CMPS 111 - 01
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Assignment 3
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Writeup
This document contains the results of the logging of both the unmodified and the modified FreeBSD kernels. Also, the document contains the hypothesis, procedure, and the analysis of how the team has made some changes to the kernel. This contains the full list of logging outputs that we have observed and we present both the analysis and procedure of how we obtained this result.

Project Objective:

In this project, we had the chance to implement the fat chance algorithm. We used a FreeBSD package called 'stress'. Stress means a procedure of imposing load on the vm. By stressing, we force the system to move pages between the inactive, active, cache, and free queues, and we can see this with logging.

Project:

Hypothesis:
In the beginning of this project, we wanted to shorten the amount of time taken to present logging results to 10 seconds instead of 600 seconds, which was equivalent to 10 minutes. By having logging take so much time, it was hard to present if there are inactive, active, and cache free queues quickly. However, we have modified the virtual memory section of the FreeBSD kernel, we have made the kernel to stress virtual memory and display the statistics on the kernel screen.

For this project, we assumed that the kernel would process its virtual memory stress procedure to run faster. By modifying vm_page.c, vm_pageout.c, we predict that there will be more inactive queues, active queues and free queues and we can see those results on the screen.

Procedure:
In order to see the results of virtual memory stressing, we need to go to the root folder by entering '*cd /'* and then find a directory called *var*. Inside this directory, there will be another directory called '*log'.* This is a directory containing a file "messages" where we can see the statistics of the *stressed* virtual memory of the FreeBSD operating system.

Please type the following to stress the FreeBSD virtual memory:
You must install a '*stress'* package to initiate the stressing procedure of the FreeBSD kernel.
Type: '*pkg install stress'*

Note that one must be on root authority on the kernel to install this package.
To utilize the stress package that was downloaded and installed on the FreeBSD kernel, the following commands must be executed on the command line.

stress [options]

A sample usage of this is as follows.

stress --vm N --vm-bytes B --timeout T
Here N stands for the number of vm workers to be started
B stands for malloc B bytes per vm worker
T is the number of seconds we want the stress workers to timeout after

Using 2 vm workers each with 128 MB, timing out after 10 seconds, we type the following.

stress **--vm** 2 **--vm-bytes** 128M **--timeout** 10s

Log Results:
To show our statistics more clearly, we have used two methods of presenting the data: a graph and sample log data/statistics. The sample log data is more for showing how we obtained our data and what methods we used to compute the graph. We begin with the log messages.

In the following, we see a sample of log messages on vms with two different base memories. The former is a set of log messages obtained from the unmodified kernel, whereas the latter was made after implementing the fat chance algorithm.

Data for the following: stress --vm 25 --vm-bytes 150M --timeout 10s
Base Memory: 2448MB, Swap space: 512MB

Mar 3 11:40:01 suomi kernel: Pages scanned: 10385
Mar 3 11:40:01 suomi kernel: Pages moved from active to inactive: 0
Mar 3 11:40:01 suomi kernel: Pages moved from inactive to cache: 0
Mar 3 11:40:01 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:01 suomi kernel: Pages queued for flush: 0
Mar 3 11:40:02 suomi kernel: Pages scanned: 10718
Mar 3 11:40:02 suomi kernel: Pages moved from active to inactive: 0
Mar 3 11:40:02 suomi kernel: Pages moved from inactive to cache: 0
Mar 3 11:40:02 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:02 suomi kernel: Pages queued for flush: 0
Mar 3 11:40:03 suomi kernel: Pages scanned: 11352
Mar 3 11:40:03 suomi kernel: Pages moved from active to inactive: 0
Mar 3 11:40:03 suomi kernel: Pages moved from inactive to cache: 0
Mar 3 11:40:03 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:03 suomi kernel: Pages queued for flush: 0
Mar 3 11:40:04 suomi kernel: Pages scanned: 12004

