB allocator for the SLOB version in our kernel and we created a new version that utilizes a Best Fit approach to the allocation.

Before writing the code, we wanted to see how the original SLOB works and we simply run the machine without making any tweaks. When using SLOB we noticed a severe drop in performance compared to the default SLUB allocator, which confirms what theory tells us.

For the tweaks part of part A, we wanted to find the best fitting block for each allocation. To do that, we changed how the page the allocation takes place is chosen. Our approach, was to loop through the available pages list, and search for the one with the best fitting block by looping the available blocks in the page. A pointer was kept to the current best fitting block at all times. The allocation only took place if a memory block was found, with the exact size as that of the requested one or if all the blocks were searched. In both cases, the current best fitting block was used for the allocation.

Furthermore, every few thousand allocations log files are kept to show the algorithm is working properly. These messages can be disabled with a specified flag.

```

[ 79.102147] slob_alloc: Request: 12
[ 79.102148] slob_alloc: Candidate block size:
[ 79.102148] 4
[ 79.102149] 28
[ 79.102149] 28
[ 79.102149] 8
[ 79.102149] 4
[ 79.102149] 8
[ 79.102149] 1
[ 79.102150] 12
[ 79.102150] 8
[ 79.102150] 4
[ 79.102150] 8
[ 79.102150] 1
[ 79.102151] slob_alloc: Best Fit: 12
[ 79.466234] slob_alloc: Request: 128
[ 79.466234] slob_alloc: Candidate block size:
[ 79.466235] 188
[ 79.466235] 28
[ 79.466235] 32
[ 79.466235] 12
[ 79.466236] slob_alloc: Best Fit: 188
[ 79.831429] slob_alloc: Request: 12
[ 79.831430] slob_alloc: Candidate block size:
[ 79.831430] 16
[ 79.831431] 12
[ 79.831431] 20
[ 79.831431] slob_alloc: Best Fit: 12
[ 80.242202] slob_alloc: Request: 12
[ 80.242202] slob_alloc: Candidate block size:
[ 80.242203] 8
[ 80.242203] 4
[ 80.242203] 4
[ 80.242203] 8
[ 80.242204] 12
[ 80.242204] 16
[ 80.242204] 28
[ 80.242204] 20
[ 80.242204] slob_alloc: Best Fit: 12
[ 80.650403] slob_alloc: Request: 12
[ 80.650404] slob_alloc: Candidate block size:
[ 80.650404] 12
[ 80.650404] 4
[ 80.650404] 12
[ 80.650405] 12
[ 80.650405] 4
[ 80.650405] 12
[ 80.650405] 32
[ 80.650405] 12
[ 80.650405] 112
[ 80.650406] 4
[ 80.650406] 8
[ 80.650406] slob_alloc: Best Fit: 12

```

Here we provide a frame of our logs during the kernel running showing how the Best Fit algorithm works

Part B

For part B we had to measure the performance of our Best Fit implementation against the original First Fit implementation. We wanted to measure the hashing effect the algorithms have on the memory as well as the amount of total memory used and unutilized memory.

To do that, we added measurement variables to our code. These variables hold logistic information on the total page memory allocated, as well as the amount of memory that the kernel does not use. In order to see these analytics, we created a few system calls that print messages on the kernel. In addition, we created system calls to invoke the memory allocator by requesting and freeing memory blocks of various sizes.

Testing

As a first step we wrote 2 very simple programs. One that simply performs 1 allocation and 1 deallocation to check that our methodology is correct and another that prints the total allocated page memory and the total unused memory.

To test our Best Fit implementation against the First Fit SLOB we wrote a user-level program to invoke the SLOB allocator. The program takes as input the number of allocations we want to take place as well as the maximum size that can be allocated in each iteration. In order to better simulate the real time behavior of our system we use a random number generator to choose the amount of memory that will be allocated between 1 and the maximum specified amount.

Results

To compare the two implementations we conducted three experiments. Each experiment run for a total of 20000 with a different maximum allocation amount each time and the same seed for the number generation. We used 3 different maximum sizes to check 3 different cases small allocations (up to 256 Bytes), medium allocations (up to 4 KiloBytes) and large allocations (up to 16 Kilobytes).

The different starting positions of each test we observe is due to the different state of our system when running each test.

