



RAPID DEVELOPMENT OF EMBEDDED SYSTEMS FOR DEVELOPERS WITH OPEN SOURCE TOOLS



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Next steps?



Q&A



BHARATH G

- **BHARATH G** - Lead Competency Developer
- Global Engineering Academy, L&T Technology Services
- 8+ Years of Experience in Firmware Development
- Medical and IoT device Design
- Embedded C++ | RTOS | Bluetooth Low Energy | Embedded Linux |





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



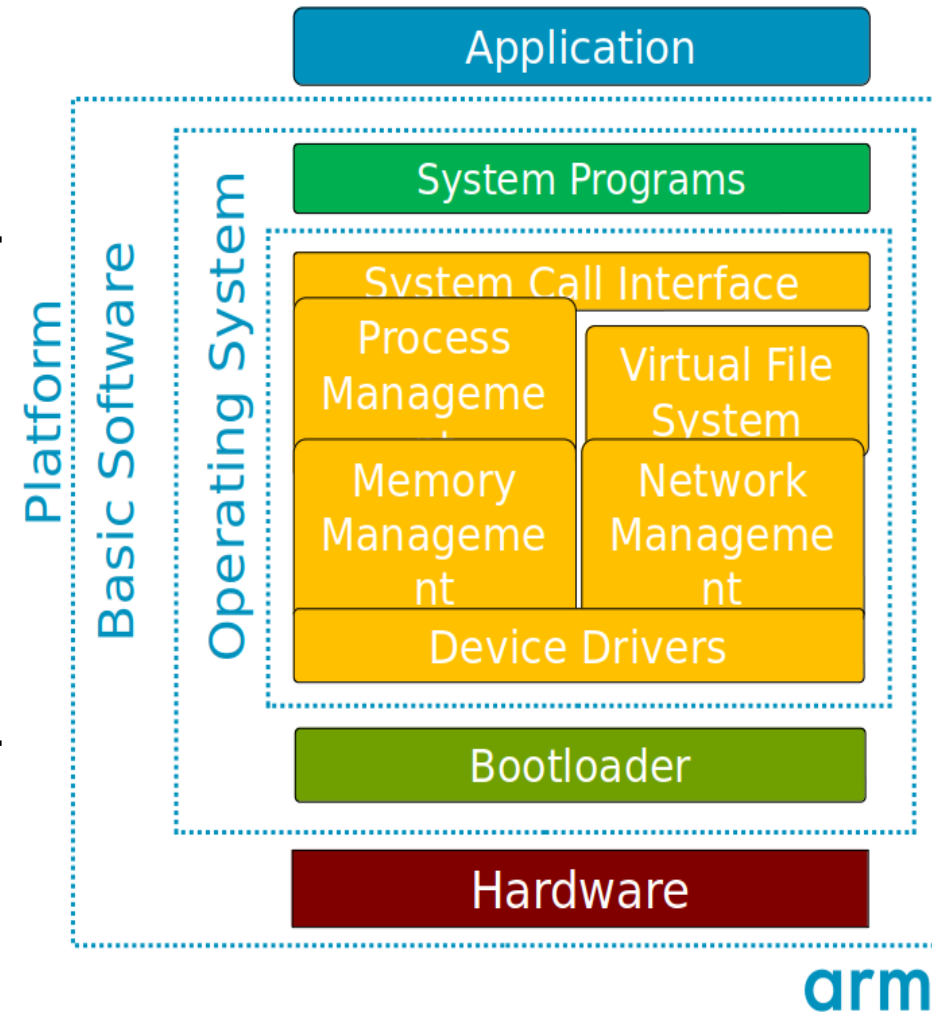
Embedded System Components

■ Application

- Software that implements the functionalities for which the embedded system is intended (e.g., to control an Internal Combustion Engine)