Mar 3 11:40:04 suomi kernel: Pages moved from active to inactive: 0
Mar 3 11:40:04 suomi kernel: Pages moved from inactive to cache: 0
Mar 3 11:40:04 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:04 suomi kernel: Pages queued for flush: 0
Mar 3 11:40:05 suomi kernel: Pages scanned: 578391
Mar 3 11:40:05 suomi kernel: Pages moved from active to inactive: 73
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to cache: 4247
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:05 suomi kernel: Pages queued for flush: 0
Mar 3 11:40:05 suomi kernel: Pages scanned: 1144570
Mar 3 11:40:05 suomi kernel: Pages moved from active to inactive: 1507
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to cache: 4432
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:05 suomi kernel: Pages queued for flush: 110
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to cache: 4432
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:05 suomi kernel: Pages queued for flush: 110
Mar 3 11:40:05 suomi kernel: Pages scanned: 1145638
Mar 3 11:40:05 suomi kernel: Pages moved from active to inactive: 1507
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to cache: 5201
Mar 3 11:40:05 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:05 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:06 suomi kernel: Pages scanned: 1146396
Mar 3 11:40:06 suomi kernel: Pages moved from active to inactive: 1507
Mar 3 11:40:06 suomi kernel: Pages moved from inactive to cache: 5201
Mar 3 11:40:06 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:06 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:07 suomi kernel: Pages scanned: 1712460
Mar 3 11:40:07 suomi kernel: Pages moved from active to inactive: 1784
Mar 3 11:40:07 suomi kernel: Pages moved from inactive to cache: 6196
Mar 3 11:40:07 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:07 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:08 suomi kernel: Pages scanned: 1713180
Mar 3 11:40:08 suomi kernel: Pages moved from active to inactive: 1784
Mar 3 11:40:08 suomi kernel: Pages moved from inactive to cache: 6196
Mar 3 11:40:08 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:08 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:09 suomi kernel: Pages scanned: 1713968
Mar 3 11:40:09 suomi kernel: Pages moved from active to inactive: 1784
Mar 3 11:40:09 suomi kernel: Pages moved from inactive to cache: 6196
Mar 3 11:40:09 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:09 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:10 suomi kernel: Pages scanned: 1714827
Mar 3 11:40:10 suomi kernel: Pages moved from active to inactive: 1788
Mar 3 11:40:10 suomi kernel: Pages moved from inactive to cache: 6196
Mar 3 11:40:10 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:10 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:11 suomi kernel: Pages scanned: 2280936
Mar 3 11:40:11 suomi kernel: Pages moved from active to inactive: 2081
Mar 3 11:40:11 suomi kernel: Pages moved from inactive to cache: 6477
Mar 3 11:40:11 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:11 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:12 suomi kernel: Pages scanned: 2281689
Mar 3 11:40:12 suomi kernel: Pages moved from active to inactive: 2081

Mar 3 11:40:12 suomi kernel: Pages moved from inactive to cache: 6477
Mar 3 11:40:12 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:12 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:13 suomi kernel: Pages scanned: 2281692
Mar 3 11:40:13 suomi kernel: Pages moved from active to inactive: 2083
Mar 3 11:40:13 suomi kernel: Pages moved from inactive to cache: 6477
Mar 3 11:40:13 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:13 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:13 suomi kernel: Pages scanned: 2281695
Mar 3 11:40:13 suomi kernel: Pages moved from active to inactive: 2084
Mar 3 11:40:13 suomi kernel: Pages moved from inactive to cache: 6477
Mar 3 11:40:13 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:13 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:15 suomi kernel: Pages scanned: 2281698
Mar 3 11:40:15 suomi kernel: Pages moved from active to inactive: 2086
Mar 3 11:40:15 suomi kernel: Pages moved from inactive to cache: 6477
Mar 3 11:40:15 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:15 suomi kernel: Pages queued for flush: 309
Mar 3 11:40:16 suomi kernel: Pages scanned: 2281704

Data for the following: stress --vm 25 --vm-bytes 150M --timeout 10s
Base Memory: 1759MB, Swap space: 512MB

