CE Linux Forum

Realtime Testing for Embedded Platforms

Tim Bird

Senior Software Engineer

Sony Corporation of America

Overview

- Introduction to realtime performance testing
- Recent RT-Preempt testing efforts
- Some RT test programs and methods
  - RealFeel-ETRI
- Testing problems in embedded
- Results from CELF members
- Open discussion

Introduction

- Goal of kernel support for realtime is to guarantee that system meets time deadline constraints
- Testing is critical to ensure that constraints are met
- RT testing is different from functionality testing

RT testing issues

- Instrumentation - why
  - To measure performance
    - Want to measure latency of different parts of response time
  - Need to instrument kernel in order to find cause of failures
- Can measure using:
  - Internal instrumentation
  - External instrumentation (separate machine)

Internal instrumentation

- Consists of event tracing, timestamp gathering, logging
- May add too much overhead
  - Instrumentation can disturb results
    - e.g. amount of time to take measurement may be longer than period being measured
  - Heisenburg uncertainty principle
    - Adding measurement code affects the latencies

Clock issues

- How can you tell the clock is correct?
  - Clock used for timestamp has some deviation from wall time
  - Need clock of high resolution, but low cost to read
- A cycle-counter is often used
  - Not all platforms have one, or can’t be read from user space
  - Other clocks are slower, and higher overhead to read

Instrumentation infrastructure

- Can use existing infrastructure??
  - LTTng found to have too much overhead
    - Samsung test indicated that overhead of LTTng had high variability
    - One log routine took > 4000 us.
  - Latency-trace introduces high overhead
    - Adds additional function call on entry to every kernel function
  - Regular kernel time routines are relatively expensive
- Specialized instrumentation used by most tests

External instrumentation

- Can use specialized hardware (e.g. logic analyzer)
- Can use another Linux machine
  - Very good for end-to-end response time.
  - Usually, no detail of latency areas
    - Does not indicate where delays are occuring
    - Can’t be used to fix latency problems.

Recent RT-Preempt testing efforts

- Many CELF members are working on realtime testing
- Some results published recently:
  - Samsung
  - IGEL
  - ETRI
  - Toshiba
  - Mitsubishi

Some RT test programs and methods

- lpptest
- realfeel-etri
- cyclictest

lpptest

- Built into RT-preempt patch
- User-space program to read and write parallel port, on host machine
- Kernel parallel port driver to repond to incoming data and send response
- Requires parallel port, which most embedded platforms don’t have
  - Trevor Woerner has a similar test, using serial port
    - Conflict with serial console may be an issue, but haven’t investigated it yet.

Realfeel-ETRI

- Programs a clock on the local system to cause periodic interrupts.
- Uses /dev/rtc
  - /dev/rtc appears to be supported on a number of platforms
  - Requires a clock that can be programmed for periodic interrupts
  - Don’t know if it conflicts with clocksources/clockevents
- ETRI added feature to kernel to return timestamp on read of /dev/rtc

realfeel-ETRI details

- Program sets up for RT performance
  - locks memory
  - sets scheduling priority
  - tells /dev/rtc to deliver periodic interrupts
- Program reads /dev/rtc
  - Call blocks until interrupt occurs
  - read returns timestamp of interrupt start
- Program compares interrupt time with time when user-space signal handler runs.
  - This isolates and measures scheduling latency

cyclictest

- Program by Thomas Gleixner to measure performance of Linux timer mechanisms
- Uses Linux timer routine (posix timer, itimer or nanosleep), and measures expected time vs. actual time for wakeup
- Needs high-res timers for some tests
- I had problems cross-compiling (but this is likely a bug in my development environment)

Problems testing embedded

- RT-preempt ports are still in progress
- clock source for timestamp (no TSC) varies per platform
- stress programs don’t match final load

Miscellaneous notes

- Many stress programs don’t test worst case
  - Heavy load is not the same as highest latency
  - e.g. ping test keeps system in small set of pages
    - no test of memory-related latency (cache misses
  - Need to test error paths

