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a)

The parameters to be changes in these experiment are as follows

CPU execution period - cpu.cfs_period_us defines the amount of execution time available for particular cpu group, default value -100000

CPU quota - cpu.cfs_quota_us, defines how much of the allocated period a particular cpu group can use , default value-100000

CPU share -cpu.shares, default value -1024

1 CPU utilization depends on the period as set in cfs_period_us.

Setup : keeping other parameters as constant change cpu.cfs_period_us. Creat a cpu group and add and execute a cpu intensive task.

cpu.cfs_quota_us = 100000

cpu.cfs_period_us	Cpu utilization
50000	100
100000	100
200000	50

The cpu utilization depends on the ration of the allocated cpu.cfs_quota_us and cpu.cfs_period_us . Since the quota is constant, the cpu utilization depends on the cpu.cfs_period_us. When the ratio exceeds 1 cpu utilization is 100% else it depends as per ratio.

2 Similarly the effect observed with change in cpu.cfs_quota_us and keeping cpu.cfs_period_us constant for 1 process.

Setup : 1 cpu intensive process in cpu group, change quota keeping others at default.

cpu.cfs_quota_us	Cpu utilization
50000	50
100000	100
200000	100

3 With change in cpu.shares keeping others at default values the cpu utilization does not change .
Setup : Add 1 cpu intensive function in cpu group and execute . Change cpu.shares keeping others at default.

cpu.shares	Cpu utilization
512	100
1024	100
2048	100

Cpu utilization does not depend on cpu.shares when there is only 1 cgroup.

4 The CPU Utilization will increase with increase in quota and the decrease the execution time

Setup : On one core create a cpu group and add 2 cpu intensive group . Keep period and shares constant and vary cpu.cfs_quota_us.

Data::

quota	Cpu utilization (%) for each process	Execution time(s)
25000	12-13	148
50000	24-25	67
100000	50 each	31
150000	75.4-75	21

200000	100 each	15

With increase in cpu utilization the execution time decreases. This cpu utilization depends on the quota allocated and period. Since period is constant in this experiment this depends on quota.

b)

In this section we create additional cpu group. If run on different cores they work as above independent of each other so we set the affinity of the groups for same core using taskset.

1 cpu.cfs_quota_us is varied keeping others at default

Quota cg1	Cpu utilization	Quota cg2	Cpu utilization
20000	20	30000	30
50000	70	30000	30
100000	60	40000	30
100000	50	500000	50
100000	50	100000	50
100000	50	200000	50

The cgroup with lesser ration gets the cpu utilization as per its demand and among the rest period the percentage utilization is full or as per ration for the other cgroup.

2 The cpu.shares are varied across both the cgroups
Setup : 2 different cpu groups containing 1 process taskset on same core.

Cg1 share	Cpu utilization	Cg2 share	Cpu utilization
512	33	1024	66
1024	50	1024	50
512	20	2048	80

2

a)

The given programs from links were studied and used for following question experimentations.

b)

- For unshare command and program
  Output of unshare program :
  $sudo ./unshare_p -p sudo /bin/bash
  # echo $$
  1

  Output of unshare cmd:
  $sudo unshare -fp --mount-proc /bin/bash
  # ps
  PID TTY TIME CMD
  1 pts/7 00:00:00 bash
  8 pts/7 00:00:00 ps

- For nsenter :

  $ sudo unshare -fp /bin/bash
  #ps
  PID TTY TIME CMD
  109474 pts/9 00:00:00 sudo
  109486 pts/9 00:00:00 unshare
  109487 pts/9 00:00:00 bash
  109512 pts/9 00:00:00 ps
  # readlink /proc/109487/ns/pid
  pid:[4026532373]

Using command :
$sudo nsenter -t 109487 -a
#ps
```
          PID TTY        TIME CMD
 109815 pts/10   00:00:00 sudo
 109816 pts/10   00:00:00 nsenter
 109817 pts/10   00:00:00 bash
 110606 pts/10   00:00:00 ps
# readlink /proc/109817/ns/pid
pid:[4026532373]
```

Above shows that the nsenter was able to create new process in th enamespace of 109487 bash process as created by unshare

c)

The changed code is attached in the folder to take the pid.

3

a)

5 child process are created an dadded to new namespace as per parent process using following steps:
1 clone main process to create namespace using CLONE_NEWPID
2 change root directory
3 using setns link the new cloned process to that namespace
4 fork 5 process , as setns is already done the new forked children will go directly into the namespace of cloned process then add them to cg group

$sudo taskset -a -c 0 ./q3
/proc/125903/ns/pidChild pid 125904
Child pid 125905
Child pid 125906
Child pid 125907
Child pid 125908
pid:2
pid:3
pid:4
pid:6
pid:5
Time taken by function: 89 seconds
Time taken by function: 89 seconds
Time taken by function: 89 seconds
Time taken by function: 89 seconds
Time taken by function: 89 seconds

Following is the result of cpu utilization of test and all 5 process being part of same cg1 group

```
top - 15:20:37 up 1 day, 23:33,  1 user,  load average:
Tasks: 269 total,   7 running, 262 sleeping,   0 stoppe
%Cpu(s): 25.2 us,  0.1 sy,  0.0 ni, 74.5 id,  0.2 wa,
MiB Mem :   7807.2 total,   4051.1 free,   1486.3 used,
MiB Swap:   2048.0 total,   2048.0 free,      0.0 used.

    PID P  %CPU  %MEM     TIME+ COMMAND
 125849 0  16.6   0.0   0:07.85 test
 125904 0  16.6   0.0   0:04.70 q3test
 125905 0  16.6   0.0   0:04.70 q3test
 125906 0  16.6   0.0   0:04.70 q3test
 125907 0  16.6   0.0   0:04.70 q3test
 125908 0  16.6   0.0   0:04.70 q3test
   1511 1   1.0   0.3   1:51.08 pulseaudio
 124339 1   0.3   0.0   0:00.01 kworker/u8:0-flush-8:0
      1 2   0.0   0.1   0:03.27 systemd
      2 3   0.0   0.0   0:00.02 kthreadd
```

For different cg groups the test2 belongs to cg2 group and others in cg1

```
top - 15:25:38 up 1 day, 23:38,  1 user,  load average:
Tasks: 269 total,   8 running, 261 sleeping,   0 stoppe
%Cpu(s): 25.3 us,  0.2 sy,  0.0 ni, 74.4 id,  0.2 wa,
MiB Mem :   7807.2 total,   4054.0 free,   1482.8 used,
MiB Swap:   2048.0 total,   2048.0 free,      0.0 used.

    PID P  %CPU  %MEM     TIME+ COMMAND
 127002 0  50.3   0.0   0:07.47 test2
 127052 0  10.0   0.0   0:00.79 q3test
 127053 0  10.0   0.0   0:00.79 q3test
 127054 0  10.0   0.0   0:00.79 q3test
 127055 0  10.0   0.0   0:00.79 q3test
 127056 0  10.0   0.0   0:00.79 q3test
   1511 1   0.7   0.2   2:03.24 pulseaudio
  71287 2   0.3   0.0   0:17.60 kworker/2:0-events
 121986 3   0.3   0.0   0:02.71 top
      1 1   0.0   0.1   0:03.27 systemd
```