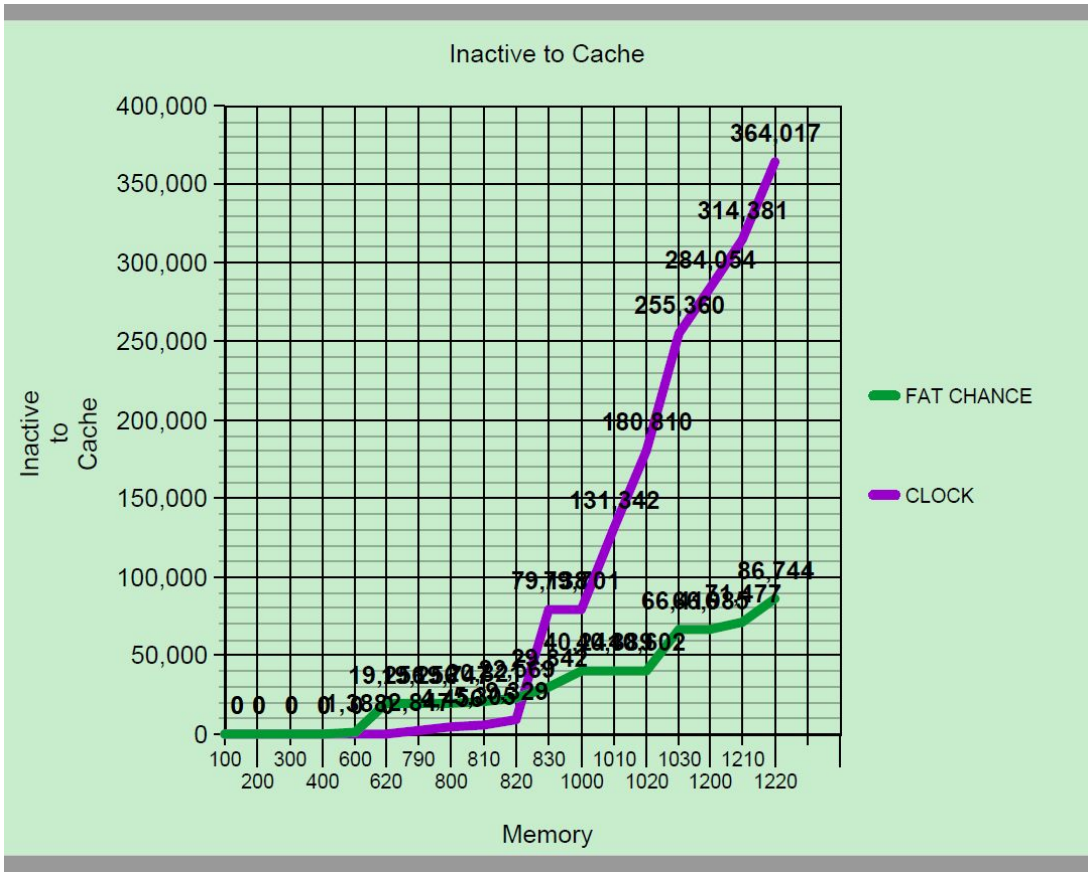
Mar 3 11:40:16 suomi kernel: Pages scanned: 1477
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 0
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 0
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 0
Mar 3 11:40:16 suomi kernel: Pages scanned: 401812
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 0
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 3734
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 0
Mar 3 11:40:16 suomi kernel: Pages scanned: 801479
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 215
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 5097
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 66
Mar 3 11:40:16 suomi kernel: Pages scanned: 902919
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 20012
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 5380
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 72
Mar 3 11:40:16 suomi kernel: Pages scanned: 946469
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 39843
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 5649
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 1352
Mar 3 11:40:16 suomi kernel: Pages scanned: 954244

Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 40372
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 11584
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 2663
Mar 3 11:40:16 suomi kernel: Pages scanned: 960469
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 40372
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 17755
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 2697
Mar 3 11:40:16 suomi kernel: Pages scanned: 966693
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 40372
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 23960
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 2697
Mar 3 11:40:16 suomi kernel: Pages scanned: 972931
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 40372
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 30165
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 2697
Mar 3 11:40:16 suomi kernel: Pages scanned: 1011745
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 44920
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 36370
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 2697
Mar 3 11:40:16 suomi kernel: Pages scanned: 1049614
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 56711
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 42276
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 2996
Mar 3 11:40:16 suomi kernel: Pages scanned: 1088597
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 69409
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 47717
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 3760
Mar 3 11:40:16 suomi kernel: Pages scanned: 1088604
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 69410
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 47717
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 3760
Mar 3 11:40:16 suomi kernel: Pages scanned: 1088611
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 69412
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 47717
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 3760
Mar 3 11:40:16 suomi kernel: Pages scanned: 1088618
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 69419
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 47717
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 3760
Mar 3 11:40:16 suomi kernel: Pages scanned: 1088625
Mar 3 11:40:16 suomi kernel: Pages moved from active to inactive: 69420
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to cache: 47717
Mar 3 11:40:16 suomi kernel: Pages moved from inactive to free: 0
Mar 3 11:40:16 suomi kernel: Pages queued for flush: 3760

