Mendel University in Brno
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MicroPython Utilizing Zephyr Port and NXP FRDM-MCXN947

Bachelor thesis

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Brno 2025

Acknowledgment

I would like to express my gratitude to everyone who contributed to completion of this thesis.
I would like to thank my thesis supervisor, Ing. Jan Kolomazník, Ph.D. , for his guidance and support. Furthermore, I express my gratitude to Zbynek Fedra Ph.D. for guiding me during the creation of this thesis.
I am also very grateful to all the professors in the Department of Informatics at Mendel University for their teaching, openness, and constant support throughout my study.
A big thank you to family members and friends for their support and encouragement.
Finally, I express gratitude to the people who directly or indirectly contributed to the creation of this work. To those who came before me and on whose shoulders I stand.

Declaration

I hereby declare that this thesis entitled **MicroPython Utilizing Zephyr Port and NXP FRDM-MCXN947** was written and completed by me. I also declare that all the sources and information used to complete the thesis are included in the list of references. I agree that the thesis could be made public in accordance with Article 47b of Act No. 111/1998 Coll., Higher Education Institutions and on Amendments and Supplements to Some Other Acts (the Higher Education Act), and in accordance with the current Directive on publishing of the final thesis.

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Abstract

Titarenko, D. MicroPython Utilizing Zephyr Port and NXP FRDM-MCXN947. Bachelor thesis. Brno, 2025.

This thesis explores MicroPython support on Zephyr RTOS using the NXP FRDM-MCXN947 development board. Zephyr RTOS itself provides extended support and easy-to-use APIs to many embedded devices and their peripherals, but the support of MicroPython remains limited and not consistent with MicroPython ports developed for target devices. This work analyzes the current limitations of MicroPython on Zephyr RTOS and selects specific functionality for implementation. The implementation involves initializing Zephyr and MicroPython development environments adjusted to FRDM-MCXN947, conducting functional testing of the development board peripherals with Zephyr and MicroPython environment, and comparing the comparability of native and Zephyr ports of MicroPython.

Key words: MicroPython, thesis, Zephyr RTOS, FRDM-MCXN947

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1 Introduction

The world of microcontrollers and embedded devices continues to grow, and such devices become more common with every day. Even though they are seldom noticeable we more often might find ourselves surrounded by them. From home appliances, to cars, to factory machines to city-wide networks embedded devices reach wide and deep in our lives.

But with the growing count of embedded devices grows complexity of functions they implement. Hence arises a need for Operating Systems(OSs) to manage sets of complex programs and provide a layer of abstraction to ease development in such constrain but demanding environments.

To cover demand of an Operating System in embedded devices the Zephyr Real Time Operating System (RTOS) was created. Zephyr RTOS is an open-source operating system with build-in security and optimization for resource limited devices. Zephyr kernel supports ARM, Intel x86, ARC, RISC-V, Nios II, Tensilica Xtensa and large number of development boards, among others NXPs FRDM-MCXN947. ALso Zephyr has rich API that allows developers to write high-level code for embedded devices.

Writing software for embedded devices is still a complex task regardless of what underlying technologies are used. Writing it in a language such as C adding an additional complexity due to need of managing program memory allocation and deallocation by hand. Leaving unhandled memory sector could lead to memory leaks or worse opens an opportunity for an attacker to execute malicious code on an embedded device. The consequences of such problems become much grater when occurring in the embedded world. MicroPython is an optimized subset of Python 3 programming language for embedded devices. It aims to ease writing software by managing memory using its garbage collector system, using easy to read Python-like syntax and providing various modules to enable work with different peripherals. Additionally, MicroPython allows for code portability, meaning that code written for FRDM-MCXN947 could be ported and ran on ESP32 with minimal updates to code.

But MicroPython does not support every single device straightaway – ported versions of MicroPython are submitted to the MicroPython repository, by a manufacturer or an enthusiasts. Later submitted port will be reviewed and tested by MicroPython maintainers, which is a lengthy process, for example MicroPython port for Zephyr was under review for 2 years.

By combining Zephyr RTOS and MicroPython in one technological stack the best of both technologies could be utilized. Potential exists for developers to write highly readable, easy-to-understand and efficient code with MicroPython that make use of various hardware support introduced by Zephyr RTOS. Yet the state of this development environment is not yet firm and have plenty of rough edges and unapparent problems that could arise during the process of software development.

The aim of this thesis is to construct a method for configuring the development environment for MicroPython, Zephyr RTOS and FRDM-MCXN947 development board, provide insight of compatibility challenges of both platforms and propose potential solutions for extending MicroPython port to Zephyr RTOS. The finding of this thesis will contribute to understanding of the state of both platforms and their integration, informing future developers and increasing usability of MicroPython and Zephyr.

1.1 Goal of this thesis

Goal of the thesis is to establish development environment and workflow for developing applications for embedded devices with the MicroPython Zephyr port. This work could be used in future to ease start of application development and as a reference.

2 Background

This chapter introduces the reader to an information about Zephyr RTOS, MicroPython and FRDM- MCXN947 board that is needed for understanding this thesis.