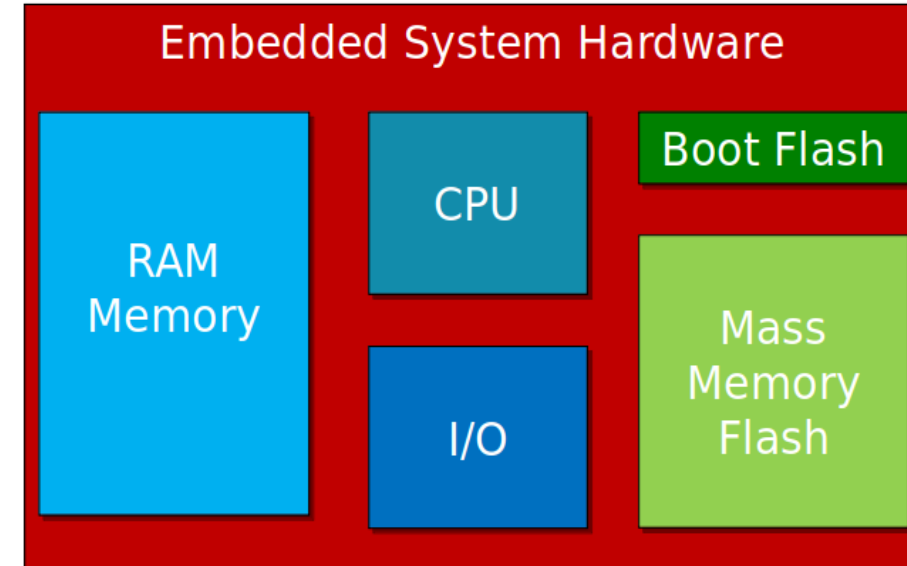
■ Platform

- 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



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





PROTOTYPE EMBEDDED SYSTEMS WITHOUT HARDWARE

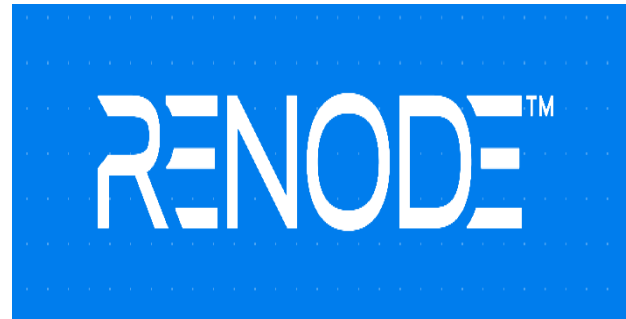


