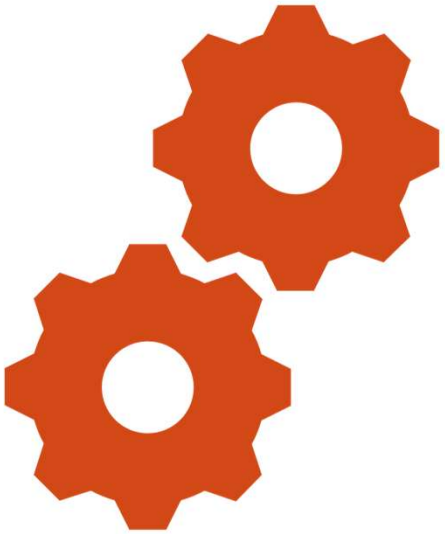
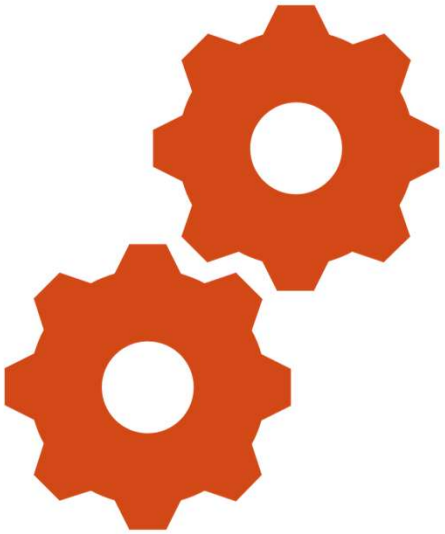


RAPID DEVELOPMENT OF EMBEDDED SYSTEMS FOR DEVELOPERS WITH OPEN-SOURCE TOOLS

BHARATH G

Senior Lead Engineer | Collins Aerospace

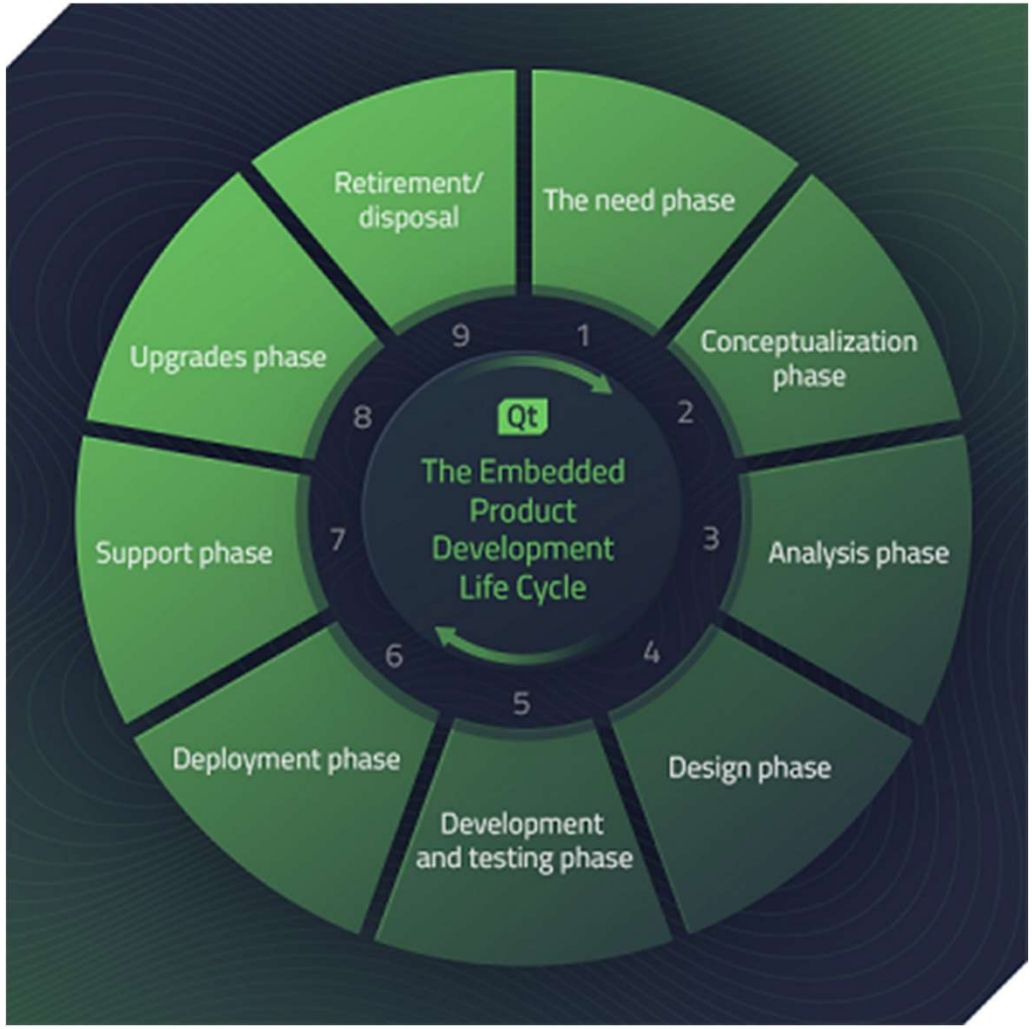
- 9+ Years of Experience in Firmware Development
- Medical, Aerospace and IoT device Design
- Embedded C++ | RTOS | Bluetooth Low Energy | Embedded Linux |Technical Training | Career Guidance



