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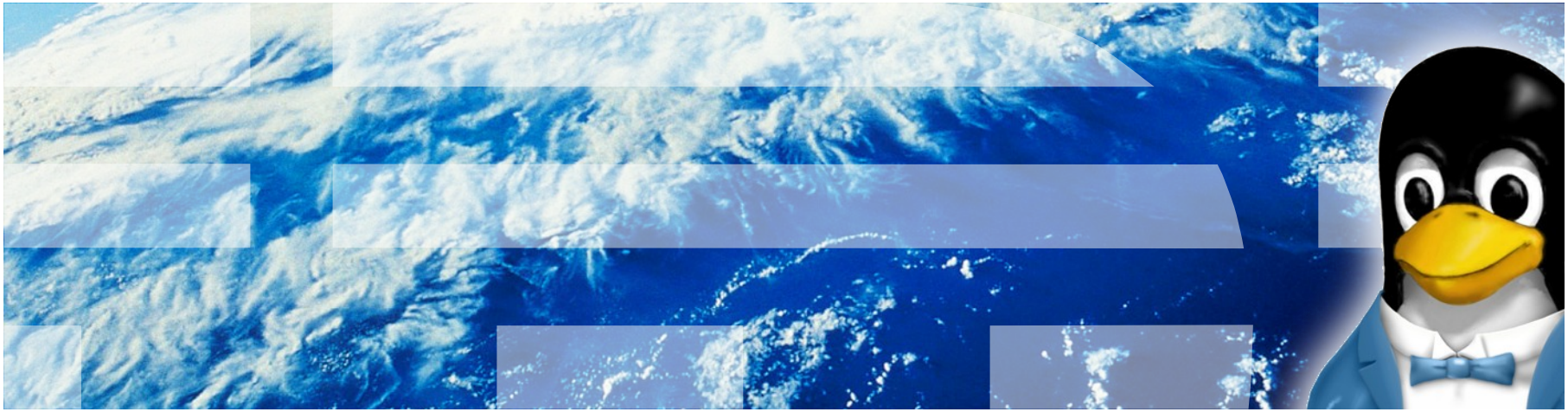
Linux Technology Center

Analyzing the impact of sysctl scheduler tunables

LinuxCon, Vancouver 2011



Agenda

- Introduction to scheduler tunables
- How to tweak the scheduler tunables
- Introduction to CFS
- A deep dive into scheduler tunables
- Test environment
- A quick overview about the workloads used
- Impact of sched_latency_ns
- Impact of sched_min_granularity_ns
- Impact of sched_compat_yield
- Impact of sched_wakeup_granularity_ns
- References

Introduction to scheduler tunables

- **What are the scheduler tunables?**
  - Scheduler knobs exported to the user
  - Controls the behavior of the scheduler
  - Exported via sysctl: ***/proc/sys/kernel/sched_****
- **Why do we need them?**
  - Scheduler is used from small embedded systems to large HPC clusters
  - Application scheduling behavior might have to be tweaked
  - Workload characteristics are different
  - Default scheduler settings might not be optimal always
- **What will you gain from this presentation?**
  - How to tune the scheduler tunables
  - How to arrive at the optimal set of values
  - Performance improvements obtained by tuning the scheduler knobs

How to tweak the scheduler tunables

- **There are two ways to alter the default values**
  - Change the values directly: ***/proc/sys/kernel/sched_****
  - Using the sysctl command to change the kernel parameters at run time

```
[root@hs22 kernel]# pwd
/proc/sys/kernel
[root@hs22 kernel]# ls sched_*
sched_autogroup_enabled      sched_migration_cost      sched_rt_period_us
sched_time_avg               sched_child_runs_first    sched_min_granularity_ns
sched_rt_runtime_us          sched_tunable_scaling     sched_latency_ns
sched_nr_migrate             sched_shares_window       sched_wakeup_granularity_ns

sched_domain:
cpu0 cpu1 cpu10 cpu11 cpu12 cpu13 cpu14 cpu15 cpu2 cpu3 cpu4 cpu5 cpu6 cpu7
cpu8 cpu9
```