HOW TO PROTOTYPE EMBEDDED SYSTEMS WITHOUT HARDWARE

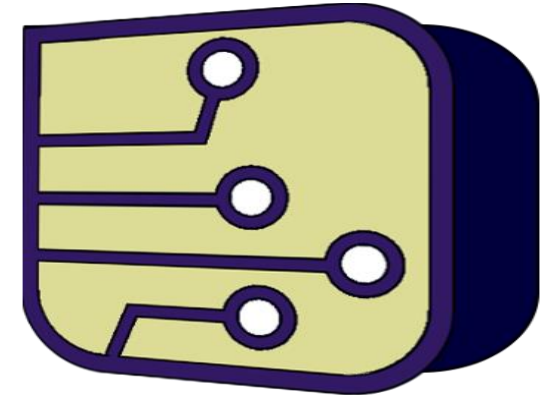
- Emulators
- Simulators



Linux Kernel,
Linux Application



Boards & SoC's
Zephyr RTOS



Electronic Circuits
AVR MCU's

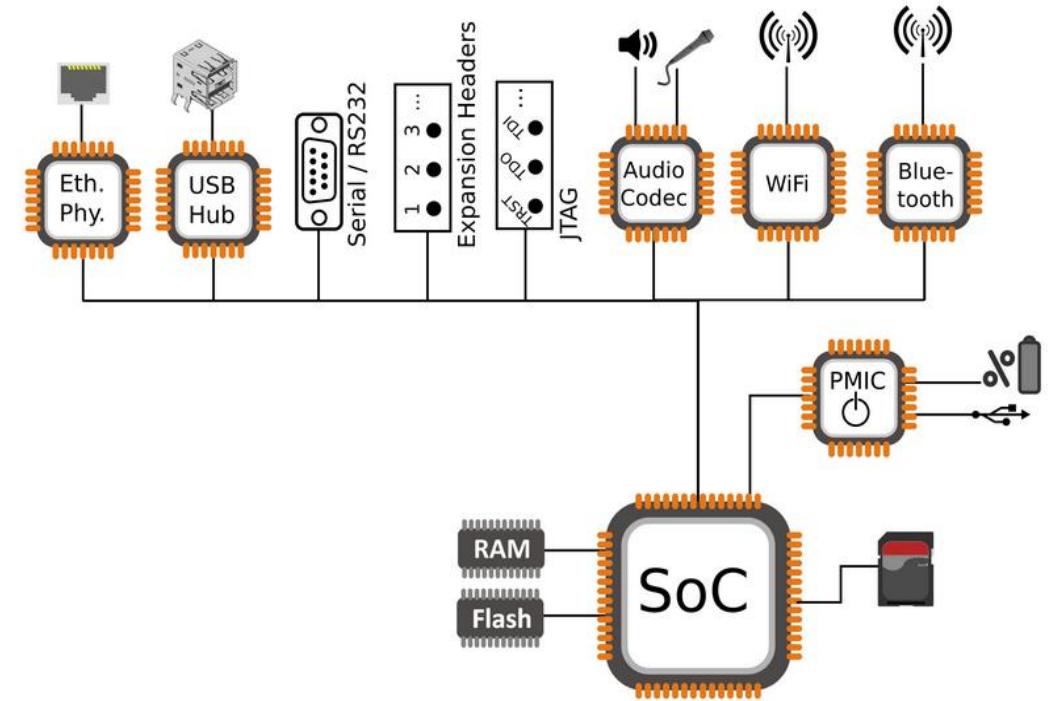
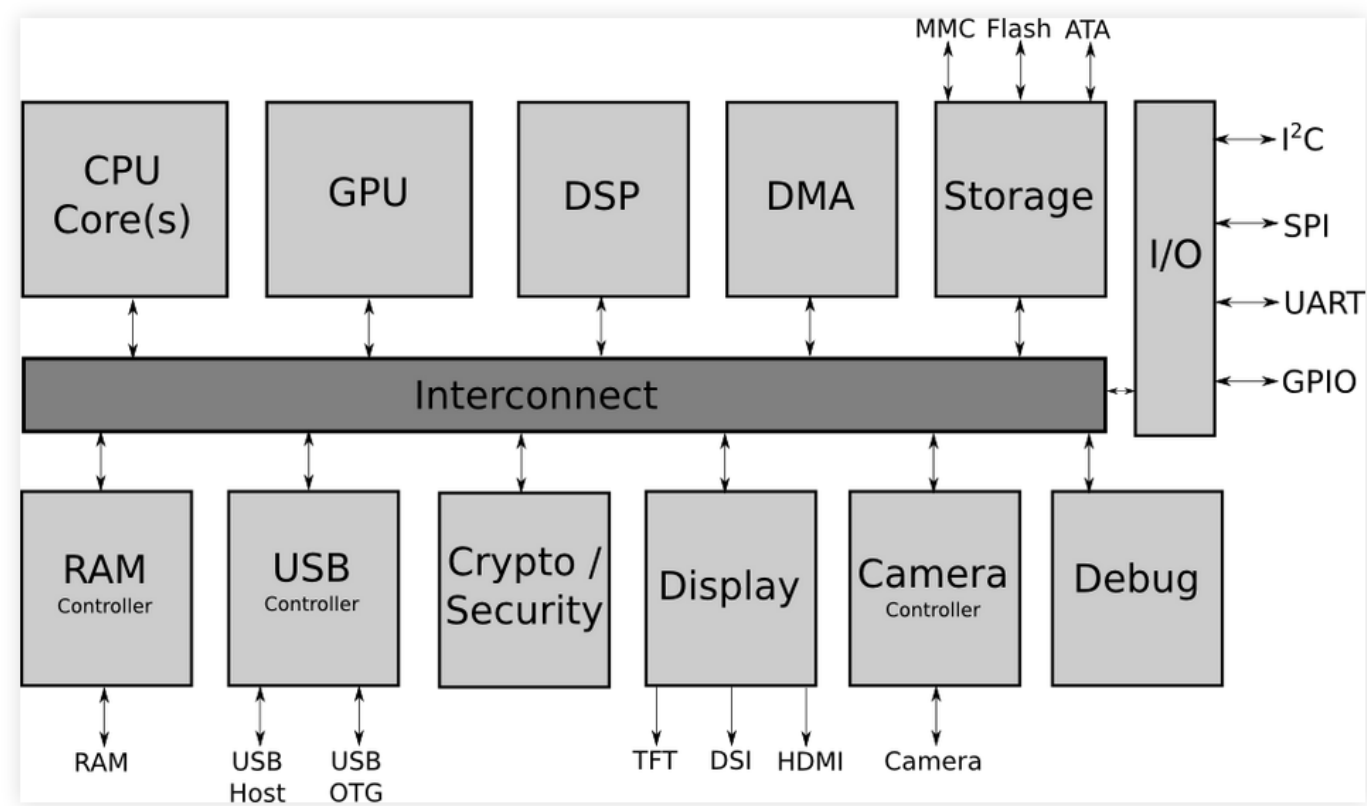