EMBEDDED SYSTEM DEVELOPMENT LIFE CYCLE

THE PRIMARY STAGES OF THE EMBEDDED PRODUCT DEVELOPMENT LIFE CYCLE

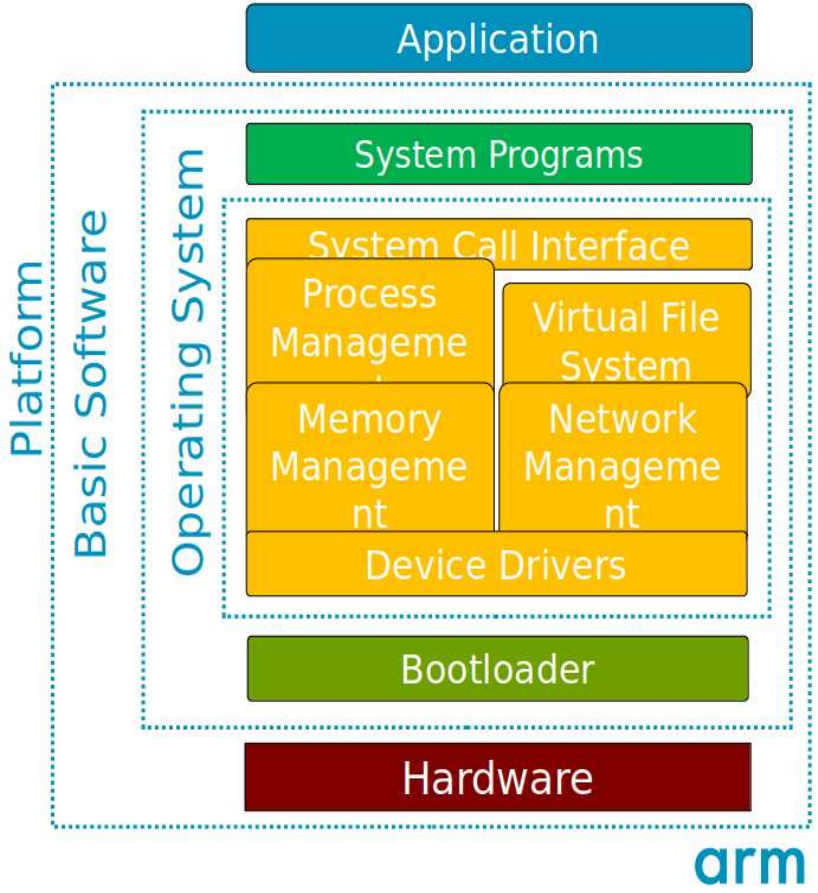
- The need phase
- Conceptualization phase
- Analysis phase
- Design phase
- Development and testing phase
- Deployment phase
- Support phase
- Upgrades phase
- Retirement/disposal



Source: Building Embedded System Design & Software Development (qt.io)

Embedded System Components

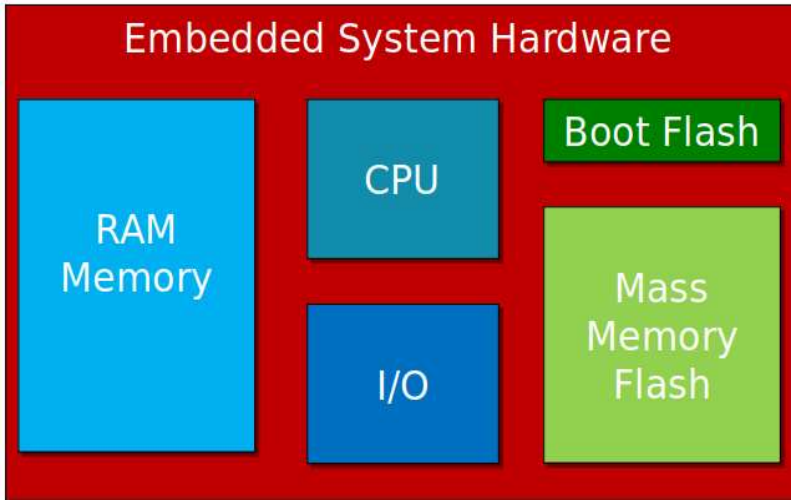
- **Application**
  - Software that implements the functionalities for which the embedded system is intended (e.g., to control an Internal Combustion Engine)
- **Platform**
  - Combination of hardware and basic software components that provides the services needed for the application to run
  - Basic software may include system programs, operating system, bootloader



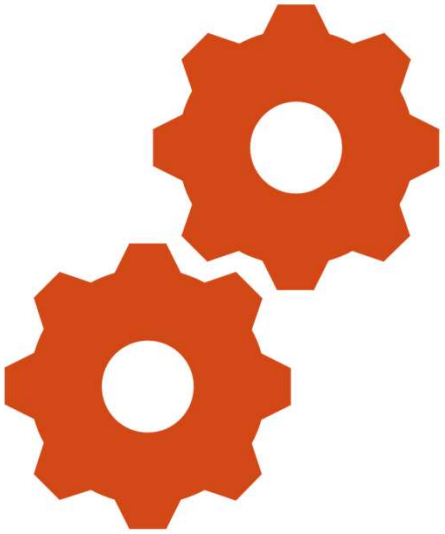
Source: Embedded Linux – Arm®

Hardware platform of Embedded Systems

- RAM memory: volatile memory storing data/code
- CPU: processor running software
- I/O: peripherals to get inputs from the user, and to provide outputs to the user
- Boot Flash: small non-volatile memory needed at power-up
- Mass Memory Flash: large non-volatile memory