- **Using /etc/sysctl.conf**
  - Eg: **kernel.sched_latency_ns = 24000000**
  - **# sysctl -p**

Introduction to CFS

- Completely Fair Scheduler
- Part of mainline kernel since v2.6.23
- Fairness imbalance is expressed via per task wait_runtime
- Tasks are ordered in a RB Tree sorted by “rq->fair_clock – p->wait_runtime”
- Scheduler picks the left most task
- CFS does not have any notion of 'timeslices'

A deep dive in to the scheduler tunables

- **sched_latency_ns**
  - Targeted preemption latency for CPU-bound tasks
  - A period in which each task runs once
  - Default = 6ms * (ilog(ncpus))
    Unit = ns
  - Not the same as time slice length

- **sched_min_granularity**
  - The minimum time after which a task become eligible to be preempted
  - The minimum possible preemption granularity
  - Default:
    0.75 msec * (ilog(ncpus)
  - sched_latency / nr_tasks

- **sched_compat_yield** *
  - Makes sys_schedule_yield more aggressive
  - Moves the yielding task to the last in the rb tree
  - Retained for compatibility

- **sched_migration_cost**
  - Tunable to determine if a task can be migrated from one cpu to another
  - Larger value means, the chances of the tasks to be migrated to another cpus becomes less
  - Also determines if the current task is cache hot

* Not present in mainline kernel anymore

A deep dive in to the scheduler tunables

- **sched_nr_migrate**
  - Number of tasks to iterate in a single load balance run
  - Limited because this is done with IRQs disabled

- **sched_child_runs_first**
  - If set to 0 (default) then parent will (try to) run first otherwise child.

- **sched_wakeup_granularity_ns**
  - Reduces over-scheduling
  - Gives an hint whether to preempt the current task or not

- **sched_tunable_scaling**
  - The initial- and re-scaling of tunables
  - Default: Scaled logarithmically
  - Scaling now takes place on all kind of cpu add/remove events

* Not present in mainline kernel anymore

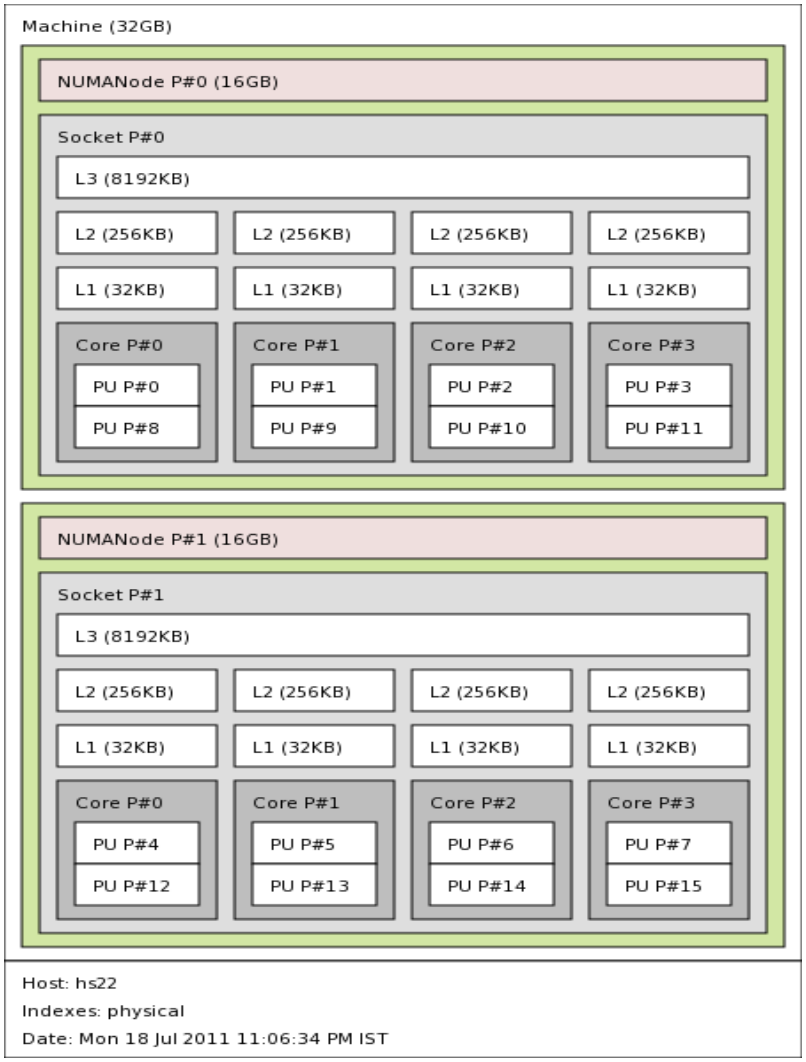
A deep dive in to the scheduler tunables