EMBEDDED LINUX APPLICATION ON QEMU

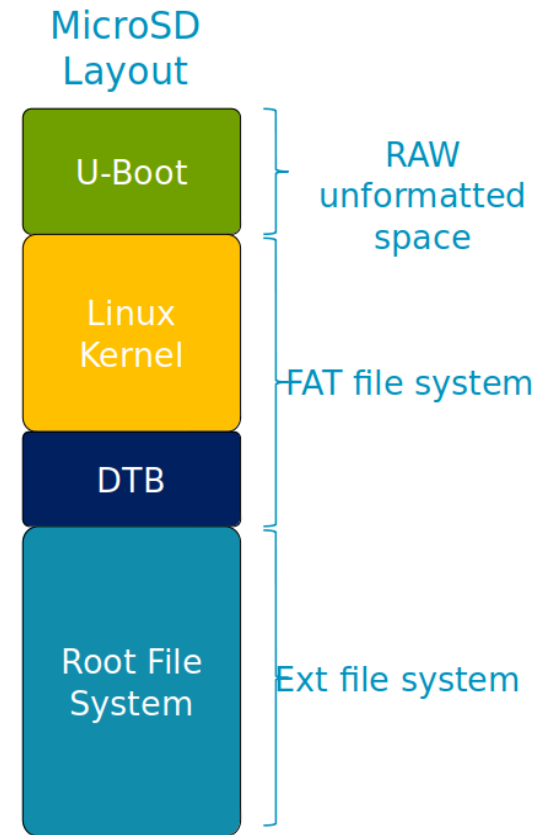


Embedded Linux Workflow



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

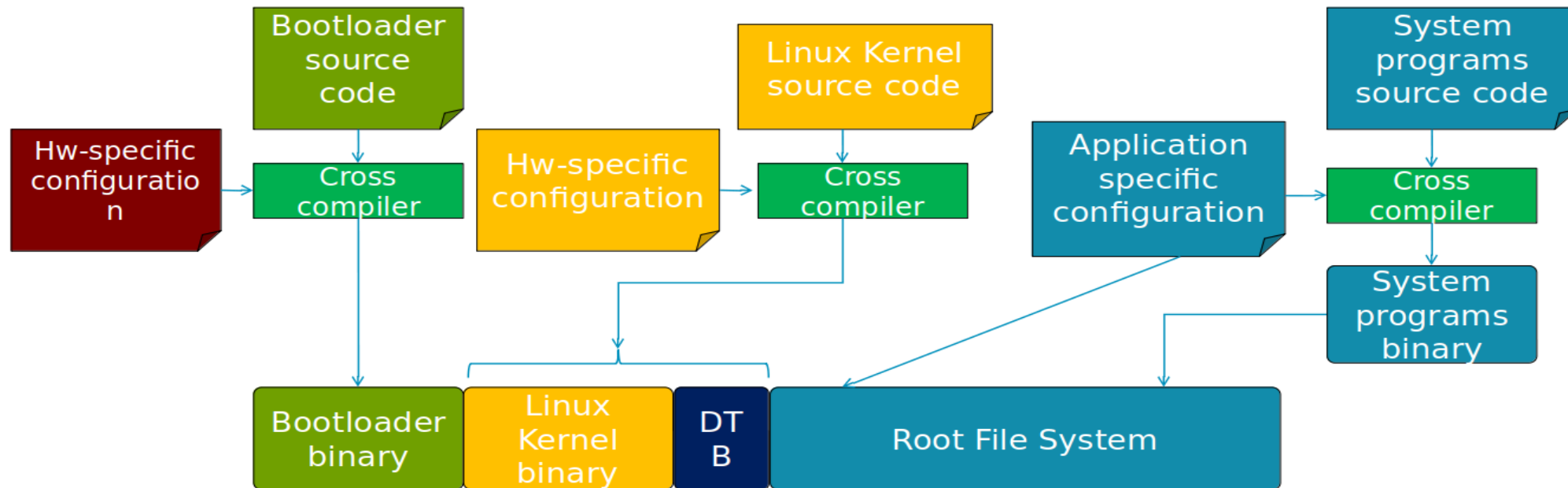


arm



Embedded Linux Workflow

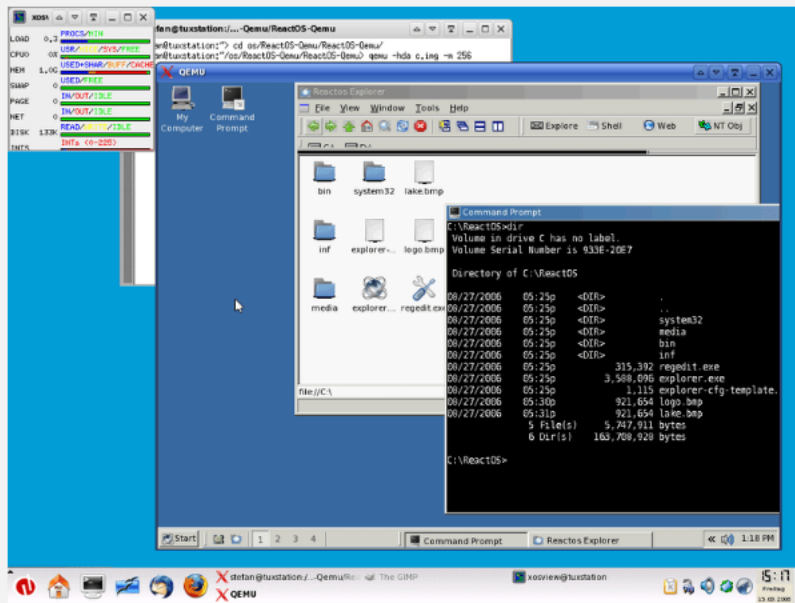
The Workflow



QEMU – Quick Emulator



Generic and open-source machine emulator and virtualizer



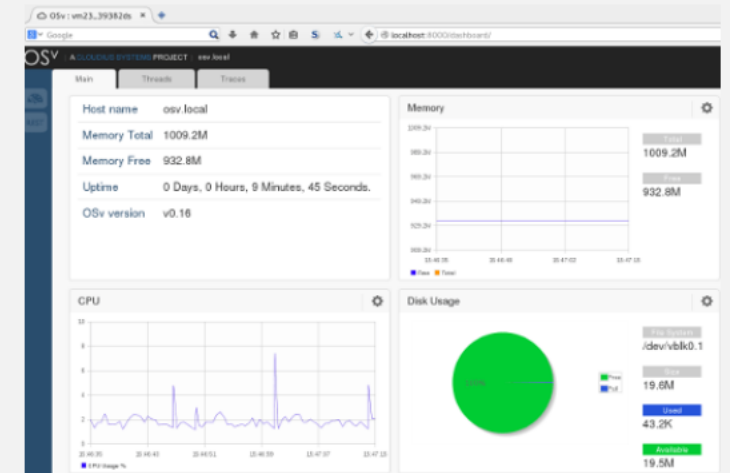
Full-system
emulation

Run operating systems for any machine, on any supported architecture

```
[test@donizetti ~]$ qemu-arm ./ls --color /
bin  etc  lib64  mnt  root  srv      system-upgrade-root  var
boot home lost+found  opt  run  sys      system-upgrade      usr
dev  lib  media  proc  sbin  system-upgrade
[test@donizetti ~]$ uname -a
Linux donizetti 4.6.7-300.fc24.x86_64 #1 SMP Wed Aug 17 18:48:43 UTC 2016 x86_64
x86_64 x86_64 GNU/Linux
[test@donizetti ~]$ file ./ls
./ls: ELF 32-bit LSB executable, ARM, EABI5 version 1 (SYSV), dynamically linked
, interpreter /lib/ld-linux-armhf.so.3, for GNU/Linux 3.0.0, stripped
[test@donizetti ~]$
```

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



Lab Setup for QEMU

Note: We are using Linux for the Demo & all the steps outlined here are for Linux OS only