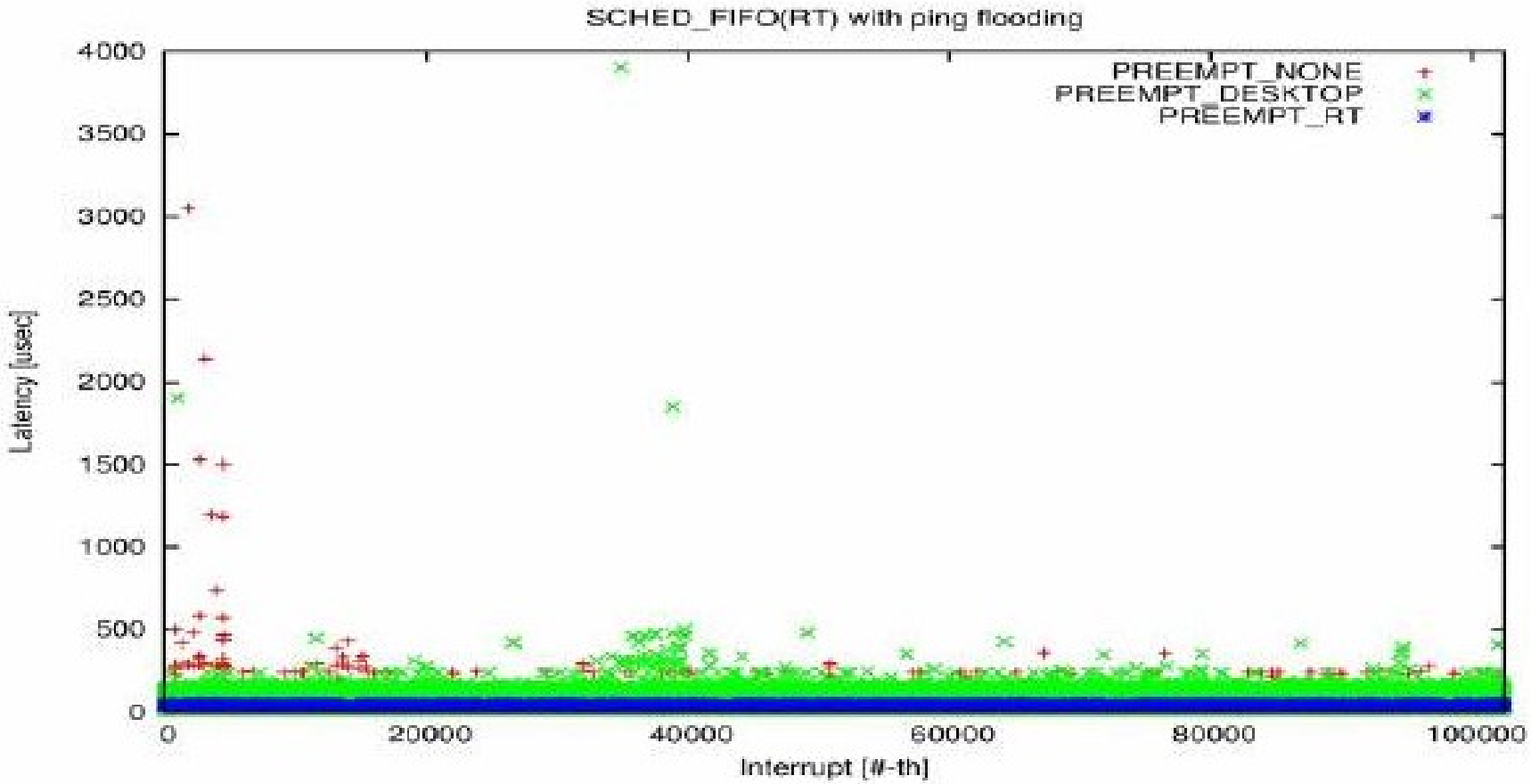
Samsung Results

- Tester: Sangbae Lee, Samsung
- Test Info:
  - Omap 5912, 192 MHZ??, 2.6.10
- What was measured:
  - interrupt latency and IRQ handler duration
- Results:
  - LTTng had long, variable latency
  - 30 us worst case, AFTER using custom instrumentation

IGEL results

- Tester: Katsuya Matsubara, IGEL
- Test Info:
  - SH7751R (SH4), 2.6.21
- What was measured:
  - UART driver implemented in user space (using UIO)
  - Time to receive
- Results:
  - Don’t have exact numbers, but graphs look good!