2.1 Zephyr RTOS

Zephyr is an Operation System designed for resource-constrained and embedded system from simple sensors to smart industrial embedded solutions with emphasis on safety. It supports a broad list of embedded devices, development boards and peripherals. Zephyr offers extensive number of features and services including multi-threading, inter-thread data passing, inter-thread synchronization, dynamic memory allocation, interrupt service, power management, networking, file system. Zephyr project is open-source, distributed under Apache 2.0 license and was created under Linux Foundation organization.(Zephyr Project, Intorduction, 2024)

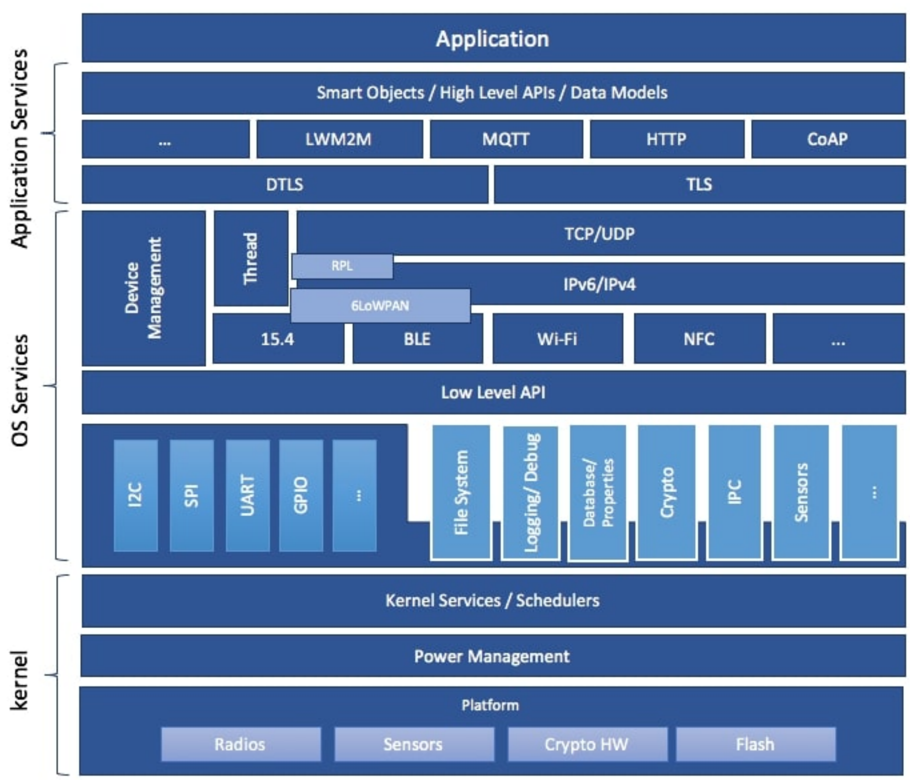

Figure 1: Zephyr System Architecture
Source: (Zephyr Project, Zephyr Security Overview, 2024)

2.1.1 West

West is a part of Zephyr's tool-chain used for building and configuring. West can initiate Zephyr workspace from official upstream repository, update or change version of a local Zephyr workspace to any version in official repository, build Zephyr application from source, flash built application to a board.(Zephyr Project, West (Zephyr's meta-tool), 2024)

2.1.2 Kconfig

Kconfig is Zephyr's kernel, drivers and subsystems configuration system that allows to configure Zephyr at a build time. Kconfig goal is to enable configuration without introducing changes to source code.

The initial board configuration can be found in **<board>_defconfig** files. For example configuration file for FRDM-MCXN947 is located at **boards/nxp/frdm_mcxn947/ frdm_mcxn947_mcxn947_cpu0_defconfig**. The board configuration for NXPs' FRDM-MCXN947 is as follows:

```
CONFIG_CONSOLE=y
CONFIG_UART_CONSOLE=y
CONFIG_SERIAL=y
CONFIG_UART_INTERRUPT_DRIVEN=y
CONFIG_GPIO=y
CONFIG_PINCTRL=y
CONFIG_ARM_MPU=y
CONFIG_HW_STACK_PROTECTION=y
CONFIG_TRUSTED_EXECUTION_SECURE=y
```

Kconfig values can be set to a **<board>_defconfig** files, temporarily with terminal graphical interfaces or with a **prj.conf** file at application level which overrides the initial configuration during application build.(Zephyr Project, Configuration System (Kconfig), 2022)

2.1.3 Devicetree

Devicetree is a data structure for describing hardware. It's a community driven standard that is heavily used in Zephyr project. In Zephyr devicetrees are usually build inherently meaning that for example FRDM-MCXN947 has a devicetree configuration **board/nxp/frdm_mcxn947/frdm_mcxn947_mcxn947_cpu0.dts** which mainly enables peripheral devices, but includes FRDM-MCXN947 specific configuration from **frdm_mcxn947.dtsi** (include file), which in turn includes **frdm_mcxn947-pinctrl.dtsi** file that mostly defines pinmux groups. Additionally the **frdm_mcxn947_mcxn947_cpu0.dts** includes **nxp_mcxn94x.dtsi** file that defines memory ranges for SRAM, FLEXSPI and peripherals and includes **nxp_mcxn94x_common.dtsi** include file where most of devices including CPU, GPIO, CTIMER and others are defined and assigned memory ranges.(devicetree.org, Devicetree Specification Release v0.4, 2023)

Same as Kconfig Devicetrees can be overwritten or have some specific devices configured differently with **overlay** files, which as well needs to be placed in build directory, from there **west tool** will use it to edit the Devicetree configuration.