- **Install QEMU**

```
sudo apt-get install qemu-system-arm
```

- **Download and extract the Linux Kernel from source**

```
wget https://cdn.kernel.org/pub/linux/kernel/v6.x/linux-6.6.11.tar.xz
```

```
tar xvf linux-6.6.11.tar.xz
```

```
cd linux-6.6.11
```

- **Configure Kernel**

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- vexpress_defconfig
```

- **Build Kernel**

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi-
```

Note: The above step may take time upto 1 hour depending on your CPU speed





Let's Boot Linux With QEMU

- **Install the Toolchain**

```
sudo apt-get install gcc-arm-linux-gnueabi
```

- **Download and rename RootFS**

```
wget https://downloads.yoctoproject.org/releases/yocto/yocto-2.5/machines/qemu/qemuarm/core-image-minimal-qemuarm.ext4
```

```
mv core-image-minimal-qemuarm.ext4 rootfs.img
```

```
e2fsck -f rootfs.img
```

```
resize2fs rootfs.img 16M
```

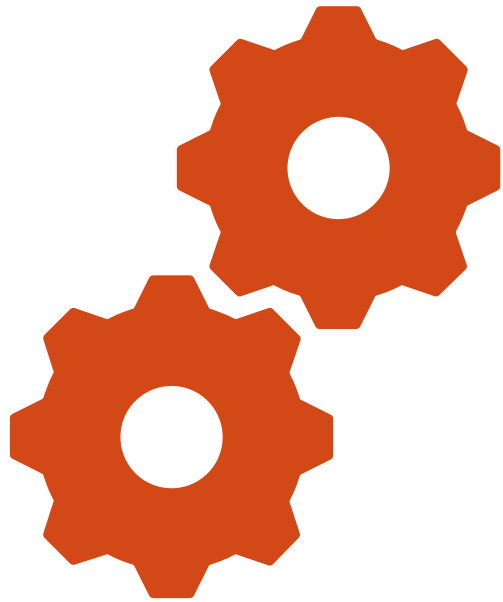
Alternatively, download pre-built binaries -

https://github.com/Bharathgopal/Simulators_Demo

- **Run Kernel on QEMU**

```
qemu-system-arm -M vexpress-a9 -kernel arch/arm/boot/zImage -  
dtb arch/arm/boot/dts/arm/vexpress-v2p-ca9.dtb -append  
"console=ttyAMA0,115200" -nographic
```