IGEL results - graph

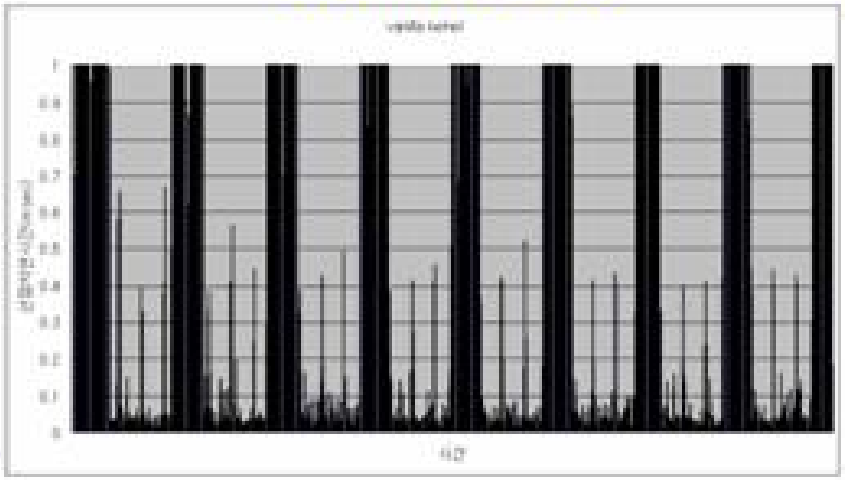


ETRI results

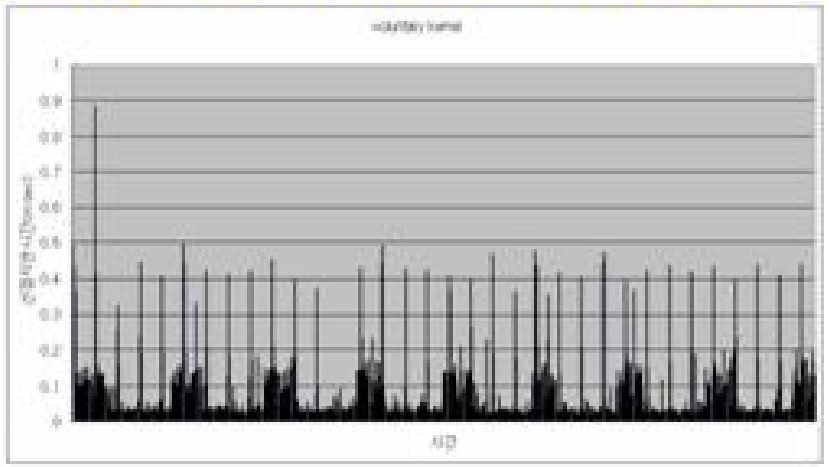
- Tester:YungJoon Jung, ETRI
- Test Info:
  - Via Eden, 800 MHZ, 2.6.20
- What was measured:
  - wakeup time from periodic tick (using /dev/rtc)
- Results:
  - 41 us worst case

