

# Building Embedded Operating System with IMGUI Demo for *Raspberry $\pi$ - 4 - model B* with *Yocto*

Kaloyan Krastev\*

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\*Triple Helix Consulting[10]

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# 1 introduction

These instructions[6] follow the configuration and build of a Linux-based operating system for *Raspberry  $\pi$  - 4 - model B*[8] with *Yocto*[1]. Find project overview in [7].

The *operating system* (OS) build is done in four steps and instructions are organized in four corresponding sections as follows.

- section 2 get *metadata*
- section 3 configure OS build
- section 4 build OS *image*
- section 5 copy *image* to *SD* card

Section 6 is dedicated to post-install issues like the configuration of the WiFi interface from the command line.

## 2 download

*Metadata* is a set of instructions to build targets. It is organized in *recipe* files with the *.bb* suffix. Further there are *class* files with the suffix *.bbclass* with information shared between *recipes*. Finally, there are configuration files with the extension *.conf*. These define configuration variables to control the build process. *Metadata* is organized in *layers*. Layers logically separate information of a project. *OpenEmbedded* defines the following layer types.

- base layer base metadata for the build
- machine aka *board support package* ([BSP](#)) layer  
*hardware* ([HW](#)) support
- distribution layer  
policy configuration
- *software* ([SW](#)) layer  
additional [SW](#)
- miscellaneous layer  
for layers that do not fall in upper categories

A complete list of *github* [SW](#) repositories used in this project includes *Yocto*, the [BSP](#), a [SW](#) layer with custom recipes, the configuration and the source code of the application and the dependencies. Note that for a relatively simple application I must fetch six [SW](#) repositories. Follow links for details.

- *Yocto* reference distribution [yoctoproject.org/poky.git](http://yoctoproject.org/poky.git)
- [BSP](#) layer for *Raspberry  $\pi$*  boards [agherzan/meta-raspberrypi.git](http://agherzan/meta-raspberrypi.git)

- *Yocto* configuration [TripleHelixConsulting/yocto\\_x86\\_BasicConfig.git](#)
- *SW* layer [kaloyanski/meta-thc.git](#)
- Immediate mode *graphical user interface* ([GUI](#)) [kaloyanski/imgui\\_aar](#)
- OpenGL library [glfw/glfw.git](#)

### 3 configuration

*Dear ImGui*[2] is a bloat-free [GUI](#) library for C++. It outputs optimized vertex buffers that you can render anytime in your 3D-pipeline-enabled application. It is fast, portable, renderer agnostic, and self-contained (no external dependencies). *Dear ImGui* is designed to enable fast iterations and to empower programmers to create content creation tools and visualization/debug tools (as opposed to UI for the average end-user). It favors simplicity and productivity toward this goal and lacks certain features commonly found in more high-level libraries. *Dear ImGui* is particularly suited to integration in game engines (for tooling), real-time 3D applications, full-screen applications, embedded applications, or any applications on console platforms where operating system features are non-standard.

*Dear ImGui* depends on *GLFW*[3], an open-source, multi-platform library for *OpenGL*, *OpenGL ES* and *Vulkan* development on the desktop. It provides a simple API for creating windows, contexts and surfaces, receiving input and events. *GLFW* is written in *C* and supports *Windows*, *macOS*, *X11* and *Wayland*.

*Dear ImGui* is licensed under the *MIT* License. *GLFW* is licensed under the *zlib/libpng* license.

## 3.1 layers

Here is a list of *Yocto* layers. The project reference distribution is *poky*.

- *meta*  
User-space data
- *meta – poky*  
*Yocto* reference distribution
- *meta – raspberrypi*  
This[4] is the general [HW](#) specific [BSP](#) overlay for the *RaspberryPi* device. The core [BSP](#) part of *meta – raspberrypi* works with different *OpenEmbedded/ Yocto* distributions and layer stacks. In short, the recipes to build the kernel and kernel modules are in this layer. For details see the package *linux-raspberrypi*. In addition, here is the [HW](#) specific firmware. By chance, the build configuration corresponds the specific [HW](#), in this case *Raspberry  $\pi$  - 4 - model B*.
- *meta – thc*  
I have introduced a new *Yocto* [SW](#) layer to control the build of *Dear ImGui* and *GLFW*. As long as the source codes have a standard build configuration, the *bitbake* recipes are straightforward. Both instructions inherit *cmake*.