ZEPHYR RTOS APPLICATION ON RENODE





**Scalable simulation framework
with an IoT focus.**



**Supports a modern, rapid
development workflow.**



**Vastly improves testing
capabilities.**



**Lets you develop complex
multinode scenarios.**



**Built for continuous
integration.**



**Enables security-hardened
devices and systems.**



**Easy to use, open and
extendible.**



ZEPHYR



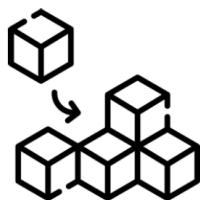
SMALL

< 8KB Flash
< 5KB RAM



yet **SCALABLE**

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



FLEXIBLE

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



SECURE

Built with safety & security in mind
Certification-ready
Long-term Support



Zephyr™



OPEN-SOURCE

Permissively licensed (Apache 2.0)
Vendor-neutral governance



ECOSYSTEM

Vibrant community
Supported by major silicon vendors

Supported Hardware Architectures



Cortex-M, Cortex-R
& Cortex-A



x86 & x86_64



32 & 64 bit



Xtensa



Vibrant Ecosystem



Development Tools



Governing Board

Technical Steering Committee

Contributors



Applications & Middlewares



Training & Consulting



Firmwares & Libraries

600+ supported boards... and growing



Arduino Portenta H7



ESP32



Sipeed HiFive1



nRF9160 DK



STM32F746G Disco



M5StickC PLUS



TDK RoboKit 1



BBC micro:bit v2



Blue Wireless Swan



Arduino Nano 33 BLE



Intel UP Squared



Dragino LSN50 LoRa Sensor Node



Microchip SAM E54 Xplained Pro Evaluation Kit



Raspberry Pi Pico



Altera MAX10



NXP i.MX8MP EVK



Adafruit Feather M0 LoRa



u-blox EVK-NINA-B3

180+ Sensors Already Integrated



ZEPHYR ON RENODE

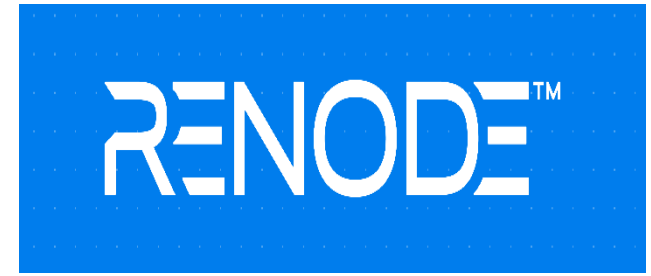
Renode and The Zephyr Project

- Zephyr on Renode – [Renodepedia](#)
- Supported boards- [Renodepedia – Boards](#)
- Example on STM32 - [Renodepedia - stm32f4 disco](#)
- Tutorials - [Renode Tutorials](#)

The Renode logo consists of the word "RENODE" in a white, sans-serif, uppercase font. The letters are slightly stylized, with the "R" and "E" having unique shapes. A small "TM" trademark symbol is located at the top right of the "E". The logo is set against a solid blue rectangular background.

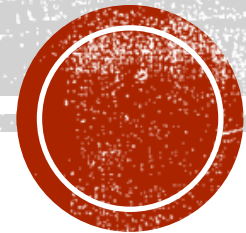
EXAMPLE ON RENODE

- 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](#)





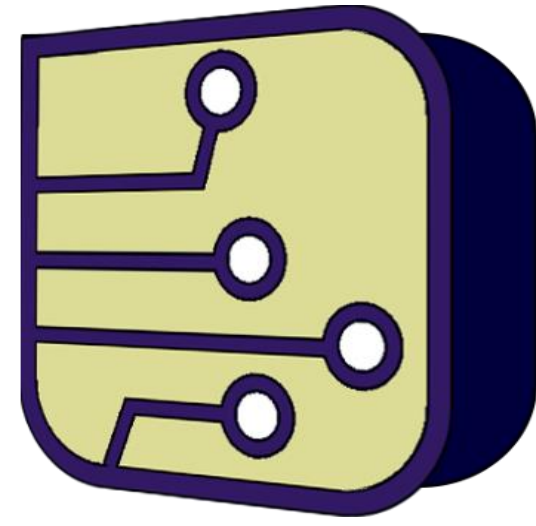
CIRCUITS WITH AVR ON SIMULIDE



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](#)