While running the small First Fit test we observed that both the allocated page memory and the amount of unused memory remain more or less the same with really minor differences in size.

Start of the log file

```
1 page_mem 702709760 unused_mem 563247334 ratio 0.801536
2 page_mem 702709760 unused_mem 563247050 ratio 0.801536
3 page_mem 702709760 unused_mem 563246904 ratio 0.801536
4 page_mem 702709760 unused_mem 563246737 ratio 0.801535
5 page_mem 702709760 unused_mem 563246612 ratio 0.801535
6 page_mem 702709760 unused_mem 563246566 ratio 0.801535
7 page_mem 702709760 unused_mem 563246370 ratio 0.801535
8 page_mem 702709760 unused_mem 563246247 ratio 0.801535
9 page_mem 702709760 unused_mem 563246050 ratio 0.801534
10 page_mem 702709760 unused_mem 563245914 ratio 0.801534
11 page_mem 702709760 unused_mem 563245791 ratio 0.801534
12 page_mem 702709760 unused_mem 563245587 ratio 0.801534
13 page_mem 702709760 unused_mem 563245352 ratio 0.801533
14 page_mem 702709760 unused_mem 563245092 ratio 0.801533
15 page_mem 702709760 unused_mem 563245034 ratio 0.801533
16 page_mem 702709760 unused_mem 563244912 ratio 0.801533
17 page_mem 702709760 unused_mem 563244791 ratio 0.801533
18 page_mem 702709760 unused_mem 563244738 ratio 0.801533
19 page_mem 702709760 unused_mem 563244574 ratio 0.801532
20 page_mem 702709760 unused_mem 563244485 ratio 0.801532
21 page_mem 702709760 unused_mem 563244463 ratio 0.801532
22 page_mem 702709760 unused_mem 563244241 ratio 0.801532
23 page_mem 702709760 unused_mem 563244093 ratio 0.801532
24 page_mem 702709760 unused_mem 563244018 ratio 0.801532
25 page_mem 702709760 unused_mem 563243885 ratio 0.801531
26 page_mem 702709760 unused_mem 563243870 ratio 0.801531
27 page_mem 702709760 unused_mem 563243846 ratio 0.801531
28 page_mem 702709760 unused_mem 563243757 ratio 0.801531
29 page_mem 702709760 unused_mem 563243638 ratio 0.801531
30 page_mem 702709760 unused_mem 563243457 ratio 0.801531
31 page_mem 702709760 unused_mem 563243264 ratio 0.801530
32 page_mem 702709760 unused_mem 563243219 ratio 0.801530
33 page_mem 702709760 unused_mem 563243202 ratio 0.801530
34 page_mem 702709760 unused_mem 563243128 ratio 0.801530
35 page_mem 702709760 unused_mem 563242925 ratio 0.801530
36 page_mem 702709760 unused_mem 563242792 ratio 0.801530
37 page_mem 702709760 unused_mem 563242681 ratio 0.801530
38 page_mem 702709760 unused_mem 563242547 ratio 0.801529
39 page_mem 702709760 unused_mem 563242300 ratio 0.801529
40 page_mem 702709760 unused_mem 563242257 ratio 0.801529
```