- **sched_rt_period_us**
  - Period over which we measure -rt task cpu usage in micro seconds
  - The scheduling period that is equivalent to 100% CPU bandwidth
  - Default = 1s

- **sched_time_avg**
  - Period over which we average the RT time consumption
  - Default: 4ms

- **sched_rt_runtime_us**
  - A global limit on how much time realtime scheduling may use
  - Part of the period that we allow rt tasks to run in micro seconds
  - Default: 0.95s
  - A run time of -1 specifies
    runtime == period

Test environment

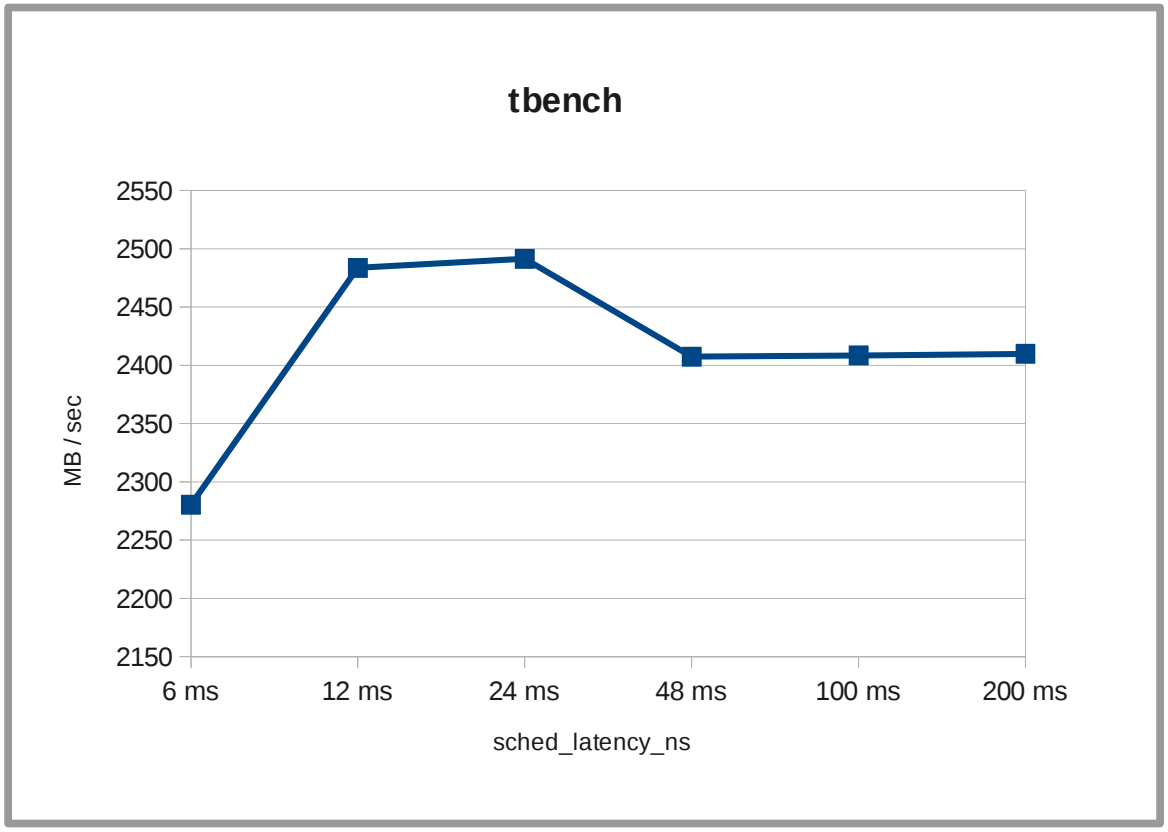


- **Hardware: Dual socket quad core with HT support**
- **Linux Distribution: Fedora 14**
- **Benchmarks**
  - Tbench
  - Dbench
  - SPECJbb
  - Lmbench
  - Kernbench
  - Hackbench

A quick overview about the workloads used

- **Dbench**
  - Generate IO loads
  - Used to stress the filesystems
- **Tbench**
  - Produces TCP and process load