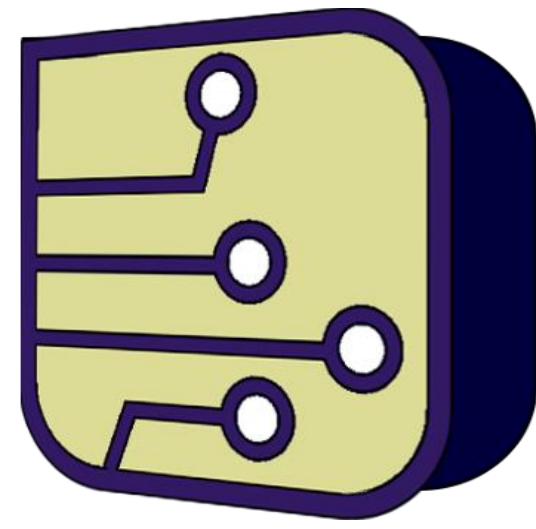
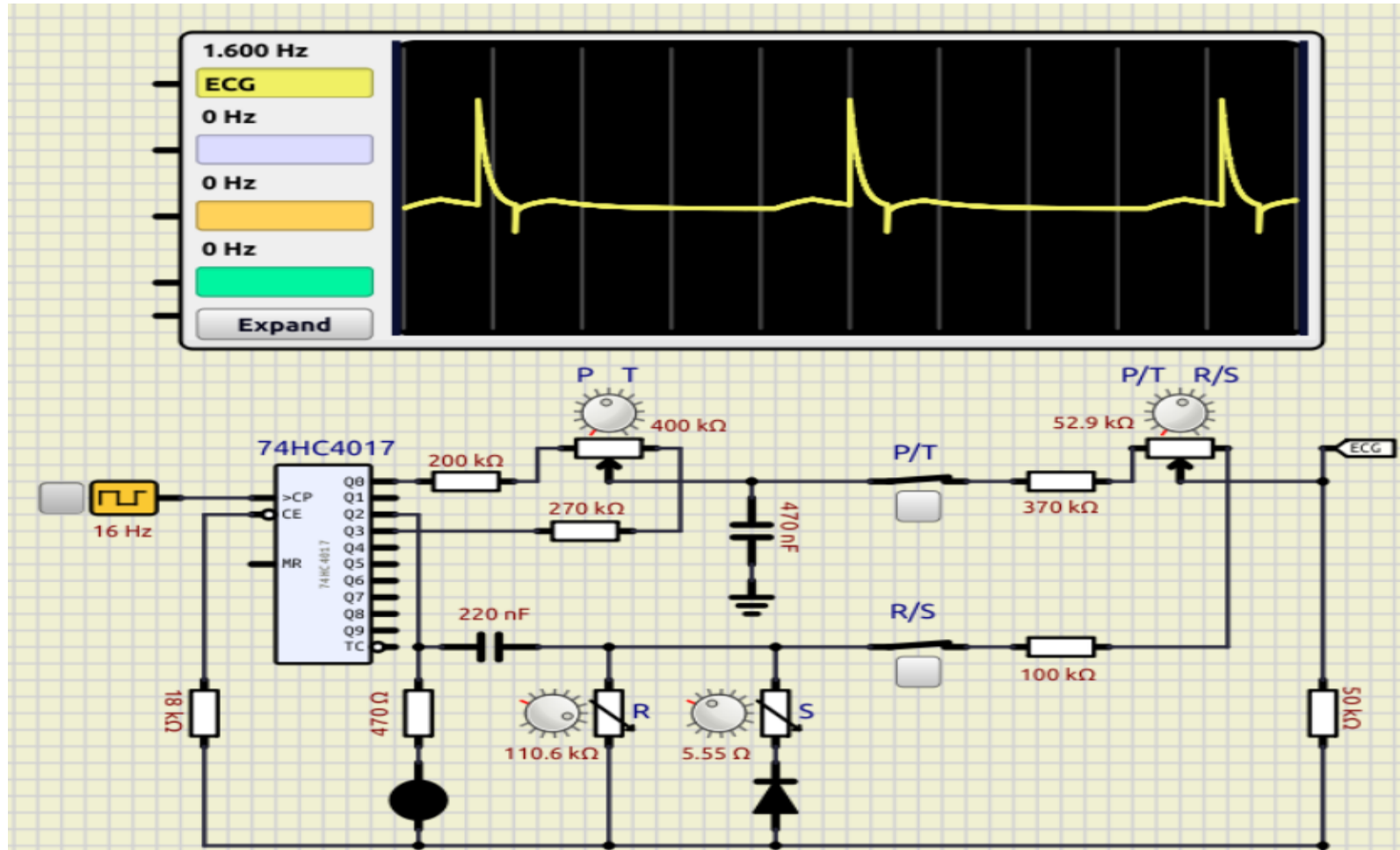


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ECG Signal Generator Circuit

- ECG signal generator. – SimulIDE



NEXT STEPS

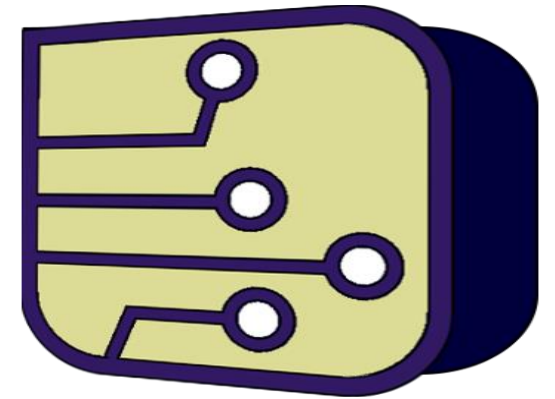
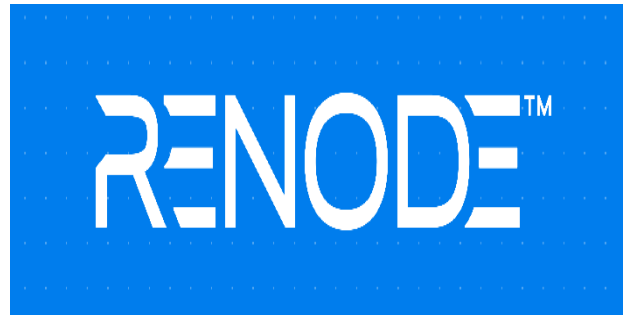
Resources to learn about QEMU, RENODE and SIMULIDE