End of the log file

```
39966 page_mem 703225856 unused_mem 563651322 ratio 0.801522
39967 page_mem 703225856 unused_mem 563651440 ratio 0.801523
39968 page_mem 703225856 unused_mem 563651557 ratio 0.801523
39969 page_mem 703225856 unused_mem 563651730 ratio 0.801523
39970 page_mem 703225856 unused_mem 563651822 ratio 0.801523
39971 page_mem 703225856 unused_mem 563651919 ratio 0.801523
39972 page_mem 703225856 unused_mem 563651996 ratio 0.801523
39973 page_mem 703225856 unused_mem 563652023 ratio 0.801523
39974 page_mem 703225856 unused_mem 563652196 ratio 0.801524
39975 page_mem 703225856 unused_mem 563652357 ratio 0.801524
39976 page_mem 703225856 unused_mem 563652443 ratio 0.801524
39977 page_mem 703225856 unused_mem 563652661 ratio 0.801524
39978 page_mem 703225856 unused_mem 563652793 ratio 0.801525
39979 page_mem 703225856 unused_mem 563652971 ratio 0.801525
39980 page_mem 703225856 unused_mem 563653033 ratio 0.801525
39981 page_mem 703225856 unused_mem 563653162 ratio 0.801525
39982 page_mem 703225856 unused_mem 563653338 ratio 0.801525
39983 page_mem 703225856 unused_mem 563653478 ratio 0.801526
39984 page_mem 703225856 unused_mem 563653541 ratio 0.801526
39985 page_mem 703225856 unused_mem 563653773 ratio 0.801526
39986 page_mem 703225856 unused_mem 563653834 ratio 0.801526
39987 page_mem 703225856 unused_mem 563653938 ratio 0.801526
39988 page_mem 703225856 unused_mem 563654100 ratio 0.801526
39989 page_mem 703225856 unused_mem 563654279 ratio 0.801527
39990 page_mem 703225856 unused_mem 563654392 ratio 0.801527
39991 page_mem 703225856 unused_mem 563654445 ratio 0.801527
39992 page_mem 703225856 unused_mem 563654514 ratio 0.801527
39993 page_mem 703225856 unused_mem 563654718 ratio 0.801527
39994 page_mem 703225856 unused_mem 563654922 ratio 0.801528
39995 page_mem 703225856 unused_mem 563655077 ratio 0.801528
39996 page_mem 703225856 unused_mem 563655201 ratio 0.801528
39997 page_mem 703225856 unused_mem 563655372 ratio 0.801528
39998 page_mem 703225856 unused_mem 563655636 ratio 0.801529
39999 page_mem 703225856 unused_mem 563655869 ratio 0.801529
40000
40001
```

While running the medium and large First Fit tests we noticed that both the total page memory and the amount of unused memory increases. What is interesting is the fact that they increase in the same pace.

This means that remarkably all three tests yield the same ratio of unused to total allocated page memory of about 80%.

