Behavior and performance evaluation of Linux 2.6.33.7.2-RT30 on ARM

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1 Document Intention

1.1 Purpose and scope

This document presents the quantitative evaluation results of the real-time **Linux** operating system (**Linux** with its real-time patches) on an ARM-based platform. The testing results of this operating system employed on an ARM processor can be found on our website. (www.dedicated-systems.com)

The layout of this report follows the one depicted in "The OS evaluation template" [Doc. 4]. The test specifications can be found in "The evaluation test report definition" [Doc. 3]. For more detailed references, See section "Related documents" of this document. These documents have to be seen as an integral part of this report!

Due to the tightly coupling between these documents, the framework version of "The evaluation test report definition" has to match the framework version of this evaluation report (which is 2.9). More information about the documents and tests versions together with their corresponding relation between both can be found in "The evaluation framework", see [Doc. 1] in section "Related documents" of this document.

The generic test code used to perform these tests can be downloaded on our website by using the link in the related documents section.

1.2 Test framework used: 2.9

This document shows the test results in the scope of the evaluation framework 2.9. More details about this framework are found in Doc 1 (see section "Related documents").

1.3 Conventions

Throughout this document, we use certain typographical conventions to distinguish technical terms. Our used conventions are the following:

- ***Bold Italic*** for OS Objects
- **Bold** for Libraries, packets, directories, software, OSs...
- `Courier New` for system calls (APIs...)

2 Introduction

This chapter talks about: 1) the OS that we are going to test and evaluate, 2) the real time patch integrated in this OS to achieve some real time performance and behavior tests, 3) the library used for interaction between the testing applications and the kernel, 4) the hardware on which the under testing OS will be employed.

2.1 Overview

The evaluation project started in 1995 and as such accumulates a long experience with different (RT) OSs. Today more and more embedded systems are equipped with **Linux** solutions using more or less real-time patches. Different vendors like MontaVista, Windriver, and Lynuxworks have now **Linux** variants in their product portfolio.

Since the kernel version 2.4, a lot of improvements regarding real-time behavior found their way into the standard "**Vanilla**" kernel. There is a well maintained real-time patch available (both have their origins from Ingo Molnar) called ***RT_PREEMPT*** patch. Remark that some real-time features (like priority-inheritance ***mutexes***, introduced in version 2.6.18) are already in the **Vanilla** kernel.

We believed that it is the time to test this kernel by our standard real-time behavior evaluation framework and find out how well it behaves.

For this evaluation, we used ***buildroot*** as target development system. On 8 June 2011, the first ***µClibc*** version (0.9.32) was released containing the **Native POSIX Thread Library (NPTL)**. Finally, ***µClibc*** is supporting the task to be used in systems with time requirements and supports the priority inheritance mutex.

It is the first time we evaluate the ***RT_PREEMPT*** kernel with the ***µClibc*** library, and as expected, the behavior is now the same as on ***glibc***.

Remark that the ***RT_PREEMPT*** patch degrades throughput performance which means that it should be used only when your project has low latency requirements. This is normal and a fundamental rule in real-time software: latency improvements have a negative impact on throughput and vice versa. Some quick measurements using an NFS mount stressing network and disk showed a negative throughput impact between 5 and 10% by enabling the ***RT_PREEMPT*** patch!

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2.2 Evaluated (RTOS) product

This section describes the OS that Dedicated Systems tested using their Evaluation Testing Suite, and the hardware on which this OS was running during the testing.

2.2.1 Software

The operating system OS that will be evaluated is **Vanilla Linux** 2.6.33.7 with real-time patch v30.This RT patch was the latest version officially released by OSADL (the Open Source Automation Development Lab) on December 21, 2010. Being as OSDAL's latest stable release was our main reason for testing this version. The RT patches can be found at http://www.kernel.org/pub/linux/kernel/projects/rt/.

The evaluation of this kernel version (2.6.33.7.2-rt30) was performed using several performance and behavior tests. The testing results are applicable only to this version as other versions may have other significant performance figures and behavior.

The library used between the testing applications and the kernel is the **µClibc** version 0.9.32 as mentioned before. This interfacing library is important because user applications (when using POSIX calls) can access the real-time features of the kernel only if this library supports them. Otherwise, direct system calls in user space applications are needed.

Further, the kernel was configured to use a high frequency timer source as clock generation and all power management was disabled. The test application was started from a RAM disk (tmpfs) and the real-time run away protection was disabled by setting `/proc/sys/kernel/sched_rt_runtime_us to -1`. All these precautions are required if real-time performance is your goal.

2.2.2 Hardware

The hardware that was used for executing our tests was a Beagle-XM Board Rev C with following characteristics:

- based on the Texas Instruments DM3730 Digital Media Processor
- ARM Cortex A8 running at 1GHz
- L1 Cache: 32KB instruction and 32KB data cache
- L2 Cache: 64KB
- 512MB RAM at 166MHz

3 Evaluation results summary

Keep in mind that the tested and evaluated product is **Vanilla Linux** 2.6.33.7 with ***RT_PREEMPT*** patch v30. If correctly used and configured, the ***RT_PREEMPT* Linux** system has the internals to provide some real-time characteristics.

Compared with the traditional RTOS that supports also memory protection between processes, the worst case latencies in **Linux *RT_PREEMPT*** are still around 5 to 10 times slower (depending on the RTOS you compare with). Our study and measurements show that the latencies are inbound and therefore this **Linux** version may be labeled Real-Time.

TAKE CARE: Using a wrong driver or wrong configuration can destroy real-time behavior. You need to follow the detailed rules described in the relevant document (Doc 5).

3.1 Positive points

- No license fees
- Source code available
- Extensible

3.2 Negative points

- The real-time characteristics of the OS are present only when everything is configured and built correctly (and not for all drivers)
- GPL license is not completely free and investment is required to build a marketable system. For instance, though demo systems can be built quickly with Linux, the debugging, tuning and verification required to build a stable system ready for long-term use is much more difficult.
- Setting up a complete embedded target from scratch is a daunting task.

3.3 Ratings

For a description of the ratings, see [Doc. 3].

RTOS Architecture	0	6	10
OS Documentation	0	4	10
OS Configuration	0	6	10
Internet Components	0	10	10
Development Tools	0	6	10
Installation and BSP	0	4	10
Test Results	0	4	10
Support	0	N.A.	10

Although [Doc. 3] gives a description of the ratings, comparison with other reports on other OS should help you understand the scoring.