Providing per-task Quality of Service

Juri Lelli <juri.lelli@arm.com>

Outline

Introduction

Energy Aware Scheduling

- Status update
- Yeah, right.. but what is it?!
- Discussion

Deadline Scheduling

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- Discussion

Who am I?

- SSG-Power team @ ARM Ltd.
- working on Linux scheduler
- Energy Aware Scheduler (sched-DVFS in particular)
- SCHED_DEADLINE

ARM

Aim

- Briefly introduce API changes/additions enhancing the Linux scheduler towards better energy efficiency and real-time(ish) behaviour
- Start again last year LPC discussion...
- regarding userspace (middleware) vs. kernel space information exchange

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Status update

- EASv5 posted July, 7th
- Foundation patches (without RFC tag) posted Aug., 14th
- SchedTUNE posted Aug., 19th

Energy Aware Scheduling

Oh, cool! But, what is it anyway?!

Did you/planning to attend EAS miniconf?

Thanks/Please do

10/15 min answer

Foundation

Per-Entity Load Tracking

- Geometric series for
  - Load (amount of time a sched_entity is runnable)
  - Utilization (amount of time a sched_entity is running)
- Utilization gives you a [0..1024] number that represents how big is your task
- Both frequency and μ-arch scaled (i.e., that number is the same wherever you are running and at whatever OPP)

Foundation

Energy Model

- It considers CPUs only, no peripherals, GPU or memory.
- It contains information about OPPs and idle states

Energy Aware Scheduling

- Use the energy model and information about tasks to evaluate implications of scheduling decisions
- The goal is to minimize energy, while still getting “good” performance
- While the default scheduler has a performance-only objective

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Energy Aware Scheduling

- Energy-aware scheduling is only active when the system is not over-utilized
- Tipping point: very conservative, one CPU fully utilized at its highest OPP
- When above the tipping point we go for the traditional way (spreading tasks)
- When below, scheduling decisions are taken considering the total energy impact of adding/removing/migrating utilization

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Sched-DVFS

Let the scheduler control OPP selection

- New cpufreq governor* that is triggered from scheduler context
- Select an OPP that has enough capacity (spare room) to accomodate tasks that we decide to schedule on a CPU
- Decisions are taken at freq-domain level
  - Per freq-domain kthread (where required) responsible for doing the actual freq change
  - Woken up via IPIs
- CFS only, but should be fairly easy to extend it to the other scheduling classes

* foundation by Mike Turquette

Sched-TUNE

Userspace power/performance tunable knob*

- Stacked on top of Sched-DVFS
- Interacts with CFS scheduler (for the time being)
- Global and CGroup based (per-task) interface
  - global: /proc/sys/kernel/sched_cfs_boost
  - cgroup: /sys/fs/cgroup/stune/performance/schedtune.boost

* Patrick Bellasi

Discussion

- Did you experiment with EAS?
- How about the interface we designed to switch between performance and efficiency?
- What we would need to go forward...

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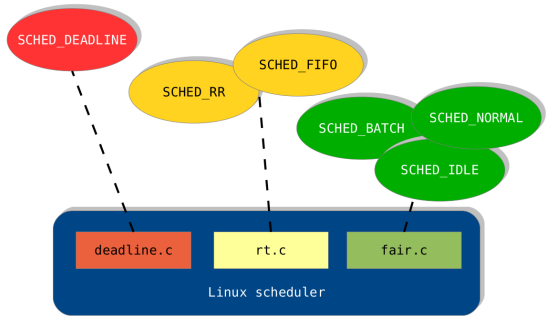
Status update

- Mainline since Linux 3.14
- Helping maintaining it (is Peter around?! :-))
- New features are coming, stay tuned!



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Deadline scheduling (a.k.a. SCHED_DEADLINE)

Yeah, right.. but, what is it?!

10/15 min answer

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Deadline scheduling (a.k.a. SCHED_DEADLINE)

it's not only about deadlines

- it's a relatively new addition to the Linux scheduler
- real-time scheduling policy
- higher priority than SCHED_NORMAL and SCHED_FIFO
- allows explicit per-task latency constraints
- enables predictable task scheduling, avoids starvation and
- enriches scheduler's knowledge about tasks' QoS requirements