Start of the log file

End of the log file

```

1 page_mem 704364544 unused_mem 564873006 ratio 0.801961
2 page_mem 704364544 unused_mem 564871186 ratio 0.801959
3 page_mem 704372736 unused_mem 564879378 ratio 0.801961
4 page_mem 704380928 unused_mem 564887570 ratio 0.801963
5 page_mem 704389120 unused_mem 564895762 ratio 0.801965
6 page_mem 704397312 unused_mem 564903954 ratio 0.801968
7 page_mem 704405504 unused_mem 564912146 ratio 0.801970
8 page_mem 704413696 unused_mem 564920338 ratio 0.801972
9 page_mem 704413696 unused_mem 564917837 ratio 0.801969
10 page_mem 704413696 unused_mem 564916933 ratio 0.801968
11 page_mem 704421888 unused_mem 564925125 ratio 0.801970
12 page_mem 704421888 unused_mem 564923641 ratio 0.801968
13 page_mem 704430080 unused_mem 564931833 ratio 0.801970
14 page_mem 704430080 unused_mem 564930293 ratio 0.801968
15 page_mem 704438272 unused_mem 564938485 ratio 0.801970
16 page_mem 704446464 unused_mem 564946677 ratio 0.801972
17 page_mem 704446464 unused_mem 564944764 ratio 0.801970
18 page_mem 704450560 unused_mem 564944967 ratio 0.801965
19 page_mem 704454656 unused_mem 564947107 ratio 0.801964
20 page_mem 704458752 unused_mem 564948298 ratio 0.801961
21 page_mem 704466944 unused_mem 564956490 ratio 0.801963
22 page_mem 704466944 unused_mem 564955756 ratio 0.801962
23 page_mem 704471040 unused_mem 564957400 ratio 0.801960
24 page_mem 704479232 unused_mem 564965592 ratio 0.801962
25 page_mem 704479232 unused_mem 564963923 ratio 0.801960
26 page_mem 704479232 unused_mem 564962372 ratio 0.801957
27 page_mem 704487424 unused_mem 564970564 ratio 0.801960
28 page_mem 704487424 unused_mem 564969451 ratio 0.801958
29 page_mem 704491520 unused_mem 564969844 ratio 0.801954
30 page_mem 704495616 unused_mem 564971199 ratio 0.801951
31 page_mem 704503808 unused_mem 564979391 ratio 0.801954
32 page_mem 704512000 unused_mem 564987583 ratio 0.801956
33 page_mem 704520192 unused_mem 564995775 ratio 0.801958
34 page_mem 704524288 unused_mem 564997237 ratio 0.801956
35 page_mem 704532480 unused_mem 565005429 ratio 0.801958
36 page_mem 704532480 unused_mem 565004272 ratio 0.801956
37 page_mem 704532480 unused_mem 565003137 ratio 0.801955
38 page_mem 704536576 unused_mem 565005563 ratio 0.801953
39 page_mem 704544768 unused_mem 565013755 ratio 0.801956
40 page_mem 704548864 unused_mem 565014224 ratio 0.801952

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```

39960 page_mem 786620416 unused_mem 632691647 ratio 0.804316
39961 page_mem 786620416 unused_mem 632691647 ratio 0.804316
39962 page_mem 786620416 unused_mem 632691647 ratio 0.804316
39963 page_mem 786616320 unused_mem 632687551 ratio 0.804315
39964 page_mem 786616320 unused_mem 632687551 ratio 0.804315
39965 page_mem 786616320 unused_mem 632688310 ratio 0.804316
39966 page_mem 786616320 unused_mem 632688310 ratio 0.804316
39967 page_mem 786616320 unused_mem 632688310 ratio 0.804316
39968 page_mem 786616320 unused_mem 632688310 ratio 0.804316
39969 page_mem 786616320 unused_mem 632688310 ratio 0.804316
39970 page_mem 786616320 unused_mem 632688310 ratio 0.804316
39971 page_mem 786616320 unused_mem 632688402 ratio 0.804316
39972 page_mem 786616320 unused_mem 632688402 ratio 0.804316
39973 page_mem 786616320 unused_mem 632688402 ratio 0.804316
39974 page_mem 786616320 unused_mem 632688402 ratio 0.804316
39975 page_mem 786612224 unused_mem 632684306 ratio 0.804315
39976 page_mem 786608128 unused_mem 632680210 ratio 0.804314
39977 page_mem 786608128 unused_mem 632680210 ratio 0.804314
39978 page_mem 786608128 unused_mem 632680210 ratio 0.804314
39979 page_mem 786604032 unused_mem 632676114 ratio 0.804313
39980 page_mem 786604032 unused_mem 632676114 ratio 0.804313
39981 page_mem 786604032 unused_mem 632676114 ratio 0.804313
39982 page_mem 786604032 unused_mem 632676114 ratio 0.804313
39983 page_mem 786604032 unused_mem 632676010 ratio 0.804313
39984 page_mem 786604032 unused_mem 632676010 ratio 0.804313
39985 page_mem 786604032 unused_mem 632676010 ratio 0.804313
39986 page_mem 786604032 unused_mem 632676010 ratio 0.804313
39987 page_mem 786599936 unused_mem 632671914 ratio 0.804312
39988 page_mem 786599936 unused_mem 632671914 ratio 0.804312
39989 page_mem 786595840 unused_mem 632667818 ratio 0.804311
39990 page_mem 786591744 unused_mem 632663722 ratio 0.804310
39991 page_mem 786591744 unused_mem 632664347 ratio 0.804311
39992 page_mem 786591744 unused_mem 632664656 ratio 0.804311
39993 page_mem 786591744 unused_mem 632665493 ratio 0.804312
39994 page_mem 786587648 unused_mem 632661397 ratio 0.804311
39995 page_mem 786587648 unused_mem 632661397 ratio 0.804311
39996 page_mem 786583552 unused_mem 632657301 ratio 0.804310
39997 page_mem 786579456 unused_mem 632653205 ratio 0.804309
39998 page_mem 786579456 unused_mem 632653205 ratio 0.804309
39999 page_mem 786579456 unused_mem 632653205 ratio 0.804309
40000 page_mem 786579456 unused_mem 632653205 ratio 0.804309

```

While running our Best Fit implementation for the small test we got better results based on the ratio we are calculating. The ratio of the unused memory to the total allocated memory dropped to 72% instead of and remained stable for that test.

