Behavior and performance evaluation of Android Linux 3.0.4 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, but as configured for Android, on an ARM-based platform.

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" in 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 library used for interaction between the testing applications and the kernel, 3) 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) OS. Today more and more embedded systems are equipped with **Linux** solutions using more or less real-time variants.

Recently, Google started with its Android phones and tablets. The advantage of Android is the availability of tools for making graphical user interfaces. All this is based on a Java virtual machine and thus hardware independent from the application level of view.

Now, what would happen if you would use for instance an Android system as a SCADA control system to control some machinery? The GUI would of course be a plus, but what would be the timing behavior?

Of course, Android is not meant to be used for any real-time purposes at all. It is even built to consume as less power as possible as it is used for handheld devices. We know that power management is an evil for good timing behavior! But even, we still wanted to compare it with a Linux RT_PREEMPT system on the same platform to clearly see the impact of kernel configuration choices made for Android and the ones used by the RT_PREEMPT patch.

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 **Linux** 3.0.4 as used by the Linaro Android build for the Beagle XM platform. We used the following build: Linaro Android Beagle 11.09 release, build 4.

We deliberately did not adapt kernel configuration settings but used them as delivered.

2.2.1.1 Android

Android is based on Linux (as it uses a Linux kernel). However, a lot of customization on the libraries, root file system and available applications are done making an Android version much different than any traditional Linux system.

Remark that Android is not meant to be used for developing in C code. Everything is built around java. The Android development tools (Android SDK) are all focused to develop "smart apps" using the Java virtual machine. However, Android provides as well a Native Development Kit (Android NDK) which can be used to develop C/C++ applications.

But the Android NDK is not meant to be used for developing pure C/C++ applications. They are meant for developing libraries which provide some interfaces towards the java environment. So their purpose is to have some acceleration for dedicated algorithms instead. Thus, this puts already some constraints on what you can build natively for Android.

Another important difference relates to the C-libraries deployed with Android. Google wanted to isolate Android based applications from the GPL license. Therefore, neither the glibc nor the µClibc libraries can be used. Instead, they developed one themselves starting from the BSD code (using the BSD license, a truly free license as used for instance by FreeBSD and OpenBSD). In fact, Google started to build its C-libraries with a branch from the OpenBSD libraries source code. These C-libraries provided for the Android system are called the "Bionic Libc".

However, Bionic does not have all the features that are already in the traditional glibc implementation. Looking at the features required for real-time behavior, we notice the lack of priority inheritance mutexes. Although they are available in the kernel, you can access them only by building your own library above the Linux system calls…

Clearly, Android is intended to be deployed on tablets and smartphones, and not on other embedded usages. But we are still interested in the OS and that's why we test it here.

2.2.2 Hardware

The hardware that was used for executing our tests on the Linaro Android operating system 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

Remember that the tested and evaluated product is an Android version, which is focused for smart phones and tablets. Thus, it is logic that it does not fit for real-time systems. However, due to the use of their proprietary bionic C library, it is even worse than expected!

First of all, Bionic does not have priority inversion protection mechanisms available on mutexes, which is an obligatory requirement to fulfill real-time requirements. Second, the semaphore implementation behaves badly: it is implemented as purely FIFO queued one (without any prioritization); further, release times are going straight through the roof once multiple threads are blocked on the same semaphore!

Finally, the bionic library contains only a limited subset of the glibc libraries. As such, a lot of open source C/C++ applications cannot be built for Android!

Conclusion is that Android should only be used where it is designed for: building Java GUI applications!

3.1 Positive points

- No license fees
- Source code available

3.2 Negative points

- No real-time characteristics at all!
- Not meant to be used for any C/C++ applications.
- **Bionic C library**, badly implemented semaphores and mutexes.

3.3 Ratings

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

RTOS Architecture (+libraries)	0	4	
OS Documentation	0	4	10
OS Configuration	0	6	10
Internet Components	0	6	10
Development Tools (C/C++)	0	6	10
Installation and BSP	0	4	10
Test Results	0	0	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.