## 4 build

### 4.1 configuration

*Yocto* provides a list of image types. For obvious reasons, I have chosen *core-image-x11*[\[1\]](#) - a very basic X11 image with a terminal. In the main build configuration, apart from *Dear ImGui* and *GLFW*, I have added the following packages;

- *os-release*  
OS identification
- *Dropbear*  
Compact *secure shell* ([SSH](#)) server[\[5\]](#)
- *dhcpcd*  
*dynamic host configuration protocol* ([DHCP](#)) client[\[9\]](#)
- *thcp*  
OS post-configuration scripts

## 5 install

The total size of the operating system is between from 250 up to 384MB or 79MB *tar.bz* archive, including kernel *ARM*, 64 bit boot executable *image* of 23MB, a *Raspberry  $\pi$  - 4 - model B* configuration of Linux 5.15. The total size of kernel modules is 21MB. Happily this kernel release has a *long-term support* ([LTS](#)). The list of packages included in the [OS image](#) in Table [1](#) gives a good idea of the contents.

*Yocto* provides multiple package and *image* formats. Further, different ways exist to install *images* on *SD* card. The result is an

package	description
packagegroup-core-boot	boot
packagegroup-base-extended	base
run-postinsts	post
opkg	package manager
psplash-raspberrypi	<i>Raspberry <math>\pi</math> - 4 - model B</i> splash
packagegroup-core-x11-base	the <i>X</i> server
os-release	OS identifier
dropbear	SSH server
dhcpcd	DHCP client
thcp	SW layer
glfw	<i>OpenGL</i>
imgui	<i>Dear ImGui</i>

Table 1: A list of packages in *core-image-x11-raspberrypi4-64*

OS with two partitions only - */root* and */boot*. There are not *swap* and *home* partitions. I recommend the classic command-line tool *dd* to copy data. It works fine with different *image* formats like *rpi-sdimg*, *hddimg* and *wic*. The last format is recommended. Find the card device name, usually */dev/sda*, unmount it with *umount* if it is mounted, and do copy data with the simple command

*dd if=whatever.wic of=/dev/sda*

Run this command with *root* privileges and be careful to not specify the device name of your hard drive. This will take a while. When it is over, put the card in you *Raspberry  $\pi$  - 4 - model B* and turn it on. That's it.



## 6 run

Connected embedded systems can communicate to one another and to cloud-based *platform-as-a-service* (PaaS) solutions. In addition, a remote control may be required. An SSH server is a standard solution for both problems.

Wireless connection is established via classic command-line tools like *ip*, *iw*, *dhcpcd*, and *wpa\_supplicant*. Custom shell scripts are installed in */usr/bin*, as well as a running GUI example to demonstrate the usage of the *Dear ImGui* library. Once an *internet protocol* (IP) address is assigned, the SSH server by *Dropbear* allows for a secured remote login, remote control and file transfer.

## 7 outlook

This reports the progress in the development of a custom Linux-based OS for *Raspberry  $\pi$  - 4 - model B*[8]. The kernel version of this embedded OS is Linux release 5.15. An example GUI application using the *Dear ImGui* library is built as a part of the OS image. In addition, an SSH server provides remote connection, data transfer and device control. As the OS is now functional, performance and real-time tests are ongoing.

## acronyms

**BSP** *board support package*

**SSH** *secure shell*

**GUI** *graphical user interface*

**SW** *software*

**HW** *hardware*

**OS** *operating system*

**DHCP** *dynamic host configuration protocol*

**IP** *internet protocol*

**PaaS** *platform-as-a-service*

**LTS** *long – term support*

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