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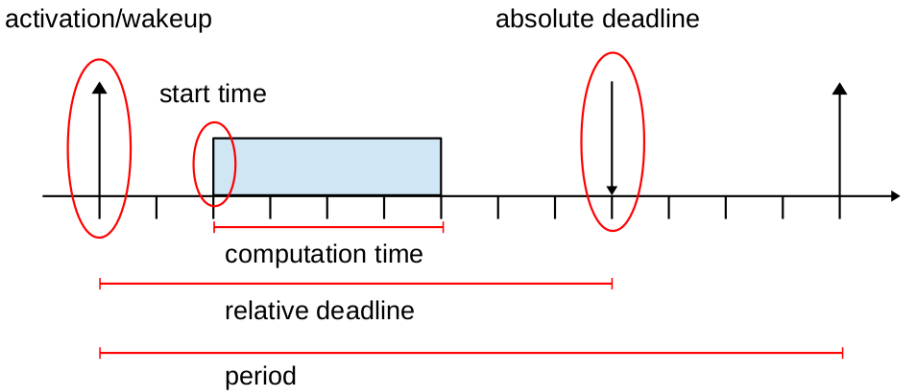
- it implements
  - Earliest Deadline First (EDF): tasks with earlier deadlines have higher priorities
  - Constant Bandwidth Server (CBS): reservation based scheduling
- CBS it's the cool thing here

Reservation Based Scheduling

- Concurrent real-time tasks compete for resources (CPU time)
- Resource Reservation mechanism
- A task is allowed to execute for:
  - Q time units (*runtime*)
  - in every interval of lenght P (*period*)
- Task *utilization* is $U = Q/P$
- Note that this is something that we don't need to estimate (like with PELT)
- It is enforced by the system
- You need to specify 3 parameters (ns): *runtime, deadline, period*

Sporadic Task Model



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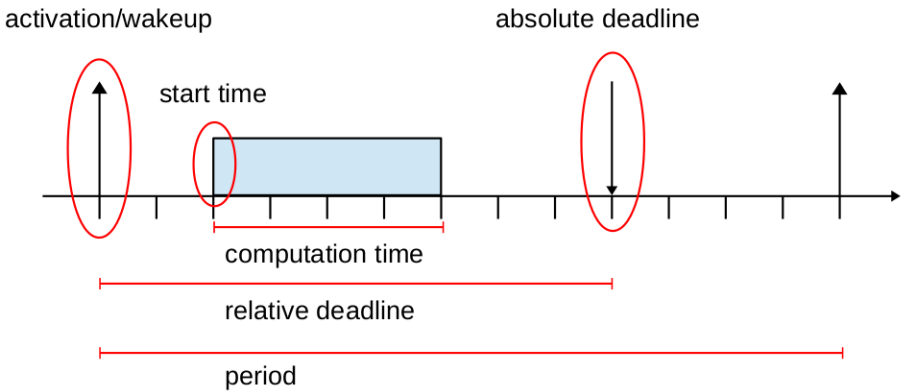

Feel free to throw whatever kind of task at it!

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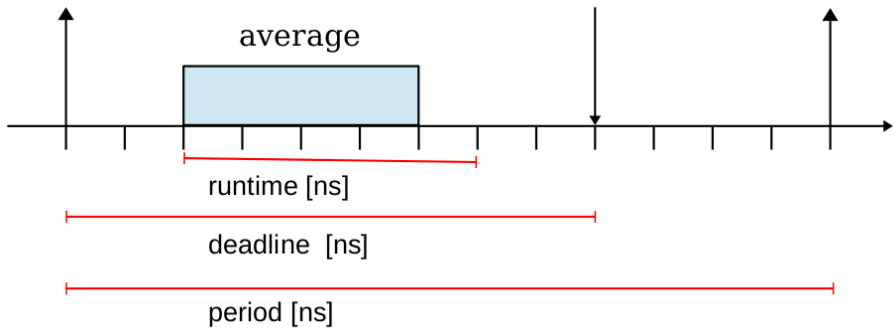
RR over Sporadic Task Model



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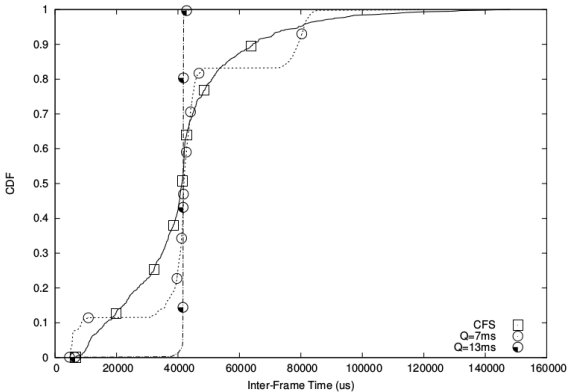
SCHED_DEADLINE: some numbers

- MPlayer with HD movie
- QoS metric: IFT, difference between DT of current and previous one
- Variation in IFT $\rightarrow$ video doesn't play smoothly
- frame rate = 23.9fps, IFT = $41708\mu s$
- P = IFT (for SCHED_DEADLINE)
- 6 other instances of ffmpeg in background
- CFS QoS highly dependent on system load
- With SCHED_DEADLINE player not affected (with reasonable CPU usage)



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Discussion

- Better quality of service provisioning
- Additional information for the scheduler
- How do you like the interface?
- Does it look usable?
- How about using it for audio pipeline instead of SCHED_FIFO (cit. Google I/O 2013 - High Performance Audio) ?
- SurfaceFlinger maybe?

Thank You