  - Does invoke the socket() calls
- **SPECJbb**
  - Java based benchmark
  - Simulates database transactions
  - Cpu intensive workload
- **Hackbench**
  - Simulates the connections established for a chat room
- **Kernbench**
  - Cpu throughput benchmark
  - Used to compare the different kernels on the same machine
- **Lmbench**
  - Suite of micro benchmarks
  - Bandwidth (cached file read, m/m read / write, pipe)
  - Latency (context switches, system call overhead, m/m read / write latency / remote wakeups)

Impact of *sched_latency_ns*

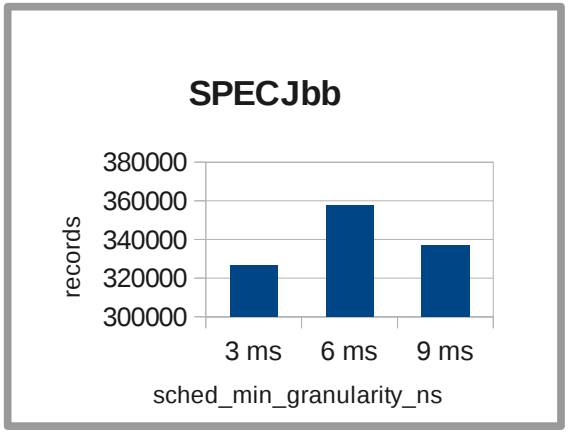


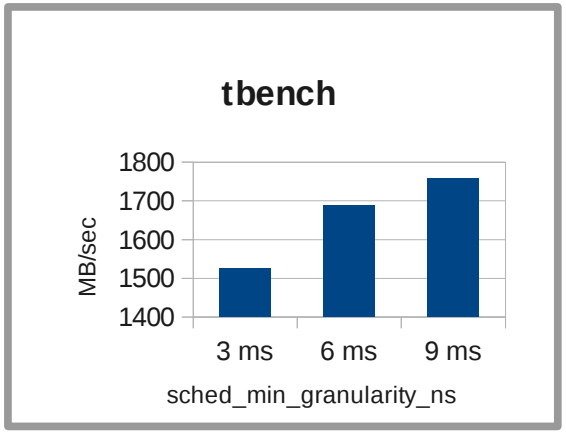
- Server and clients were running in the same machine
- Number of clients: 50
- Gave the best throughput at 24 ms
- Variation upto +/- 10%
- Matches with the equation

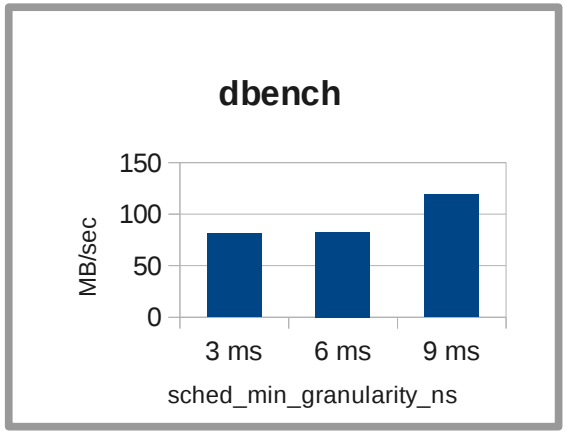
  sched_latency =

  6ms * log(nr_cpus)

