Real-Time performance comparisons and improvements between 2.6 Linux Kernels

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Outlines

- Preemptibility effects in Latency reduction and Performance (Analysis)
- Approaches to Real-Time under Linux
- Perceptions and definitions to improve the preemption of the Kernel
- Experiments, benchmarks, estimations

Preemptibility effects

- Throughput and the associated time constrains
- Hard real time & soft real time tasks
- When the number of task grows, the scheduler manage the situation expanding within the limits the period of SRT tasks
- Scheduler overhead ,the Big O
- Synchronization and priority inheritance via mutexes not with spin – locks
- Planning high resolution timers(reduce error scale during period estimation).

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Approaches to Real-Time under Linux

- **Non-CONFIG_PREEMPT –** for best effort & for soft real time tasks**. -** poor responsiveness for real time environment, low-level interrupt-handing code

- **CONFIG_PREEMPT -** Kernel code preemptible, except the spinlock section and RCU read side.

  - Performance penalty very small
  - The amount of code more complicated

Approaches to Real-Time under Linux

- **CONFIG_PREEMPT_RT** – priority inheritance (prevent priority inversion) ,mutexes, RCU read side.
  - To implement the priority inheritance for read-write locks is very difficult.
  - Is not fair since generally the real time systems are not fair.
  - the shortest the period of execution time, higher priority is given by the scheduler policy.

Nested OS – Linux as user mode, over RTOS.

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Improve the preemption of the Kernel

- Defining the non-preemptible zones in the Linux kernel
- Interrupt off paths
- Lowest-level interrupt management
- Scheduling Code
- Context switching code

Improve the preemption of the Kernel

- Introducing the preemption points
- Calls to the disk buffer cache
- Memory page management
- Calls to the file system
- VGA and console management
- The forking and exits of large processes
- The keyboard driver

Improve the preemption of the Kernel

Trying to make kernel preemptible in general

- Minimized interrupt disable times
- Interrupt handling via schedulable threads
- Preemptible kernel
  - Short critical sections
- Perform synchronization via mutexes (not spin locks)
  - Allows involuntary preemption
- Mutex support for priority inheritance
- High Resolution timers

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- **Experiments, benchmarks, estimations**

Experiments, benchmarks, estimations

- Motivation
- Preliminary conditions
  - *2.6.20 – 2.6.26 – 2.6.31*
  - *patch-2.6.20-rt8 – patch-2.6.26-rt1 – patch-2.6.31-rt10*
  - GenuineIntel, Intel(R) Pentium(R) 4 CPU 2.40GHz
  - Total memory: 757 MB - Total swap: 2212 MB
  - disk - Model: SAMSUNG SP1213N - Capacity: 117.2 GB - Cache: 8.192 MB
  - VGA controller - nVidia Corporation NV18 [GeForce4 MX 4000 AGP 8x] (rev c1) (prog-if 00 [VGA])

Experiments, benchmarks, estimations

- Stream 0
  - Codec: XVID
  - Language:
  - Type: Video
  - Resolution: 512x320
  - Frame rate: 25.000000
- Stream 1
  - Codec: mpga
  - Language:
  - Type: Audio
  - Channels: 2
  - Sample rate: 48000 Hz
  - Bitrate: 130 kb/s

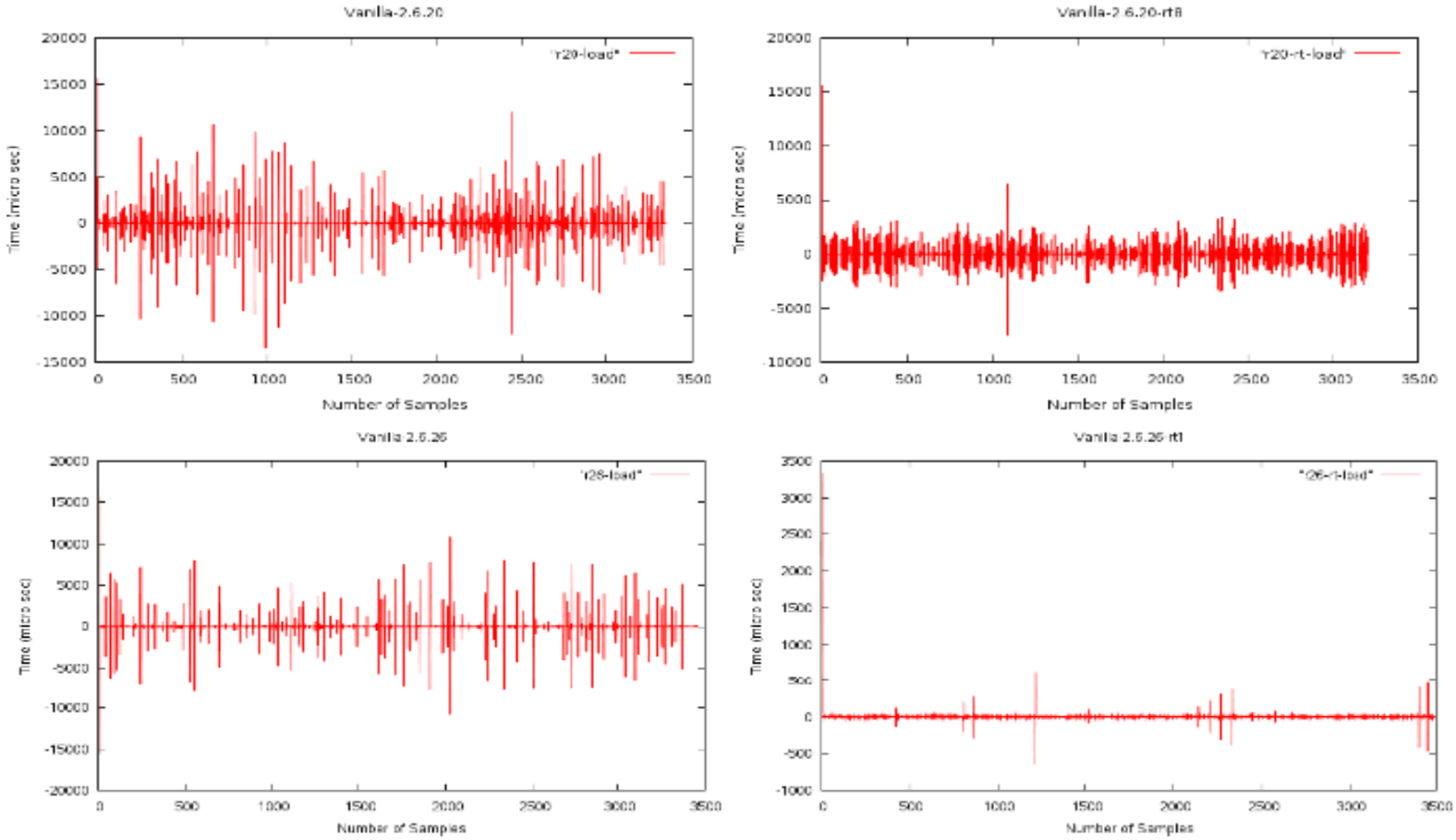
- VLC player
- Play time = 60 sec
- Benchmark = Realfeel
- Gnome = Off
- VLC = Terminal mode
- Plotter = Gnuplot
- SSh sessions opened = 3
- ACPI = disabled for 2.6.26 && 2.6.31 rt-patch(RTC)