Source: Embedded Linux – Arm®

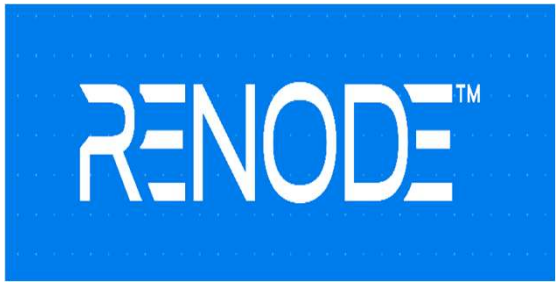


PROTOTYPE EMBEDDED SYSTEMS WITHOUT HARDWARE

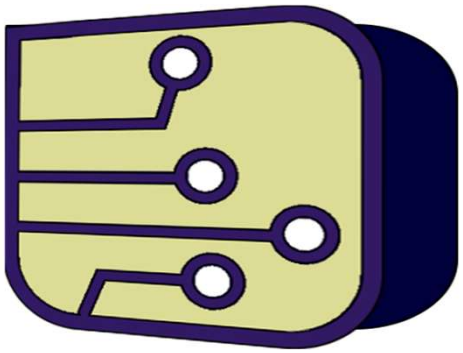
HOW TO PROTOTYPE EMBEDDED SYSTEMS WITHOUT HARDWARE

- Emulators
- Simulators

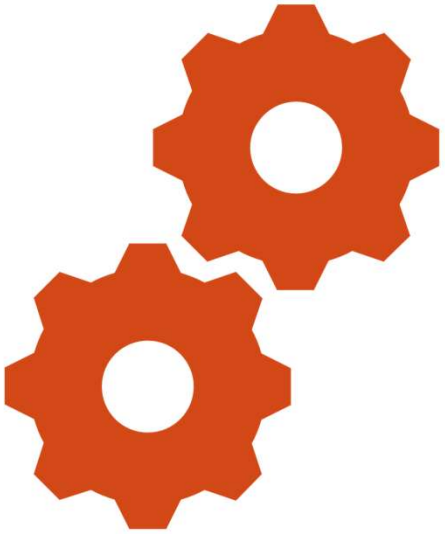
Linux Kernel,
Linux Application



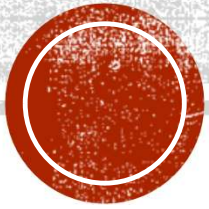
Boards & SoC's
Zephyr RTOS



Electronic Circuits
AVR MCU's

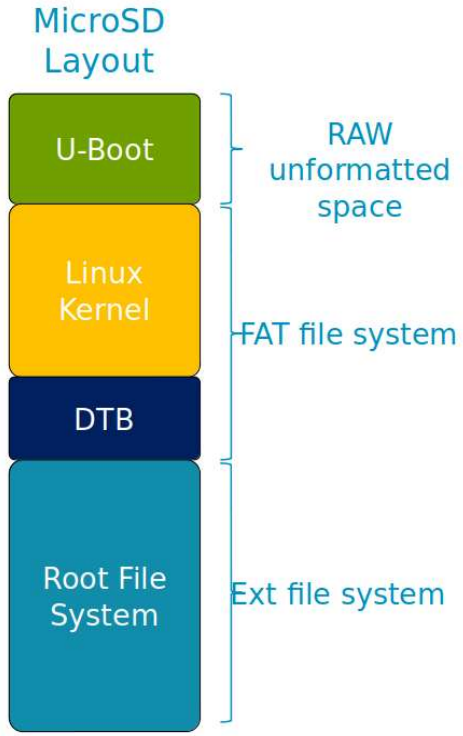


EMBEDDED LINUX APPLICATION ON QEMU



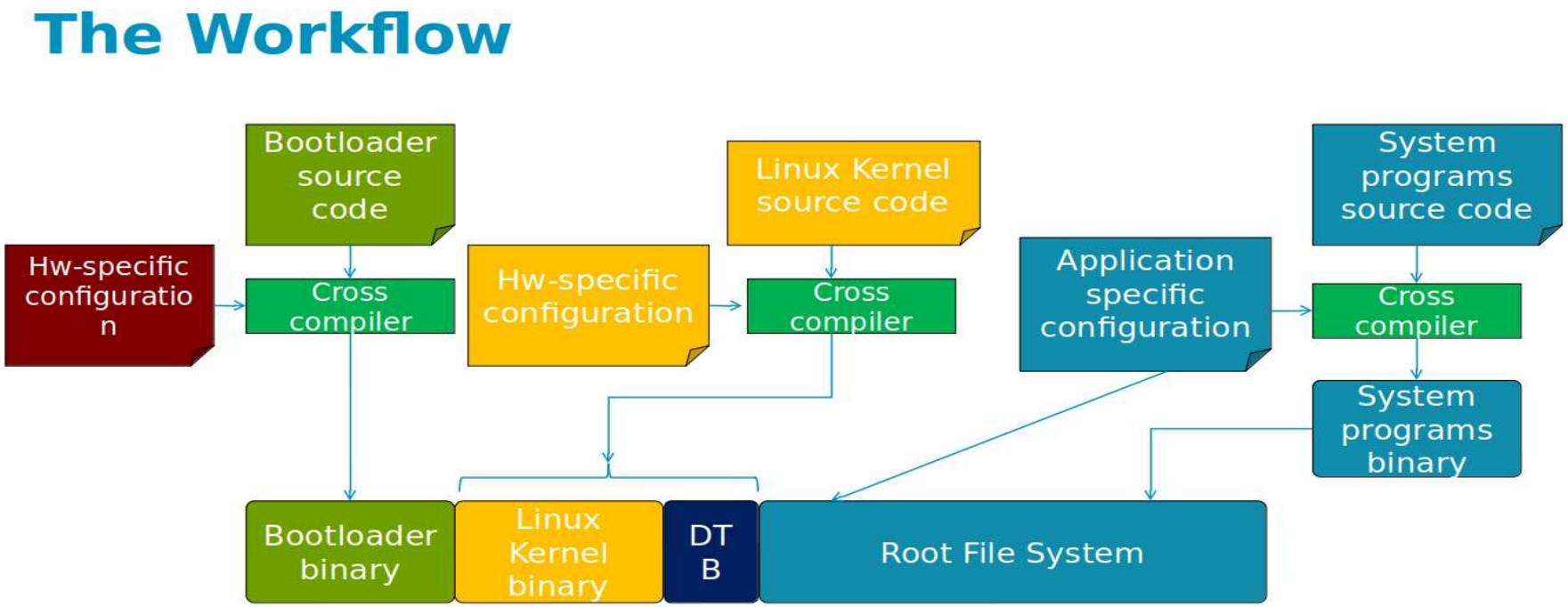
Components required to build Embedded Linux on target