Start of the log file

End of the log file


```

1 page_mem 374243328 unused_mem 272437704 ratio 0.727969
2 page_mem 374247424 unused_mem 272439980 ratio 0.727968
3 page_mem 374255616 unused_mem 272448172 ratio 0.727974
4 page_mem 374263808 unused_mem 272456364 ratio 0.727979
5 page_mem 374272000 unused_mem 272464556 ratio 0.727985
6 page_mem 374280192 unused_mem 272472748 ratio 0.727991
7 page_mem 374288384 unused_mem 272480940 ratio 0.727997
8 page_mem 374296576 unused_mem 272489132 ratio 0.728003
9 page_mem 374300672 unused_mem 272490727 ratio 0.728000
10 page_mem 374300672 unused_mem 272489823 ratio 0.727997
11 page_mem 374308864 unused_mem 272498015 ratio 0.728003
12 page_mem 374308864 unused_mem 272496531 ratio 0.727999
13 page_mem 374317056 unused_mem 272504723 ratio 0.728005
14 page_mem 374317056 unused_mem 272503183 ratio 0.728001
15 page_mem 374325248 unused_mem 272511375 ratio 0.728007
16 page_mem 374333440 unused_mem 272519567 ratio 0.728013
17 page_mem 374337536 unused_mem 272521750 ratio 0.728011
18 page_mem 374341632 unused_mem 272521953 ratio 0.728003
19 page_mem 374341632 unused_mem 272519997 ratio 0.727998
20 page_mem 374345728 unused_mem 272521188 ratio 0.727993
21 page_mem 374353920 unused_mem 272529380 ratio 0.727999
22 page_mem 374353920 unused_mem 272528646 ratio 0.727997
23 page_mem 374358016 unused_mem 272530290 ratio 0.727994
24 page_mem 374366208 unused_mem 272538482 ratio 0.728000
25 page_mem 374370304 unused_mem 272540909 ratio 0.727998
26 page_mem 374370304 unused_mem 272539358 ratio 0.727994
27 page_mem 374378496 unused_mem 272547550 ratio 0.728000
28 page_mem 374378496 unused_mem 272546437 ratio 0.727997
29 page_mem 374382592 unused_mem 272546830 ratio 0.727990
30 page_mem 374386688 unused_mem 272548185 ratio 0.727986
31 page_mem 374394880 unused_mem 272556377 ratio 0.727992
32 page_mem 374403072 unused_mem 272564569 ratio 0.727998
33 page_mem 374411264 unused_mem 272572761 ratio 0.728004
34 page_mem 374415360 unused_mem 272574223 ratio 0.728000
35 page_mem 374423552 unused_mem 272582415 ratio 0.728006
36 page_mem 374423552 unused_mem 272581258 ratio 0.728002
37 page_mem 374423552 unused_mem 272580123 ratio 0.727999
38 page_mem 374423552 unused_mem 272578453 ratio 0.727995
39 page_mem 374431744 unused_mem 272586645 ratio 0.728001
40 page_mem 374435840 unused_mem 272587114 ratio 0.727994

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```

39970 page_mem 373530624 unused_mem 271731022 ratio 0.727467
39971 page_mem 373530624 unused_mem 271731114 ratio 0.727467
39972 page_mem 373530624 unused_mem 271731211 ratio 0.727467
39973 page_mem 373530624 unused_mem 271731288 ratio 0.727467
39974 page_mem 373530624 unused_mem 271731315 ratio 0.727467
39975 page_mem 373530624 unused_mem 271731488 ratio 0.727468
39976 page_mem 373530624 unused_mem 271731649 ratio 0.727468
39977 page_mem 373530624 unused_mem 271731735 ratio 0.727468
39978 page_mem 373530624 unused_mem 271731953 ratio 0.727469
39979 page_mem 373530624 unused_mem 271732085 ratio 0.727469
39980 page_mem 373530624 unused_mem 271732263 ratio 0.727470
39981 page_mem 373530624 unused_mem 271732325 ratio 0.727470
39982 page_mem 373530624 unused_mem 271732454 ratio 0.727470
39983 page_mem 373530624 unused_mem 271732630 ratio 0.727471
39984 page_mem 373530624 unused_mem 271732770 ratio 0.727471
39985 page_mem 373530624 unused_mem 271732833 ratio 0.727471
39986 page_mem 373530624 unused_mem 271733065 ratio 0.727472
39987 page_mem 373530624 unused_mem 271733126 ratio 0.727472
39988 page_mem 373530624 unused_mem 271733230 ratio 0.727472
39989 page_mem 373530624 unused_mem 271733392 ratio 0.727473
39990 page_mem 373530624 unused_mem 271733571 ratio 0.727473
39991 page_mem 373530624 unused_mem 271733684 ratio 0.727474
39992 page_mem 373530624 unused_mem 271733737 ratio 0.727474
39993 page_mem 373530624 unused_mem 271733806 ratio 0.727474
39994 page_mem 373530624 unused_mem 271734010 ratio 0.727475
39995 page_mem 373530624 unused_mem 271734214 ratio 0.727475
39996 page_mem 373530624 unused_mem 271734369 ratio 0.727475
39997 page_mem 373530624 unused_mem 271734493 ratio 0.727476
39998 page_mem 373530624 unused_mem 271734664 ratio 0.727476
39999 page_mem 373530624 unused_mem 271734928 ratio 0.727477
40000 page_mem 373526528 unused_mem 271730832 ratio 0.727474