Experiments, benchmarks, estimations

- Measurement method
  - RealFeel benchmark
  - RTC (real time clock) driver with a particular frequency
  - GCC
  - Timelines
  - Estimated Value

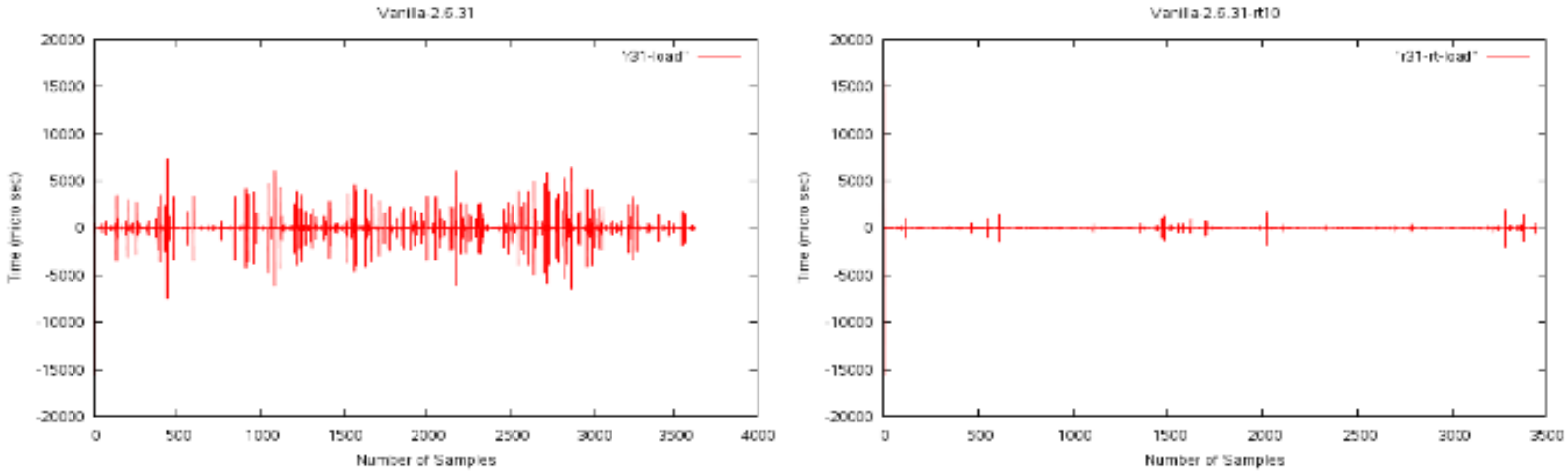
Experiments, benchmarks, estimations

- Results



Experiments, benchmarks, estimations

- Results



Kernel releases	AVG Samples
٢.٦.٢٠	٣٩٣.٩
٢.٦.٢٠-rt	١٢٨.٣
٢.٦.٢٦	٢١٧.٩
٢.٦.٢٦-rt	٢٨.٤٣
٢.٦.٣١	١٨٥.٣
٢.٦.٣١-rt	١٧.٣

Experiments, benchmarks, estimations

- Results
  - General preemption Kernel (Voluntary Preempted)
  - Responsiveness means predictability doing the expectations to be much more predictable than they are when running the respective Kernel release without rt-patch.
  - Greater performance for 2.6.31 release

Conclusions

- Responsiveness and throughput are opposite with each other.
- Reduce as much as possible interrupt off regions.
  Why low throughput ??
- Complexity of mutex operations vs spinlocks
- The complexity of mutex increase the cs operations during priority inheritance.

Conclusions

- High resolution Timer on 2.6.20 release
- After 2.6.20 kernel release threaded interrupt handler and sleeping spinlocks (mutexes).
- Voluntary preempted kernel (general kernel)
- 2.6.26 now possible to create a work queue running at realtime priority
- Better documentation for RT scheduling options

Conclusions

- Expanded kernel premtion to other arch(CF)
- 2.6.27 CFS called SMP-nice for group policy scheduling(Sys hibernation

Thanks
for the attention... and support !

Any questions ??