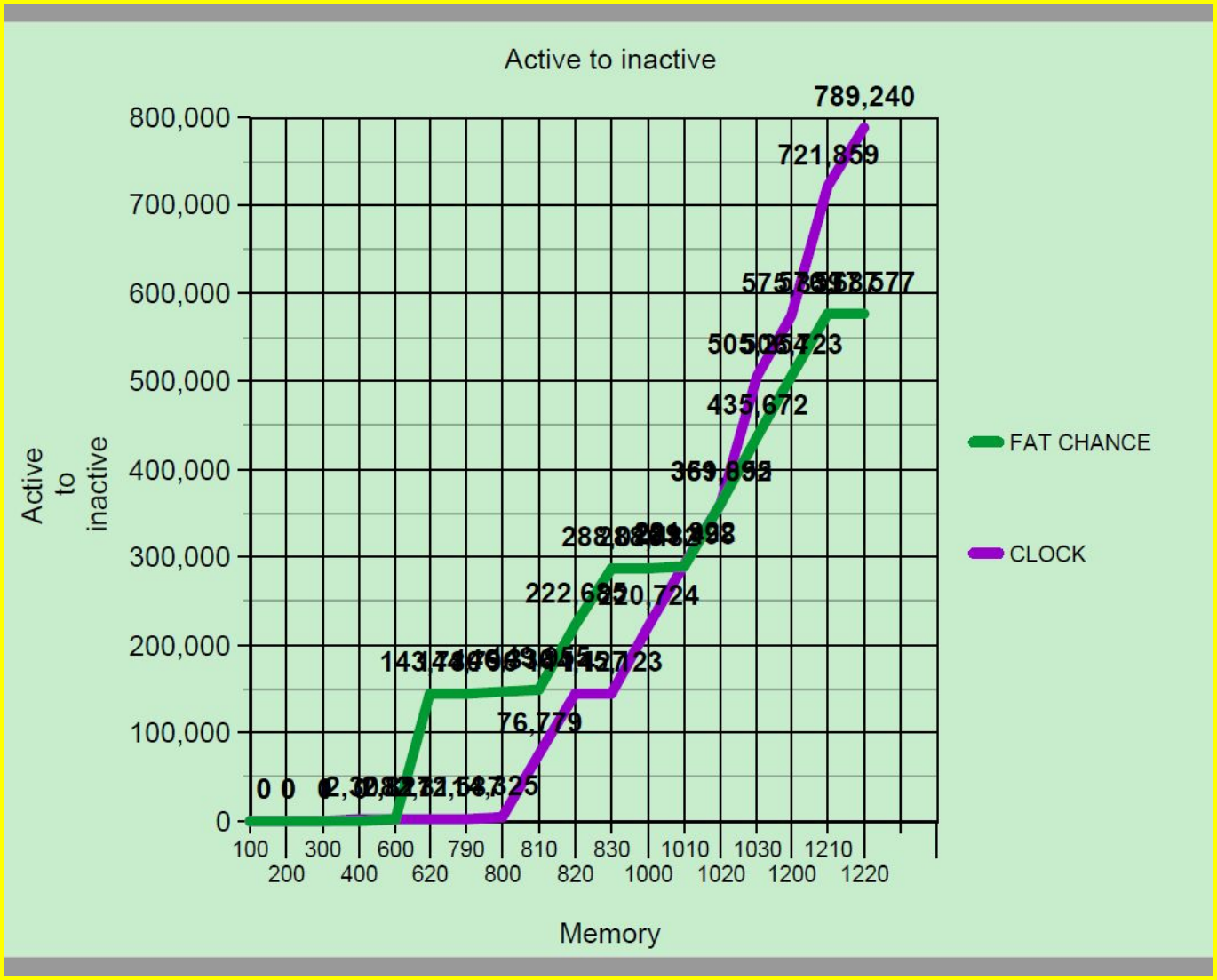
Mar 3 11:40:16 suomi kernel: ***Pages scanned: 1088636***
Mar 3 11:40:16 suomi kernel: ***Pages moved from active to inactive: 69420***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to cache: 47717***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to free: 0***
Mar 3 11:40:16 suomi kernel: ***Pages queued for flush: 3760***
Mar 3 11:40:16 suomi kernel: ***Pages scanned: 1088647***
Mar 3 11:40:16 suomi kernel: ***Pages moved from active to inactive: 69420***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to cache: 47717***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to free: 0***
Mar 3 11:40:16 suomi kernel: ***Pages queued for flush: 3760***
Mar 3 11:40:16 suomi kernel: ***Pages scanned: 1088658***
Mar 3 11:40:16 suomi kernel: ***Pages moved from active to inactive: 69420***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to cache: 47717***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to free: 0***
Mar 3 11:40:16 suomi kernel: ***Pages queued for flush: 3760***
Mar 3 11:40:16 suomi kernel: ***Pages scanned: 1088669***
Mar 3 11:40:16 suomi kernel: ***Pages moved from active to inactive: 69420***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to cache: 47717***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to free: 0***
Mar 3 11:40:16 suomi kernel: ***Pages queued for flush: 3760***
Mar 3 11:40:16 suomi kernel: ***Pages scanned: 1088680***
Mar 3 11:40:16 suomi kernel: ***Pages moved from active to inactive: 69420***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to cache: 47717***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to free: 0***
Mar 3 11:40:16 suomi kernel: ***Pages queued for flush: 3760***
Mar 3 11:40:16 suomi kernel: ***Pages scanned: 1088691***
Mar 3 11:40:16 suomi kernel: ***Pages moved from active to inactive: 69420***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to cache: 47717***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to free: 0***
Mar 3 11:40:16 suomi kernel: ***Pages queued for flush: 3760***
Mar 3 11:40:16 suomi kernel: ***Pages scanned: 1088702***
Mar 3 11:40:16 suomi kernel: ***Pages moved from active to inactive: 69420***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to cache: 47717***
Mar 3 11:40:16 suomi kernel: ***Pages moved from inactive to free: 0***
Mar 3 11:40:16 suomi kernel: ***Pages queued for flush: 3760***