```

For the medium test on the Best Fit implementation the behaviour was slightly different with the ratio having increasing tendencies, climbing from 72% to 74%.

Start of the log file

End of the log file

```

page_mem 374243328 unused_mem 272437784 ratio 0.727969
page_mem 374247424 unused_mem 272439988 ratio 0.727968
page_mem 374255616 unused_mem 272448172 ratio 0.727974
page_mem 374263888 unused_mem 272456364 ratio 0.727979
page_mem 374272000 unused_mem 272464556 ratio 0.727985
page_mem 374280192 unused_mem 272472748 ratio 0.727991
page_mem 374288384 unused_mem 272480940 ratio 0.727997
page_mem 374296576 unused_mem 272489132 ratio 0.728003
page_mem 374300672 unused_mem 272490727 ratio 0.728000
page_mem 374300672 unused_mem 272489823 ratio 0.727997
page_mem 374308864 unused_mem 272498015 ratio 0.728003
page_mem 374308864 unused_mem 272496531 ratio 0.727999
page_mem 374317056 unused_mem 272504723 ratio 0.728005
page_mem 374317056 unused_mem 272503183 ratio 0.728001
page_mem 374325248 unused_mem 272511375 ratio 0.728007
page_mem 374333440 unused_mem 272519567 ratio 0.728013
page_mem 374337536 unused_mem 272521750 ratio 0.728011
page_mem 374341632 unused_mem 272521953 ratio 0.728003
page_mem 374341632 unused_mem 272519997 ratio 0.727998
page_mem 374345728 unused_mem 272521188 ratio 0.727993
page_mem 374353920 unused_mem 272529380 ratio 0.727999
page_mem 374353920 unused_mem 272528646 ratio 0.727997
page_mem 374358016 unused_mem 272530290 ratio 0.727994
page_mem 374366208 unused_mem 272538482 ratio 0.728000
page_mem 374370304 unused_mem 272540909 ratio 0.727998
page_mem 374370304 unused_mem 272539358 ratio 0.727994
page_mem 374378496 unused_mem 272547550 ratio 0.728000
page_mem 374378496 unused_mem 272546437 ratio 0.727997
page_mem 374382592 unused_mem 272546830 ratio 0.727990
page_mem 374386688 unused_mem 272548185 ratio 0.727986
page_mem 374394880 unused_mem 272556377 ratio 0.727992
page_mem 374403072 unused_mem 272564569 ratio 0.727998
page_mem 374411264 unused_mem 272572761 ratio 0.728004
page_mem 374415360 unused_mem 272574223 ratio 0.728000
page_mem 374423552 unused_mem 272582415 ratio 0.728006
page_mem 374423552 unused_mem 272581258 ratio 0.728002
page_mem 374423552 unused_mem 272580123 ratio 0.727999
page_mem 374423552 unused_mem 272578453 ratio 0.727995
page_mem 374431744 unused_mem 272586645 ratio 0.728001
page_mem 374435840 unused_mem 272587114 ratio 0.727994
page_mem 374439936 unused_mem 272588615 ratio 0.727990