- **An embedded Linux system requires the following components to operate:**
  - The bootloader
  - The Linux Kernel
  - The device tree blob
  - The Root File System
- **All these components shall be:**
  - Configured for the embedded system hardware platform
  - Compiled and linked into an executable format
  - Deployed into the embedded system persistent storage for booting and operations



Source: Embedded Linux – Arm®

Embedded Linux Workflow

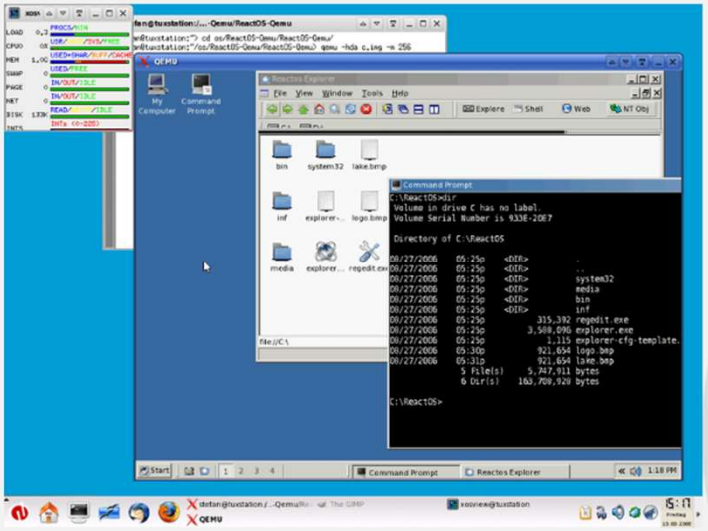


arm

Source: Embedded Linux – Arm®

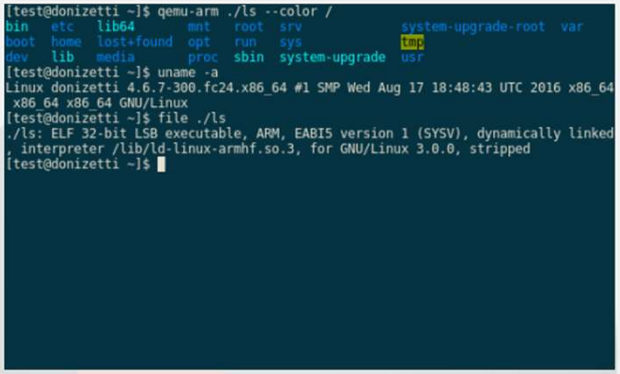
QEMU – Quick Emulator

Generic and open-source machine emulator and virtualizer



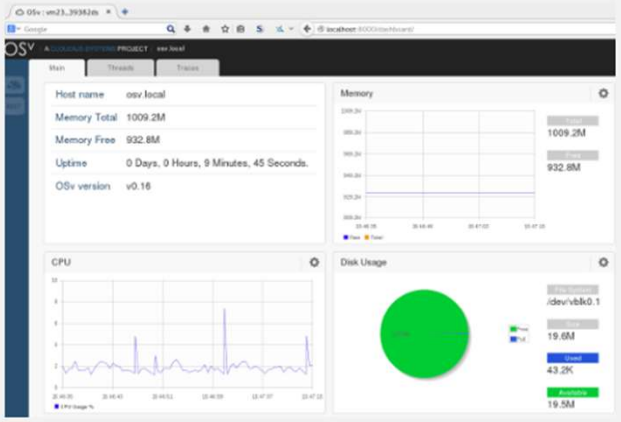
Full-system emulation

Run operating systems for any machine, on any supported architecture



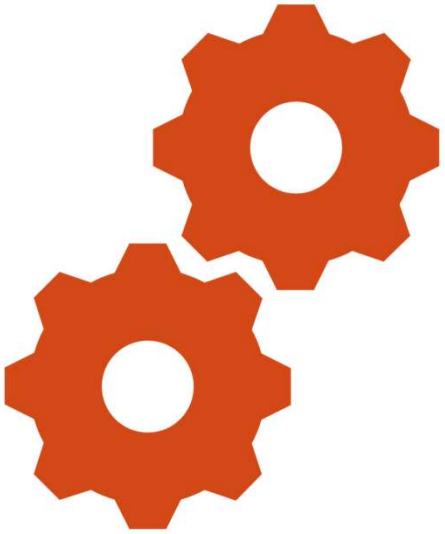
User-mode emulation

Run programs for another Linux/BSD target, on any supported architecture

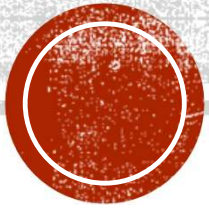


Virtualization

Run KVM and Xen virtual machines with near native performance



ZEPHYR RTOS APPLICATION ON RENODE

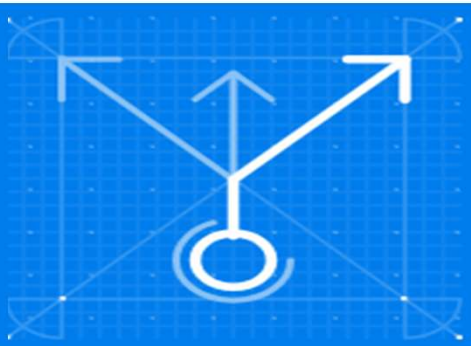


RENODE

RENODE™

Scalable simulation framework with an IoT focus.

Vastly improves testing capabilities.



Supports a modern, rapid development workflow.

Enables security-hardened devices and systems.

Lets you develop complex multinode scenarios.

Easy to use, open and extendible.

Built for continuous integration.