Impact of *sched_min_granularity_ns*

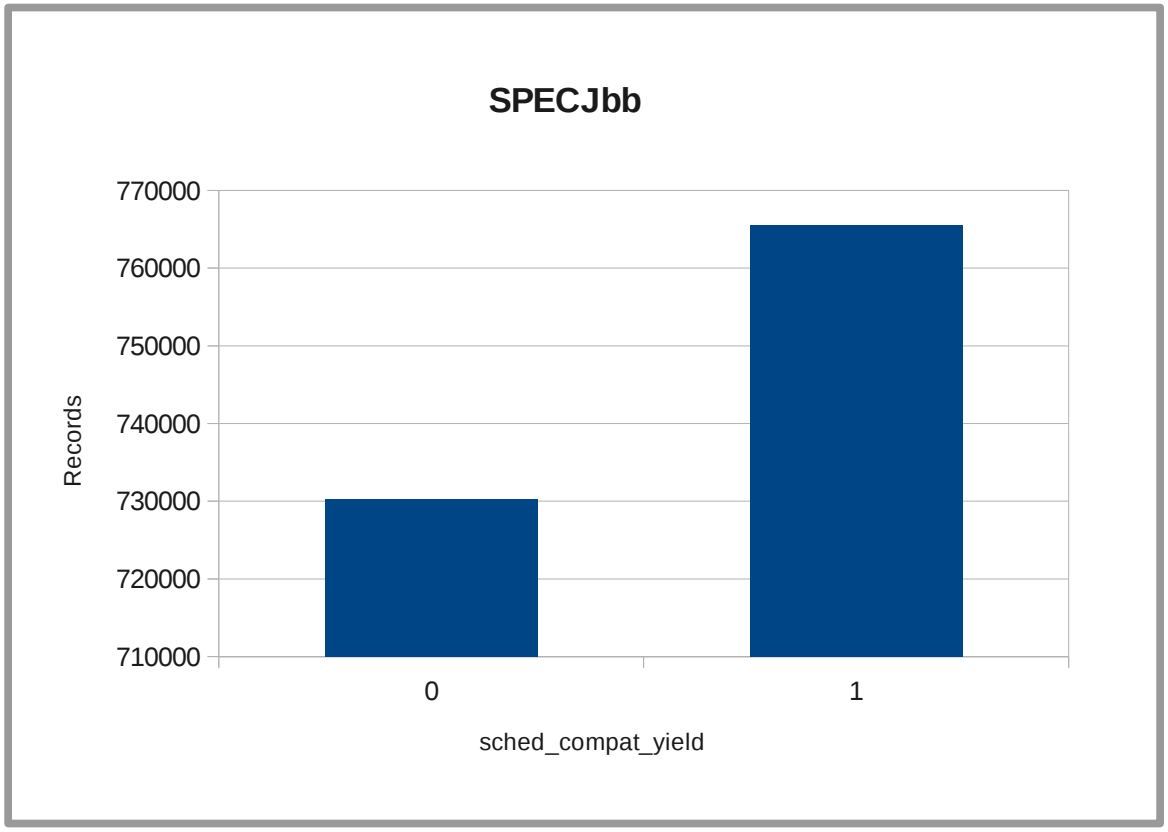






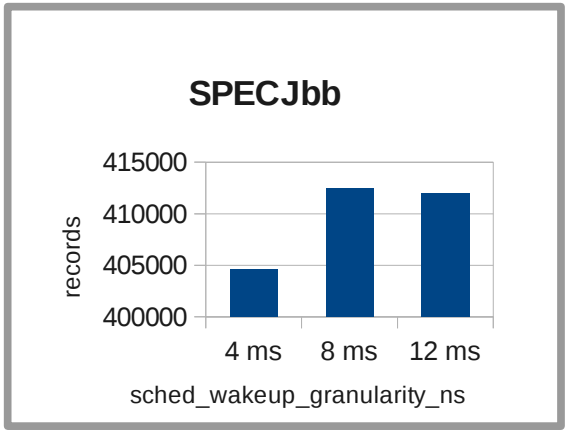
- Mixed workloads were used
- SPECJbb 32 warehouses
- Tbench 25 clients
- Dbench 25 clients
- Significant improvement in the performance
- Longer execution cycles helping the workloads
- Kernel: 2.6.35.fc14

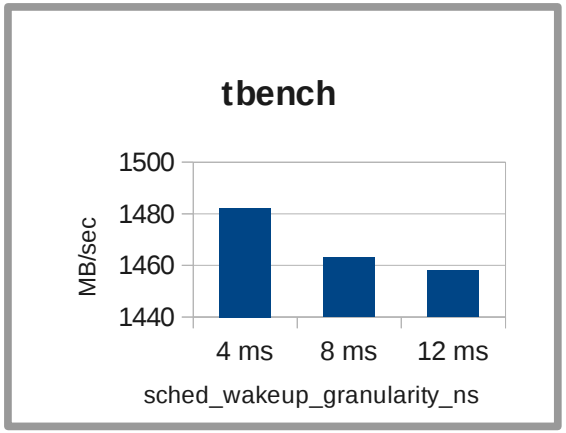
Impact of *sched_compat_yield*

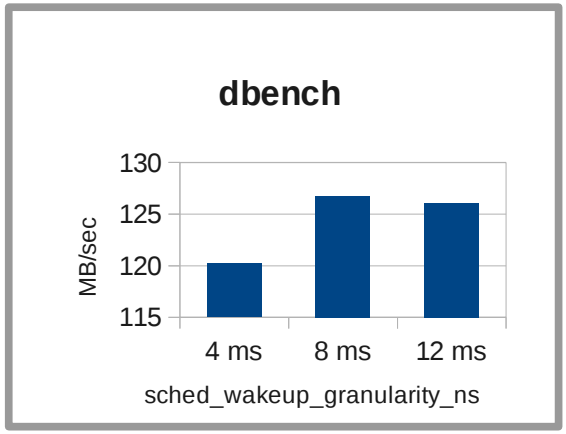


- **Kernel: 2.6.35.6-45.fc14**
- **SPECJbb**
  - 8 Instances with 4 warehouses each
  - Total 32 warehouses
- **+5% improvement**
- **Around +15% improvement was observed in a 2.6.32 based kernel**
- **sched_compat_yield is no longer present in mainline kernels**

Impact of *sched_wakeup_granularity_ns*







- Mixed workloads were used
- SPECJbb 32 warehouses
- Tbench 25 clients
- Dbench 25 clients
- Significant improvement in the performance for SPECJbb & dbench
- Tbench performance goes down as it is a client/server benchmark, which needs faster responses

References

- CFS documentation: Kernel/Documentation/sched-*
- CFS scheduler: kernel/sched_fair.c
- CPU bandwidth control: http://lwn.net/Articles/452584/
- Cgorups: Kernel/Documentation/cgroups/
- My blog: http://krm4linux.blogspot.com/

Acknowledgments

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Questions / Discussions

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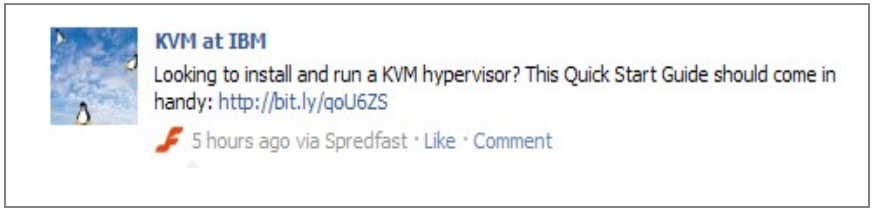

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