ETRI results - graph

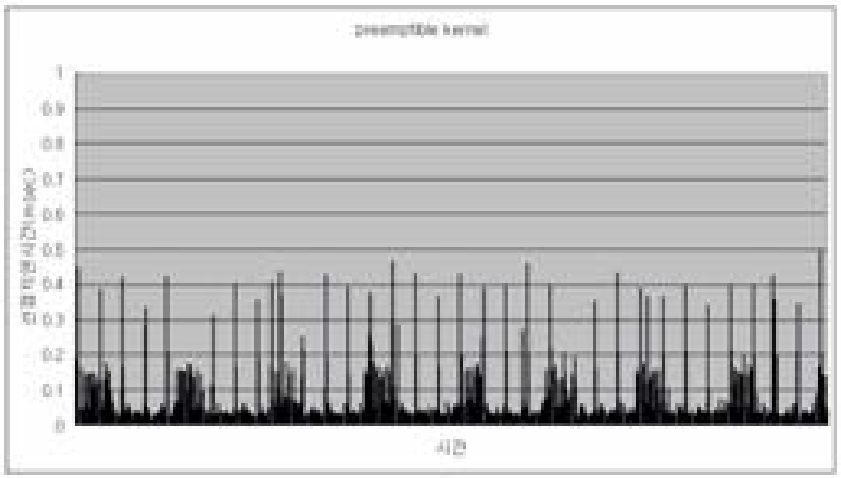
vanilla kernel



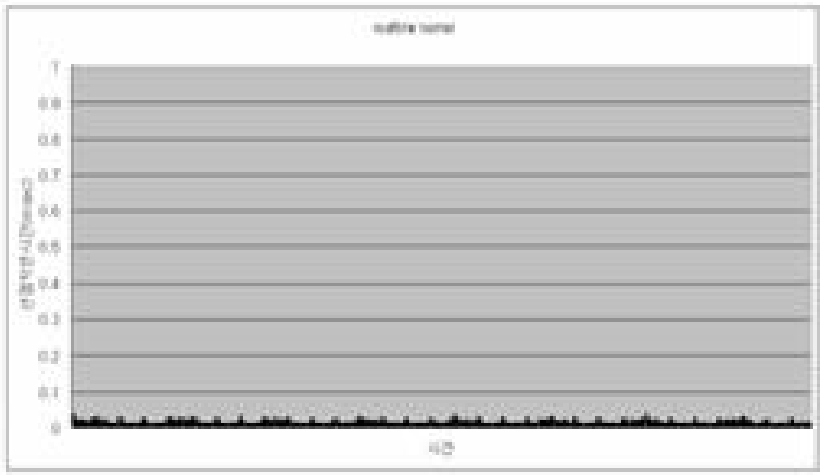
voluntary preemption kernel



preemptible kernel



real-time preemption kernel



Toshiba results

- Tester:Tsutomu Owa, Toshiba
- Test Info:
  - Cell (PPC64), 2.6.12 running on hypervisor
- What was measured:
  - ping response time
  - response to logical partition switch interrupt
- Results:
  - with RT-preempt, ping response time becomes much less variable
  - under load, response to lpar interrupt was faster with RT-preempt
    - there were still some bad lags

Mitsubishi results - SH4

- Tester: Shinichi Ochai, Mitsubishi
- Test Info:
  - SH4, 240 MHZ, 2.6.8
- What was measured:
  - Interrupt latency, process wakeup latency
- Results:
  - 1300 us worst case
  - worst case depended on load
    - Load with access to compact flash had problems

Mitsubishi results - i386

- Tester: Shinichi Ochai, Mitsubishi
- Test Info:
  - Via Eden, 600 MHZ, 2.6.8
- What was measured:
  - Interrupt latency, process wakeup latency
- Results:
  - 226 us worst case
  - 2.6.14 (with RT-preempt patches) had even worse performance with compact flash access (12 ms)

Results summary

Company	Test Info	Results with RT-preempt
Samsung	Omap 5912, 2.6.10	30 us worst case
IGEL	SH7751R, 2.6.21-rc5	good graph (<50us?)
ETRI	Via Eden, 800 Mhz, 2.6.20	41 us worst case
Mitsubishi	SH4, 240 Mhz, 2.6.8	1300 us worst case
Mitsubishi	Via Eden, 600 Mhz, 2.6.8	226 us worst case
Toshiba	Cell, 2.6.12	less variability

Open discussion