```

```

39953 page_mem 456527872 unused_mem 341423934 ratio 0.747871
39954 page_mem 456527872 unused_mem 341424133 ratio 0.747871
39955 page_mem 456527872 unused_mem 341424133 ratio 0.747871
39956 page_mem 456523776 unused_mem 341428037 ratio 0.747869
39957 page_mem 456523776 unused_mem 341428037 ratio 0.747869
39958 page_mem 456519680 unused_mem 341415941 ratio 0.747867
39959 page_mem 456515584 unused_mem 341411845 ratio 0.747865
39960 page_mem 456511488 unused_mem 341407749 ratio 0.747862
39961 page_mem 456511488 unused_mem 341407749 ratio 0.747862
39962 page_mem 456511488 unused_mem 341407749 ratio 0.747862
39963 page_mem 456507392 unused_mem 341403653 ratio 0.747860
39964 page_mem 456507392 unused_mem 341403653 ratio 0.747860
39965 page_mem 456507392 unused_mem 341404412 ratio 0.747862
39966 page_mem 456507392 unused_mem 341404412 ratio 0.747862
39967 page_mem 456507392 unused_mem 341404412 ratio 0.747862
39968 page_mem 456507392 unused_mem 341404412 ratio 0.747862
39969 page_mem 456507392 unused_mem 341404412 ratio 0.747862
39970 page_mem 456507392 unused_mem 341404412 ratio 0.747862
39971 page_mem 456507392 unused_mem 341404504 ratio 0.747862
39972 page_mem 456507392 unused_mem 341404504 ratio 0.747862
39973 page_mem 456507392 unused_mem 341404504 ratio 0.747862
39974 page_mem 456507392 unused_mem 341404504 ratio 0.747862
39975 page_mem 456503296 unused_mem 341400408 ratio 0.747860
39976 page_mem 456499200 unused_mem 341396312 ratio 0.747857
39977 page_mem 456499200 unused_mem 341396312 ratio 0.747857
39978 page_mem 456499200 unused_mem 341396312 ratio 0.747857
39979 page_mem 456495104 unused_mem 341392216 ratio 0.747855
39980 page_mem 456495104 unused_mem 341392216 ratio 0.747855
39981 page_mem 456495104 unused_mem 341392216 ratio 0.747855
39982 page_mem 456495104 unused_mem 341392216 ratio 0.747855
39983 page_mem 456495104 unused_mem 341392112 ratio 0.747855
39984 page_mem 456495104 unused_mem 341392112 ratio 0.747855
39985 page_mem 456495104 unused_mem 341392112 ratio 0.747855
39986 page_mem 456495104 unused_mem 341392112 ratio 0.747855
39987 page_mem 456491008 unused_mem 341388016 ratio 0.747853
39988 page_mem 456491008 unused_mem 341388016 ratio 0.747853
39989 page_mem 456486912 unused_mem 341383920 ratio 0.747850
39990 page_mem 456482816 unused_mem 341379824 ratio 0.747848
39991 page_mem 456482816 unused_mem 341388449 ratio 0.747850
39992 page_mem 456482816 unused_mem 341380758 ratio 0.747850
39993 page_mem 456478720 unused_mem 341376558 ratio 0.747848
39994 page_mem 456474624 unused_mem 341372462 ratio 0.747845
39995 page_mem 456470528 unused_mem 341368366 ratio 0.747843
39996 page_mem 456466432 unused_mem 341364270 ratio 0.747841
39997 page_mem 456466432 unused_mem 341364270 ratio 0.747841
39998 page_mem 456466432 unused_mem 341364270 ratio 0.747841
39999 page_mem 456466432 unused_mem 341364270 ratio 0.747841
40000 page_mem 456466432 unused_mem 341364270 ratio 0.747841
40001

```

When allocating really big chunks of memory (up to 16KiloBytes) using our Best fit implementation we noticed a different trend. The ratio we were calculating was actually increasing instead of decreasing as the system was left to run. Since the pages in our Linux are 4 KiloBytes long the room left on the pages after successful allocations was not sufficient to service any other request of this size. The operating system handles these requests by allocating new pages. This

accumulates as the system runs for a prolonged period of time, leaving huge memory chunks unused.

