Behavior and performance evaluation of FreeRTOS 8.0.0 on RX63N

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Authors

Fei Guan (2), Long Peng (2) and Martin Timmerman (1, 2)
1: Dedicated Systems Experts, 2: VUB-IR-ETRO-EmSlab Brussels

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1 Document Intention

1.1 Purpose and scope

This document presents the quantitative evaluation results of the FreeRTOS operating system from Real Time Engineers Ltd. It was evaluated on a Renesas RX63N based platform. The testing results of this operating system employed on a RX63N 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 hardware on which the under testing OS will be employed, 3) how to implement the evaluation adapted to µC/OS-III on the Renesas RX63N platform.

2.1 Overview

The evaluation project started in 1995 and as such accumulates a long experience with different (RT) OSs. FreeRTOS is claimed to be a prevalent, well-developed, and highly efficient real-time operating system that supports 34 embedded system architectures. It can be used freely in uncommercial or commercial products. The latest release of FreeRTOS is V8.0.0.

For this evaluation, we tested FreeRTOS on YLCDRX63NE which uses a Renesas RX63N microcontroller. The development environment is e2 studio V2.2.0.13 in combination with Renesas RXC Toolchain V2.00.01.

A simultaneous evaluation of µC/OS-III has also been done which you can find in "Behavior and performance evaluation of µC/OS V3.03.01 on RX63N" [Doc. 5]. So, in order to provide a better view for the reader, some comparison comments are given all along this document.

2.2 Evaluated (RTOS) product

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

2.2.1 Software

The RTOS that will be evaluated and tested is FreeRTOS V8.0.0, which is the latest version when we did the test. FreeRTOS is an open source real time operating system which is free to use in commercial products. A fully indemnified commercial license is also available with dedicated support.

FreeRTOS supports optional preemptive scheduling policy with as well as round robin policy with time slicing, Cooperative scheduling policy and Hybrid scheduling policy. It also supports message passing, semaphore, recursive semaphore and mutexes with priority inheritance through FreeRTOS queue usage model.

The Renesas Peripheral Driver Library (RPDL) is a unified API for controlling the peripheral modules on the microcontrollers made by Renesas Electronics. It is used to support the functions of timers (one Compare Match Timer for system clock tick, one Compare Match Timer for interrupt generation and two Multi-function Timers for time measurement) and UART.

RX600 Series USB Host Mass Storage Class Driver is used in combination with M3S-TFAT-Tiny (TFAT) to make the USB functional for saving all the test results.

2.2.2 Hardware

We tested this FreeRTOS version on Renesas RX63N MCU with the following characteristics:

- Renesas RX63N MCU running at 100MHz
- On Chip Memory: 128KB RAM, 2MB FLASH
- On Module Memory: 16MB RAM, 16MB serial FLASH
- Four on-chip 8-bit timers (TMR), four on-chip 16-bit compare match timers (CMT) and six 16-bit on-chip multi-function timers (MTU2).

2.2.3 Evaluation Implementation

All the compiling works were done under Windows with the compile tool Renesas RXC Toolchain v2.00.01. The development and debug environment is Renesas eclipse studio v2.2.0.13. The debugging and flash writing tool is J-Link.

RX63N MCU has four on-chip 8-bit timers (TMR), four on-chip 16-bit compare match timers (CMT) and six 16-bit on-chip multi-function timers (MTU2). We used two MTU2 timers in cascaded operating mode to obtain the same function as a 32-bit timer for our measurements, one CMT timer to generate system clock tick and one CMT timer to generate interrupts.

Although RPDL and USB drivers provided by Renesas was used to support on board devices such as USB, UART and timers, we make sure no test results are affected by this. There are no tasks or interrupts related to USB or UART enabled during the tests. The tests for evaluating this OS were done in February 2014.

3 Evaluation results summary

Following is a summary of the results of evaluating FreeRTOS 8.0.0 on Renasas RX63N.

3.1 Positive points

- No license fees.
- Source code available.
- Very small, suitable for embedded systems considering the limited hardware resources.
- The kernel is highly configurable.
- Active maintenance and upgrade paths.
- Good interrupt handling mechanism.

3.2 Negative points

- The instruction documents are not free.
- Only limited Board Support Packages (BSP) can be found which makes it relatively hard to get references when making a product.
- Setting up a complete embedded target from scratch is not easy. Hard to find usable drivers in the official release BSP.
- The number of threads pending on a semaphore has great impact on acquisition time.
- The memory handling mechanism is not the best choice for memory limited system.

3.3 Ratings

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

RTOS Architecture	0	7	10
OS Documentation	0	7	10
OS Configuration	0	8	10
Internet Components	0	7	10
Development Tools	0	7	10
Installation and BSP	0	7	10
Test Results	0	8	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.