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Overview of Real-time Operating Systems for embedded devices

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Abstract: Real-time OS are very useful for embedded devices and home automation. This paper describes well known real-time OS such as Zephyr OS, FreeRTOS and GNU/Linux. They are multi-thread OS. Their features will be compared. The paper performs the Overview task of PhD thesis.

Keywords: risc-v assembly, avr assembly, operating system, micro-controller modules

1. Introduction

Real-time operating systems can be used for embedded devices management or for civil or military aviation – for optical devices and weapon controls management. Real-time operating system manages devices with that has:

→ limited resources
→ limited time to complete task
→ sensors for communication

Target of the paper is to explore and describe features of well-known RTOS such as: FreeRTOS, Zephyr and Armbian GNU/Linux.

[1] PhD Theme: Methods and Tools to develop an assembly-based operating system for embedded devices

2. Material and Methods

Programming languages for real-time os development are C or Assembly language. Usage of assembly language gives more control of current task execution. For every RTOS will be analyzed:

→ Short description
→ Supported virtualizators
→ Supported toolchains
→ Supported Instruction set architectures
→ Possible assembly languages that can be used
→ Embedded device whitch is supported by the os

1) FreeRTOS Analysis

FreeRTOS is open-source real-time operating system that has portable libraries written in C programming language. Libraries provides support for popular communication protocols such as: MQTT, TCP/IP, etc. FreeRTOS is available for different instruction set architectures such as:

→ x86
→ ARM
→ ARM-64
→ PIC

This OS can be used for different micro-controller boards like STM32-based, PIC24-based and SiFive RISC-V – based boards. FreeRTOS can be used for IoT boards witch supports connection to Amazon Web Services-based remote services.
There are several options for developing FreeRTOS applications:

→ using default C-based SDK
→ using inline assembly language in C function
→ using standalone assembly language according to instruction set of target device.Options are shown on ***Figure1***.

Applications can be developed on standard x86 computer using virtual environment using QEMU or Virtual-Box – based virtualization. It's shown on **Figure2**.

GNU Make, Cmake can be used for automation of build process of the project. Compiled once the project can be deployed to multiple compatible boards using pipelines based on chosen build tool. Build automatization is shown on ***Figure3. (*FreeRTOS Docs ,2023).**

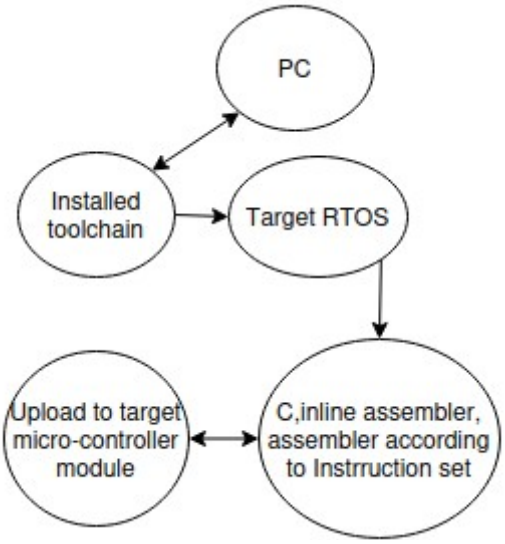

Figure1. RTOS development options

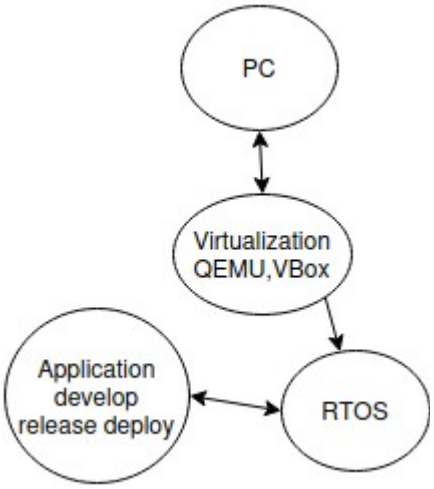

Figure2. RTOS application development

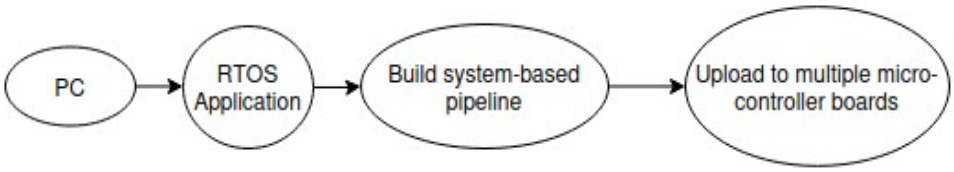

Figure3. RTOS application pipeline automatization

2) Zephyr Analysis

Zephyr is real-time operating system written in C programming language. Zephyr is available for different instruction set architectures such as:

→ ARM-64
→ x86
→ MIPS

This OS can be used for different micro-controller boards like NEORV32,KB-2040. There are several options for developing Zephyr applications:

→ using default C-based SDK

→ using standalone assembly language according to instruction set of target device. Zephyr can be used throught QEMU virtualizator.ARM C Toolchain is supported. Cmake can be used for automation of build process of the project. (Zephyr Docs 2023**).**

3) Armbian GNU/Linux Analysis

Armbian is real-time Debian – ported OS for microcontroller modules; SD card can be used for storage. Armbian is available for different instruction set architectures such as:

→ x86_64

→ RISC

This OS can be used for different micro-controller boards like OrangePi, BananaPi. **(Armbian Docs 2023).**

3. Results

FreeRTOS, Zephyr and Armbian OS key features are analyzed and compared. Virtualizators for x86 application debug and simulation are shown. For every OS are described supported devices.

4. Conclusions and future work

Analyzed operating systems are written in C and they support RISC-V architecture because of C language abstraction. But when requirements for the RTOS are OS to be much faster and more useful for RISC-V projects then exists need to develop truly RISC-V assembly-based OS. That is main target of my PhD thesis.

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