ZEPHYR

Zephyr™

SMALL *yet* SCALABLE

< 8KB Flash
< 5KB RAM

from small sensor nodes
... to complex multi-core systems

FLEXIBLE *yet* SECURE

Heavily customizable

Out-of-the-box support for
450+ boards and 100s of sensors

Built with safety & security in mind

Certification-ready

Long-term Support

OPEN-SOURCE

Permissively licensed (Apache 2.0)

Vendor-neutral governance

ECOSYSTEM

Vibrant community

Supported by major silicon vendors

Supported Hardware Architectures

ARC

arm
Cortex-M, Cortex-R
& Cortex-A

intel
x86 & x86_64

MIPS

Nios II
Processor

RISC-V
32 & 64 bit

SPARC

tensilica
Xtensa

docs.zephyrproject.org/latest/hardware/index.html#hardware-support

Vibrant Ecosystem

Development Tools

Zephyr

Governing Board

Technical Steering Committee

Contributors

Applications & Middlewares

Training & Consulting

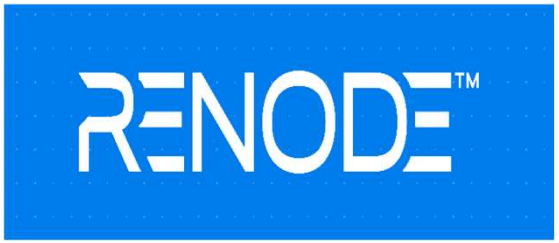
Firmwares & Libraries

600+ supported boards... and growing

180+ Sensors Already Integrated

github.com/zephyrproject-rtos/zephyr/tree/main/drivers/sensor

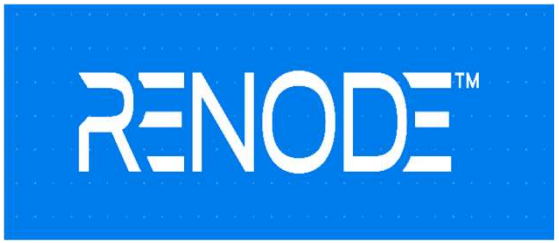
ZEPHYR ON RENODE



Renode and The Zephyr Project

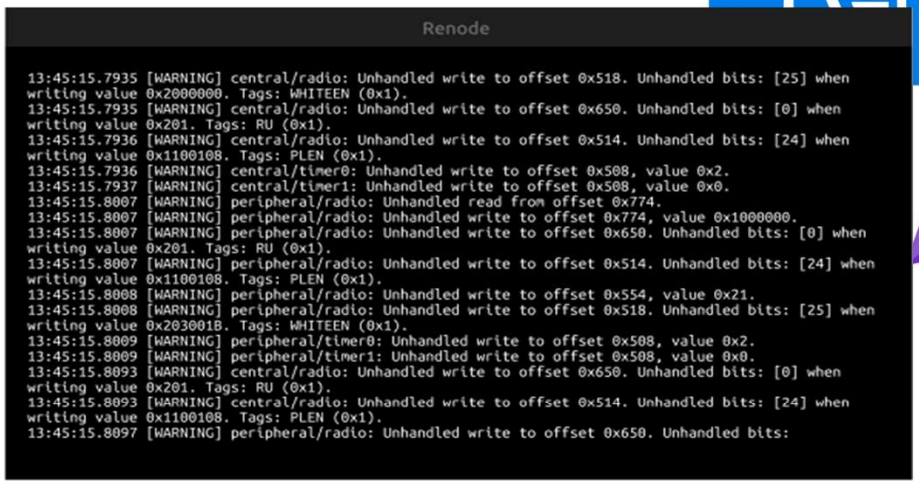
- Zephyr on Renode – Renodepedia
- Supported boards- Renodepedia – Boards
- Example on STM32 - Renodepedia - stm32f4_disco
- Tutorials - Renode Tutorials

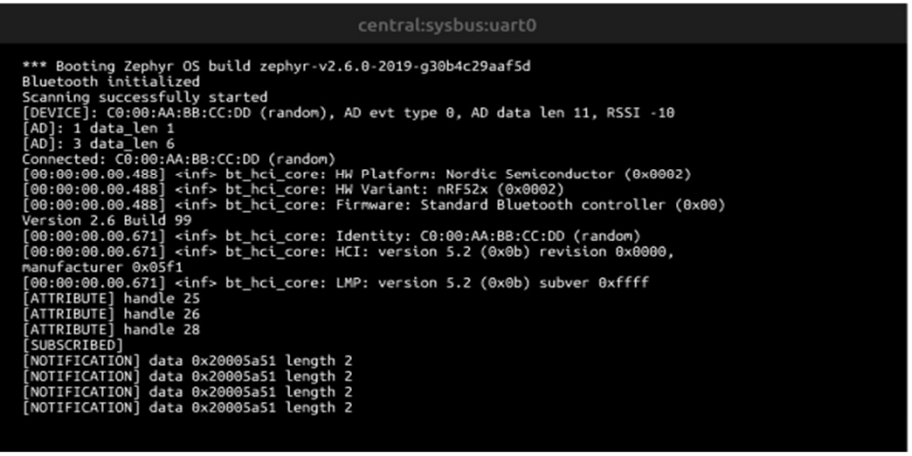
EXAMPLE ON RENODE

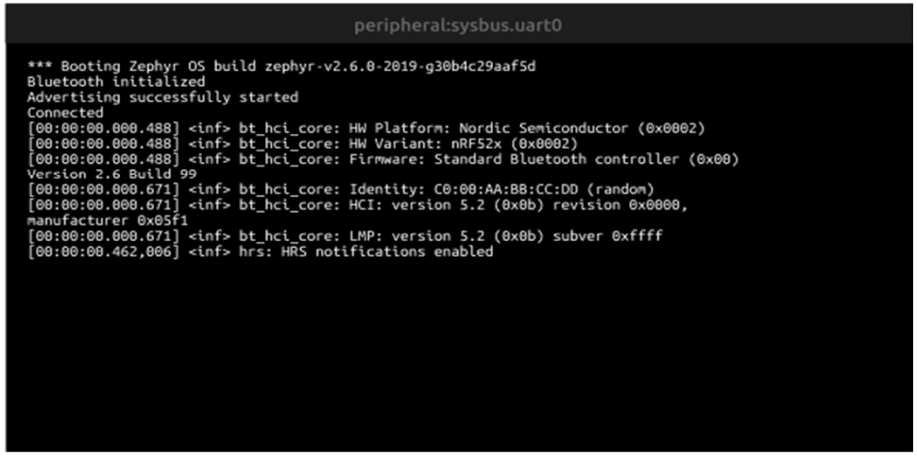


- Blinking LED on STM32F4 Disc - Renodepedia - stm32f4_disco
- BLE on nRF52840 - Developing and testing Bluetooth Low Energy products on nRF52840 in Renode and Zephyr - Blogs - Nordic Blog - Nordic DevZone (nordicsemi.com)
  - Running your own Binaries - Developing and testing BLE products on nRF52840 in Renode and Zephyr