Start of the log file

```
1 page_mem 665780224 unused_mem 544015732 ratio 0.817110
2 page_mem 665796608 unused_mem 544031932 ratio 0.817114
3 page_mem 665804800 unused_mem 544040124 ratio 0.817117
4 page_mem 665821184 unused_mem 544056508 ratio 0.817121
5 page_mem 665837568 unused_mem 544072892 ratio 0.817126
6 page_mem 665845760 unused_mem 544081084 ratio 0.817128
7 page_mem 665862144 unused_mem 544097468 ratio 0.817132
8 page_mem 665878528 unused_mem 544113852 ratio 0.817137
9 page_mem 665894912 unused_mem 544130236 ratio 0.817141
10 page_mem 665911296 unused_mem 544146620 ratio 0.817146
11 page_mem 665919488 unused_mem 544154812 ratio 0.817148
12 page_mem 665919488 unused_mem 544153328 ratio 0.817146
13 page_mem 665927680 unused_mem 544161520 ratio 0.817148
14 page_mem 665927680 unused_mem 544159980 ratio 0.817146
15 page_mem 665935872 unused_mem 544168172 ratio 0.817148
16 page_mem 665944064 unused_mem 544176364 ratio 0.817150
17 page_mem 665944064 unused_mem 544174451 ratio 0.817147
18 page_mem 665948160 unused_mem 544174654 ratio 0.817143
19 page_mem 665948160 unused_mem 544172698 ratio 0.817140
20 page_mem 665964544 unused_mem 544189082 ratio 0.817144
21 page_mem 665972736 unused_mem 544197274 ratio 0.817146
22 page_mem 665989120 unused_mem 544213658 ratio 0.817151
23 page_mem 666005504 unused_mem 544230042 ratio 0.817155
24 page_mem 666013696 unused_mem 544238234 ratio 0.817158
25 page_mem 666013696 unused_mem 544236565 ratio 0.817155
26 page_mem 666013696 unused_mem 544235014 ratio 0.817153
27 page_mem 666030080 unused_mem 544251398 ratio 0.817157
28 page_mem 666046464 unused_mem 544267782 ratio 0.817162
29 page_mem 666050560 unused_mem 544268175 ratio 0.817157
30 page_mem 666066944 unused_mem 544284559 ratio 0.817162
31 page_mem 666075136 unused_mem 544292751 ratio 0.817164
32 page_mem 666083328 unused_mem 544300943 ratio 0.817166
33 page_mem 666091520 unused_mem 544309135 ratio 0.817169
34 page_mem 666107904 unused_mem 544325519 ratio 0.817173
35 page_mem 666116096 unused_mem 544333711 ratio 0.817175
36 page_mem 666116096 unused_mem 544332554 ratio 0.817174
```

End of the log file

```
39969 page_mem 870760448 unused_mem 742346536 ratio 0.852527
39970 page_mem 870760448 unused_mem 742346536 ratio 0.852527
39971 page_mem 870760448 unused_mem 742346536 ratio 0.852527
39972 page_mem 870760448 unused_mem 742346536 ratio 0.852527
39973 page_mem 870760448 unused_mem 742346536 ratio 0.852527
39974 page_mem 870760448 unused_mem 742346536 ratio 0.852527
39975 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39976 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39977 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39978 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39979 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39980 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39981 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39982 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39983 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39984 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39985 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39986 page_mem 870756352 unused_mem 742342440 ratio 0.852526
39987 page_mem 870752256 unused_mem 742338344 ratio 0.852525
39988 page_mem 870752256 unused_mem 742338344 ratio 0.852525
39989 page_mem 870748160 unused_mem 742334248 ratio 0.852525
39990 page_mem 870748160 unused_mem 742334248 ratio 0.852525
39991 page_mem 870748160 unused_mem 742334873 ratio 0.852525
39992 page_mem 870748160 unused_mem 742334873 ratio 0.852525
39993 page_mem 870748160 unused_mem 742334769 ratio 0.852525
39994 page_mem 870744064 unused_mem 742330673 ratio 0.852525
39995 page_mem 870744064 unused_mem 742330673 ratio 0.852525
39996 page_mem 870744064 unused_mem 742330673 ratio 0.852525
39997 page_mem 870739968 unused_mem 742326577 ratio 0.852524
39998 page_mem 870739968 unused_mem 742326577 ratio 0.852524
39999 page_mem 870739968 unused_mem 742326577 ratio 0.852524
40000 page_mem 870739968 unused_mem 742326577 ratio 0.852524
40001
```

Conclusions

Our conclusions are that the Best Fit implementation improves the memory hashing by a good amount for small allocations but performs worse for bigger ones.