[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>



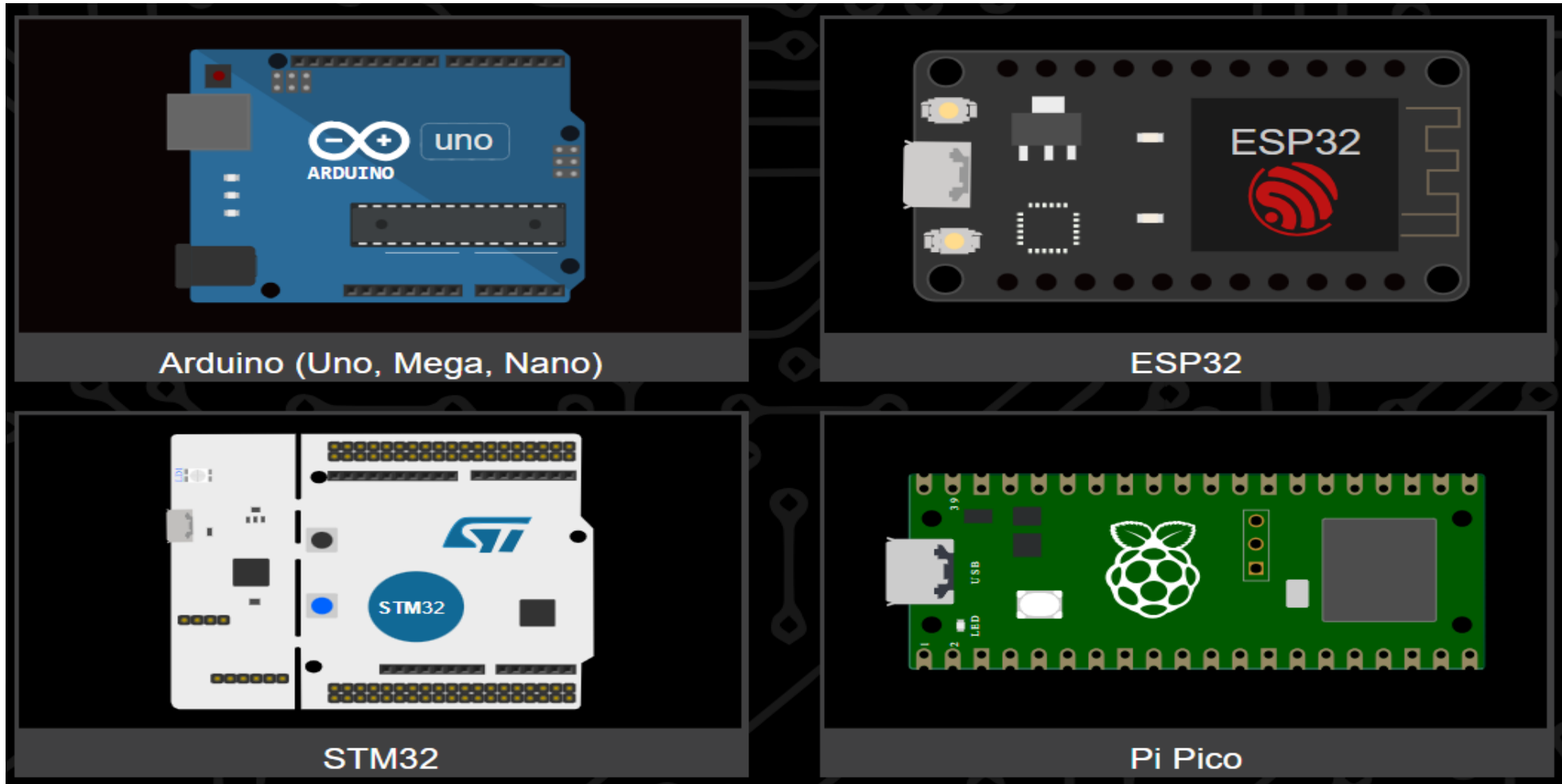


BONUS – WOKWI



Wokwi – Online Simulator + VSCode Offline

- Wokwi - Online ESP32, STM32, Arduino Simulator





Q & A



KEEP IN TOUCH



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