EXAMPLE ON RENODE

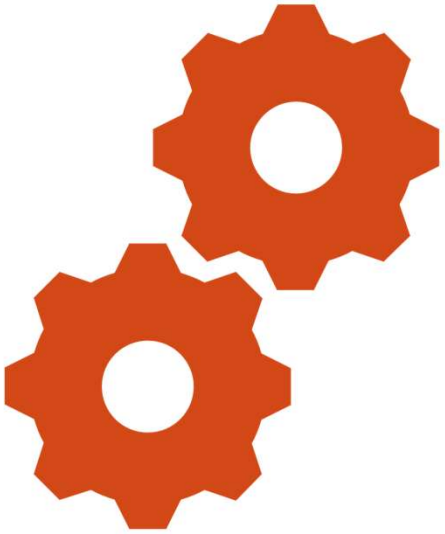




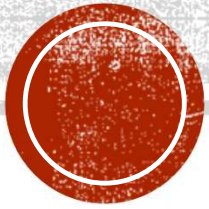


BLE on nRF52840 - Developing and testing Bluetooth Low Energy products on nRF52840 in Renode and Zephyr

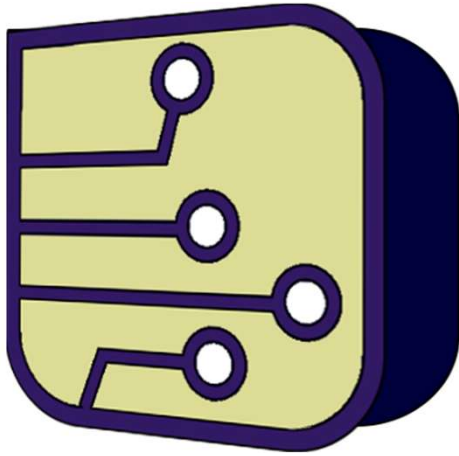
Running your own Binaries - Developing and testing BLE products on nRF52840 in Renode and Zephyr