We drew graphs to demonstrate our results. For these graphs, we used the same system - using stress, we sent out 15 vms each at a varying amount of memory (in MB). The x-axis of these graphs represents the number of bytes allocated to each vm worker in MB, and the y-axis represents number of pages as detailed in the log. The vm used had a base memory of around 6 GB.

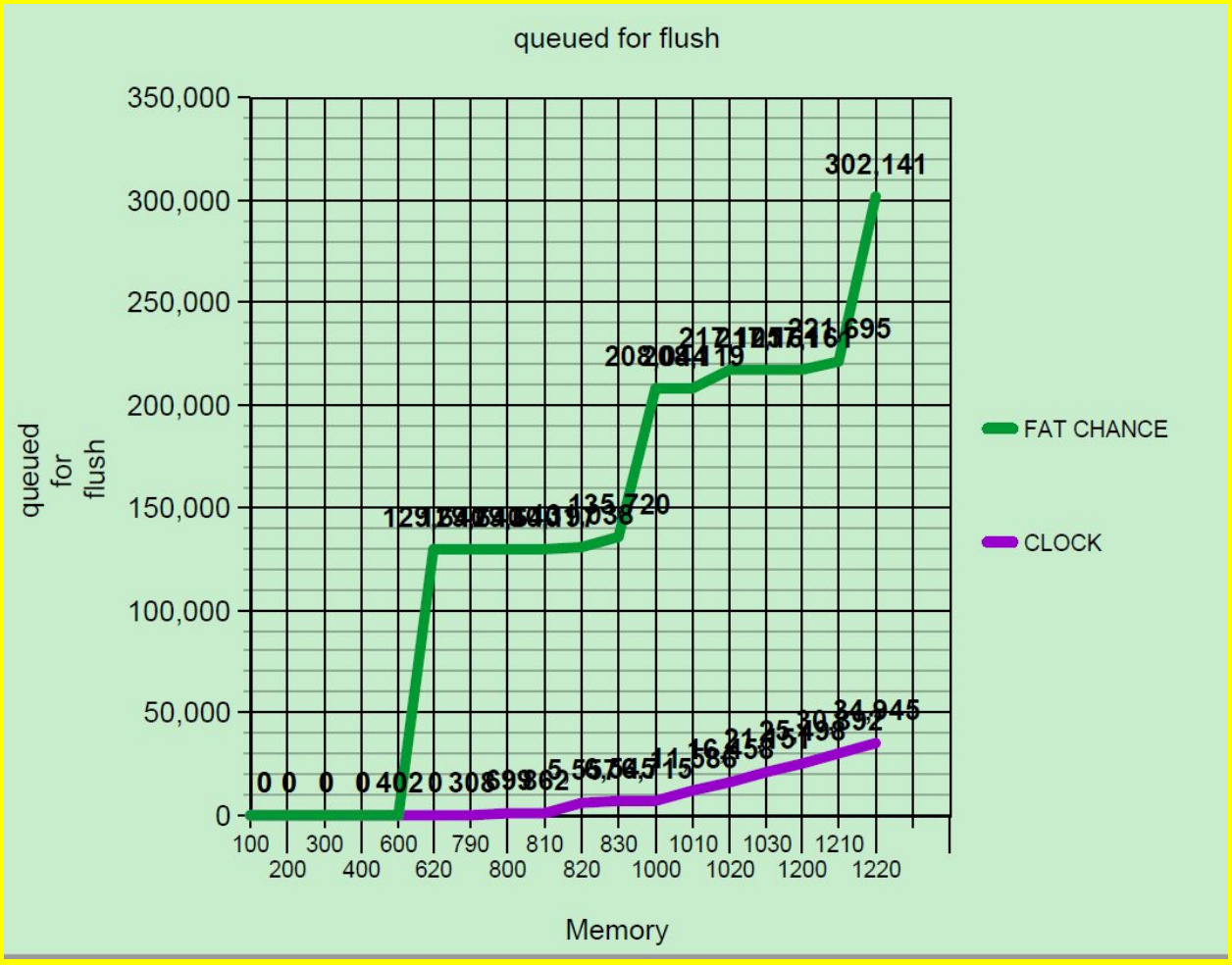
Graph Data & Analysis of the Graphs:



In this graph, we are showing the results of the Inactive to Cache graph. The statistics show that the reading of the clock algorithm was higher than the reading of the fat chance algorithm. With 15 vms each at 1220 MB, the clock algorithm had 364017 pages moved from Inactive to Cache compared to 86744 pages moved with the fat chance algorithm. We can conclude that the fat chance has fewer pages scanned than the clock algorithm. As the graphs merge at a point between 820 and 830 MB, the fat chance algorithm may be better when each vm has higher memory allocated to it, as fewer pages are scanned. However, the fat chance algorithm still has more pages scanned between 600 MB and 820 MB in comparison to the clock algorithm.



The rate at which the pages move from the active to inactive queue has a higher slope when using the clock algorithm than the fat chance algorithm, but the graphs intersect at between 1010 and 1020 MB allocated per vm for 15 vms. Similar to what we saw with the inactive to cache graph, the clock algorithm begins with fewer pages being moved between the queues, and slowly overtakes the fat chance algorithm, ending up with over 200,000 more pages moved at 1220 MB than with the fat chance algorithm (compare 789,240 with 577,577 - a difference of 211,663).



We see here that with the fat chance algorithm, a lot more pages are queued for flush than with the clock algorithm, and for 15 vms each from 600 MB up to 1220 MB (and by extent higher values) this is constant. As memory allocated is increased, the fat chance algorithm queues pages for flush at a much higher rate than the clock algorithm. This is not particularly efficient for the fat chance algorithm because the system requires a lot of memory to flush pages. The fewer pages we can get away with flushing, the better. As can be seen, with 15 vms each at 1220MB, the clock algorithm has queued 34,945 pages, whereas the fat chance algorithm has queued 302,141 pages, a difference of 267,196 pages.

This is the end of write up. Thank you so much for reading.