LINUX 2.6.33.7.2-RT30

Authors: Luc Perneel (1, 2), Hasan Fayyad-Kazan (2) and Martin Timmerman (1, 2, 3)

1: Dedicated Systems Experts, 2: VUB-Brussels, 3: RMA-Brussels

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http://www.dedicated-systems.com

E-mail: info@dedicated-systems.com

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1 Document Intention

1.1 Purpose and scope

This document presents the qualitative evaluation results of the real-time **Linux** operating system (Linux with its real-time patches). The testing results of this operating system employed on an x86 processors can be found on our website. (www.dedicated-systems.com)

The layout and the content of this report follow the one depicted in “The evaluation test report definition” [Doc. 3] and “The OS evaluation template” [Doc. 4]. See section 1.4 of this document for more detailed references. Therefore 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 can be found in “The evaluation framework” see [Doc. 1] in section 1.4 of this document.

1.2 Document issue: the 2.9 framework

This document shows the results in the scope of the evaluation framework 2.9.

1.3 Conventions

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

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 behaviour tests, 3) the library used for interaction between the testing applications and the kernel, 4) the CPUs that such OS supports.

2.1 Overview

The evaluation project started in 1995 and as such accumulates a long experience with different (RT) OS. 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 behaviour 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 behaviour evaluation framework and find out how well it behaves.

For this evaluation, we used the standard **glibc** library as the **µClibc** package does not include yet the Native POSIX Thread Library (**NPTL**). Moreover, **µClibc** also does not use ***futexes*** which means that it also does not have any support for priority inheritance (which must be available when considering real-time behaviour). Further **µClibc** uses internal protection systems (***mutex***, ***semaphores***) and signals for the ***pthread POSIX*** layer, which behaves differently while compared to the usage of direct **NPTL** calls. From a real-time point of view, using **µClibc** in its current form makes the kernel real-time support unavailable in user space. It has to be said that there is an active **NPTL** branch in the **µClibc** code base. Therefore we suspect that it is only a matter of time before it will become available in the official releases.

It is a pity that the **µClibc** wagon is not yet on the **NPTL** rail. Using the **buildroot**, **µClibc**, and **busybox** combo makes it easier to have an embedded **Linux** platform with a small storage footprint. But without the **NPTL** support, real-time applications cannot be used in user space, unless you use direct system calls to the kernel.

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

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 behaviour tests. The testing results are applicable only to this version as other versions may have other significant performance figures and behaviour.

The library used between the testing applications and the kernel is the **glibc** version 2.11.1 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.

2.3 Supported CPU

☺ One of the advantages of using **Linux** OS is its support for most available CPUs around, although the stability can be sometimes an issue for less common-used platforms. As **Linux** is used a lot on x86 processors, it is very stable on these PC-like platforms. Also the ARM version is used a lot (portable/low power devices) and thus very stable.

For less-used platforms, this can however be an issue. For instance, we had to solve some problems for a customer running **Linux** on a MIPS based platform due to very sporadic crashes on that platform. We discovered that they were solved in more recent kernels. This also demonstrates that the open source community works. However, in real-life embedded software development, it is not a real option to update each month the kernel to a newer version.

Remark as well that some **Linux** behaviour can change seriously between versions! So being on the bleeding edge can be… indeed bleeding, be warned!

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3 Evaluation Results summary

Remember that the tested and evaluated product is **Vanilla Linux** 26.33.7 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 the latencies are bound and therefore this **Linux** version may be labelled Real-Time.

TAKE CARE: Using a wrong driver or wrong configuration can destroy real-time behaviour. You need to follow the detailed rules described in this document to insure RT-behaviour.

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…
- Setting up a complete embedded target from scratch is a daunting task.
- **uClibc**, which is used a lot in embedded systems, does not have currently **NPTL** support and as such cannot provide real-time characteristics to the user level. Thus, **glibc** should be used.

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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 to understand the scoring.