CIRCUITS WITH AVR ON SIMULIDE



CIRCUITS WITH AVR ON SIMULIDE



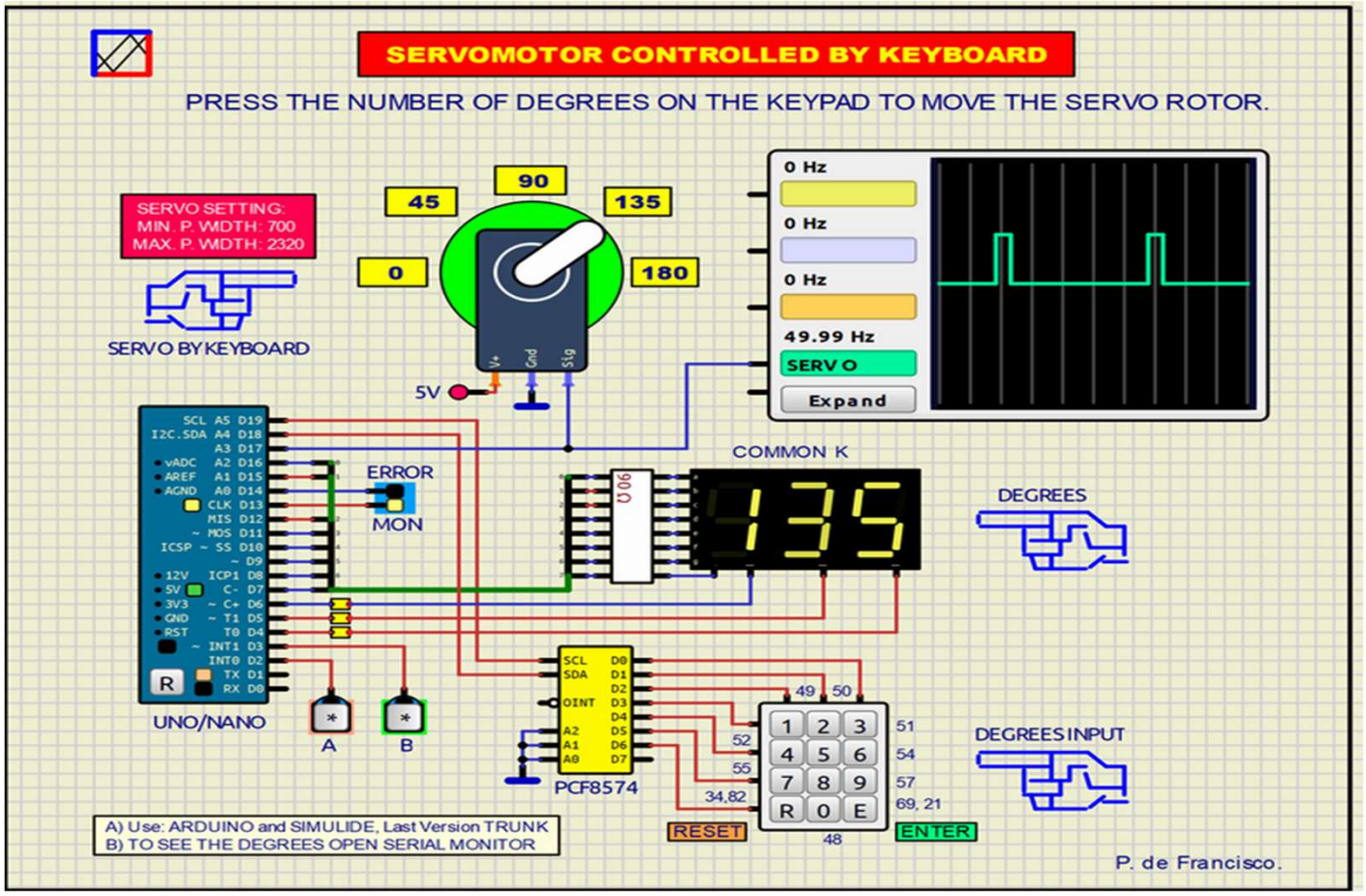
SimulIDE – Circuit Simulator

- Real time electronic circuit simulator
- Analog and digital electronic circuits and microcontrollers
- Supports PIC, AVR , Arduino and other MCUs and MPUs.

- Examples - Projects – SimulIDE
- Tutorials - https://simulide.blogspot.com/p/tutorials-0415.html
- Projects - Projects – SimulIDE

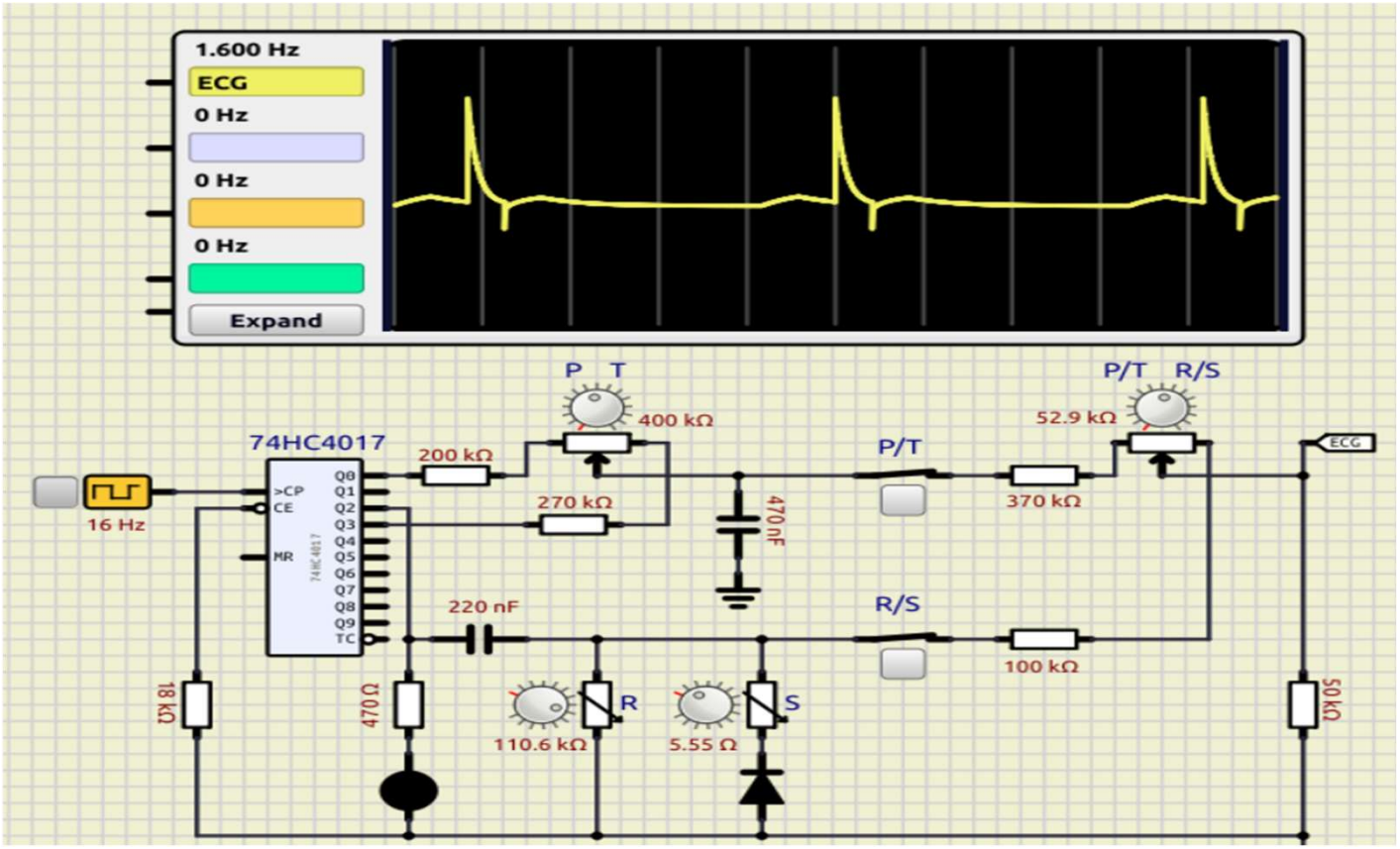
Controlling Servo With Keyboard

- SERVO CONTROLLED BY KEYBOARD__(DF330) – SimulIDE



ECG Signal Generator Circuit

- ECG signal generator. – SimulIDE



NEXT STEPS

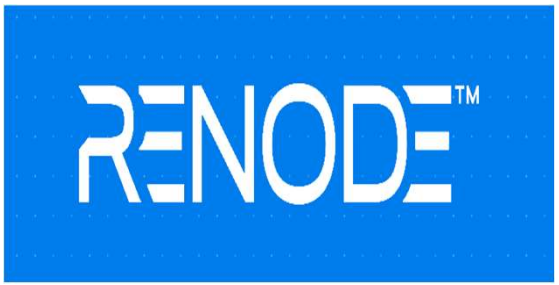
Resources to learn about QEMU, RENODE and SIMULIDE

