

Building Embedded Operating System with IMGUI Demo for *Raspberry π - 4 - model B* with *Yocto*

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October 17, 2023

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1 introduction

These instructions[6] follow the configuration and build of a Linux-based operating system for *Raspberry π - 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
base metadata for the build
- machine aka *board support layer* ([BSP](#))
hardware ([HW](#)) support
- distribution
policy configuration
- *software* ([SW](#))
additional [SW](#)
- miscellaneous
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
- [BSP](#) layer for *Raspberry* π boards 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 π - 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 π - 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 π - 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 π - 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 π - 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 layer*

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*

bibliography

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