2.2 MicroPython

MicroPython is an open-source project founded by Damien George. MicroPython is an implementation of the Python programming language that is optimized to be run on embedded and resource constraint devices. It implements the entire Python 3.4 syntax with some selected features from the later versions such as **async/await** from Python 3.5 , additionally on par with Python it uses garbage collection system for memory management. MicroPython final build include a compiler that compiles MicroPython code to bytecode and an runtime interpreter of the compiled bytecode. Programs could be written directly to the MicroPython REPL(Read–eval–print loop) or be loaded onto MicroPython host device with use of serial connection and utility programs like **ampy**.

There are many supported devices and architectures that MicroPython can run on. MicroPyton has additional support to be run on operating systems Zephyr RTOS and on OSes from UNIX family, as well as experimental Windows port.

MicroPython remains in beta-stage, hence it is a subject to possible API and code-base changes in the future.(Nicholas H. Tollervey, 2017)

2.3 FRDM-MCXN947

The FRDM-MCXN947 is a low-cost development board designed by NXP semiconductors. FRDM-MCXN947 integrates Dual Arm Cortex-M33 microcontroller, a neural processing unit, P3T1755DP I3C temperature sensor, TJA1057GTK/3Z CAN PHY, Ethernet PHY, SDHC circuit, RGB LED, touch pad, high-speed USB, MCU-Link debuger, push buttons and has an option to be extended with external devices. (NXP semiconductors, UM12018 FRDM-MCXN947 Board User Manual, 2024)

2.3.1 Signal Multiplexing

FRDM-MXCN947 enables use of several functions for different pins by utilizing Signal Multiplexing. For example pin **P0_10** which is an red RGB pin can use **GPIO** functionality directly, **FLEXCOMM** by utilizing **FC0_P6** FLEXCOMM device, **CTIMER** by utilizing **CT0_MAT0** CTIMER device, and **FLEXIO** functionality by utilizing **FLEXIO0_D2** device.

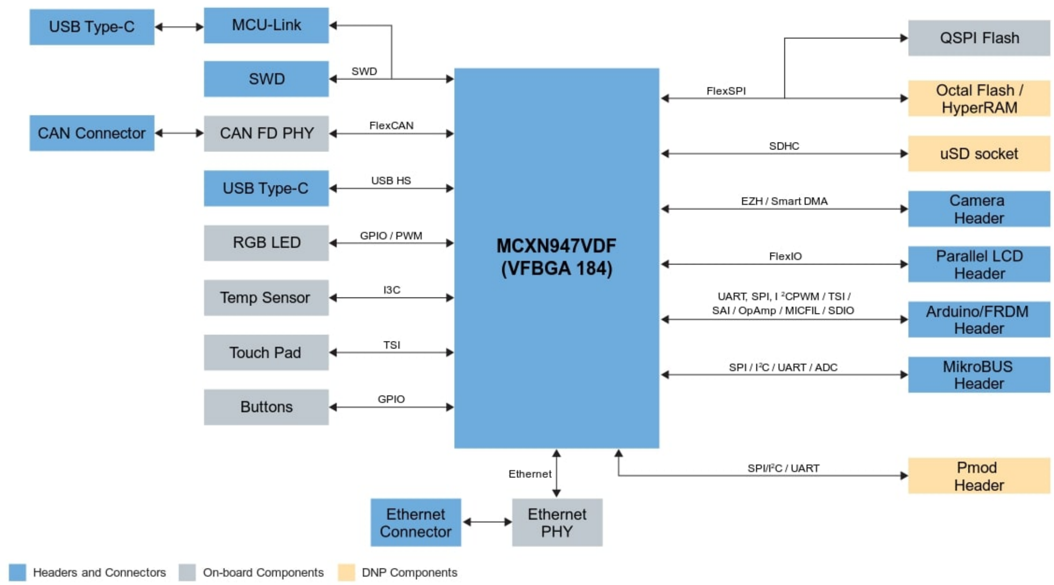

Figure 2: FRDM-MCXN947 Block diagram
Source: (NXP semiconductors, FRDM Development Board for MCX N94/N54 MCUs , 2025)

Only one function can be used at a time on a pin and only one pin can be assigned to a peripheral device. (NXP semiconductors, MCX Nx4x Reference Manual, 2025)

2.3.2 LinkServer

LinkServer is an NXP command-line utility that provides target flashing capabilities and firmware updates for FRDM-MCXN947. (NXP semiconductors – LinkServer for Microcontrollers, 2025)

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