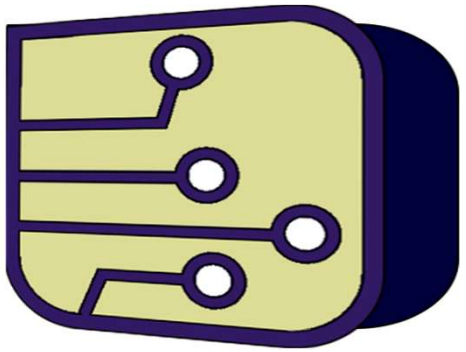
Welcome to QEMU's documentation! — QEMU documentation

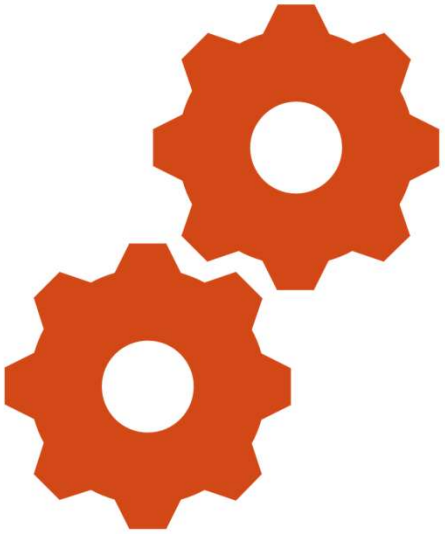
Compiling_linux_kernel_for_qemu_arm_emulator GitHub

Renode Tutorials

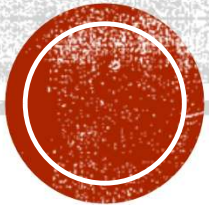
https://simulide.blogspot.com/p/tutorials-0415.html





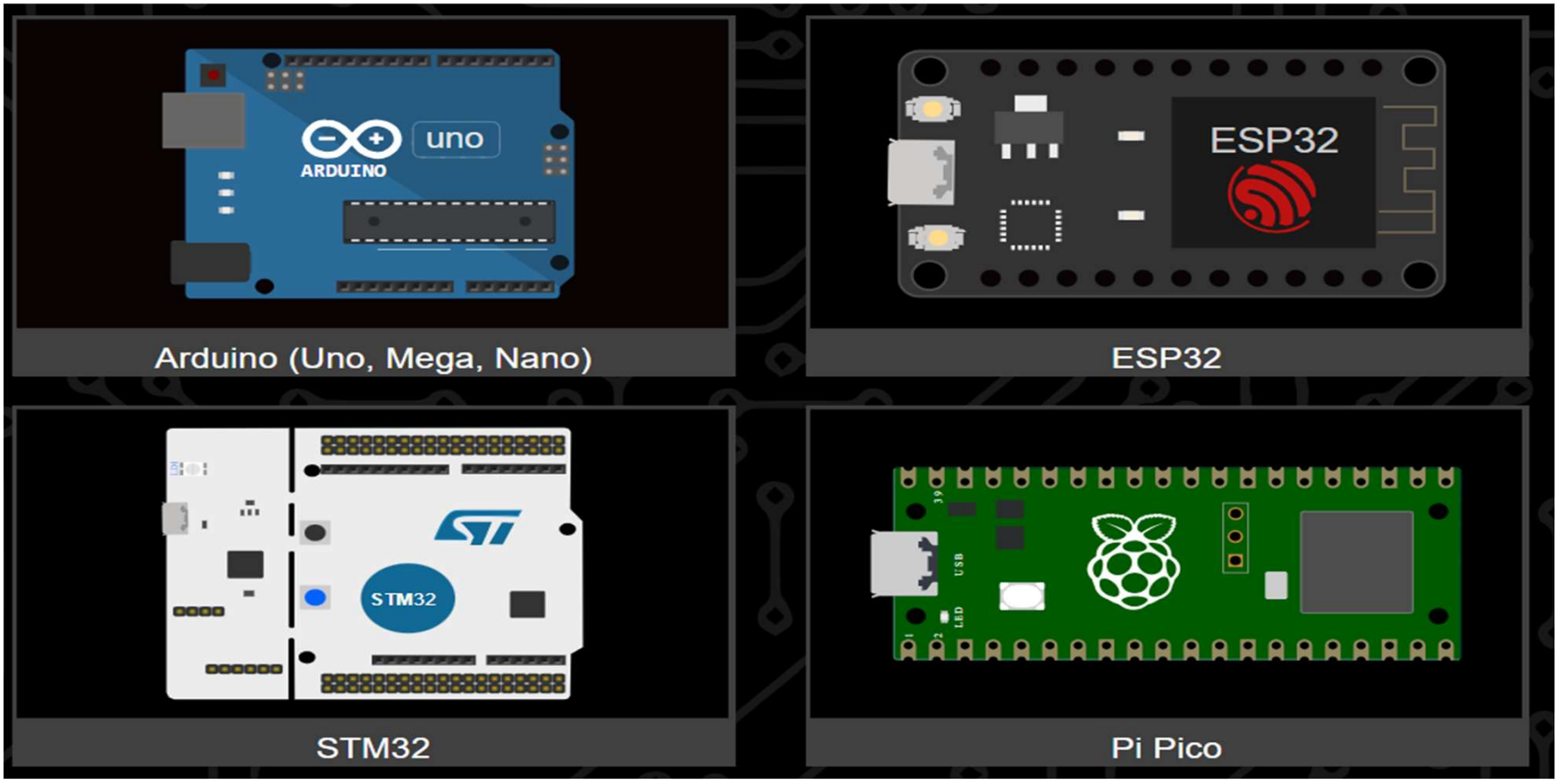


BONUS – WOKWI



Wokwi – Online Simulator + VSCode Offline

- Wokwi - Online ESP32, STM32, Arduino Simulator



Q & A

STAY CONNECTED

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- Linkedin.com/in/Bharathgopal
- LinkedIn- QR Code