# Graphics stack updates for Raspberry Pi devices

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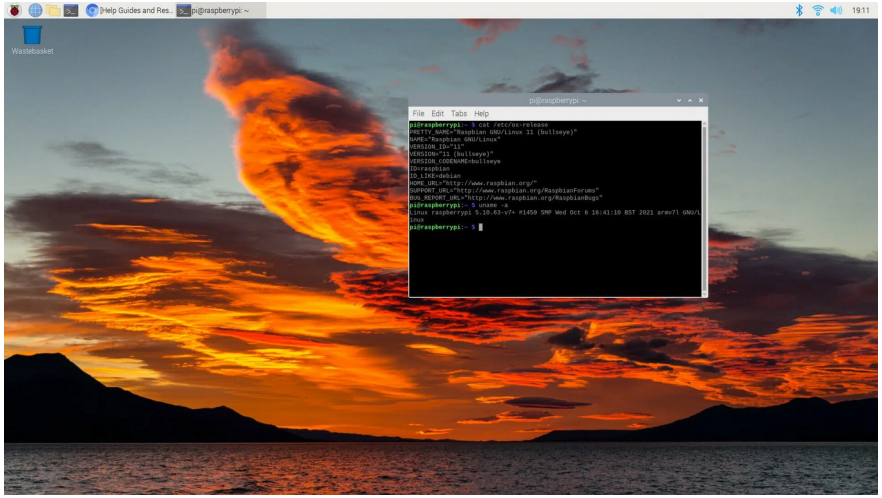
# Who we are

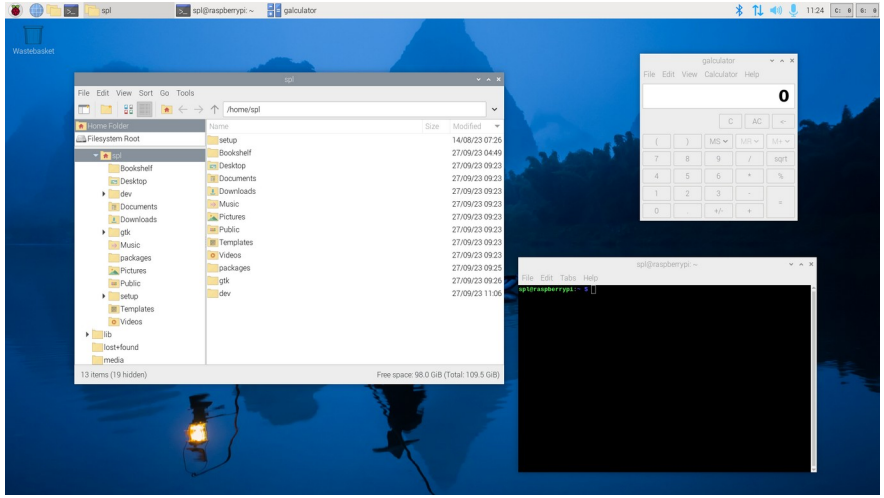
- Chema Casanova (@txenoo@fosstodon.org)
- Juan A. Suarez (@jsuarezr@floss.social)
  - Working at Igalia graphics team on Raspberry Pi graphics stack for 4 years, and previously on Intel GPU.



# Bookworm Raspberry Pi OS



Bullseye Raspberry Pi OS (November 2021)



Bookworm Raspberry Pi OS (October 2023)

# Terminology

| Kernel Driver | Mesa Driver | HW | GPU |
|---|---|---|---|
| vc4 (display+render) | vc4(GL/ES) | Raspberry Pi 1/2/3 | VideoCore 4 |
| vc4 (display)<br>**v3d (render)** | **v3d (GL/ES)**<br>**v3dv(Vulkan)** | Raspberry Pi 4/5 | VideoCore 6/7 |



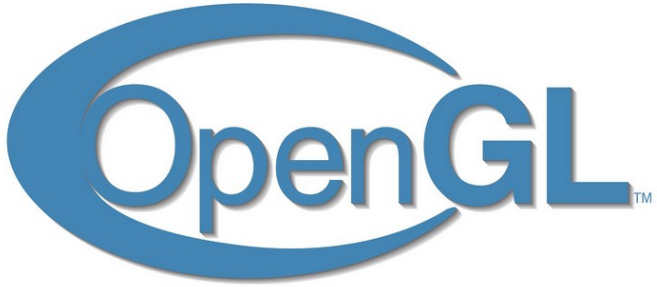
# Raspberry Pi 5

- GPU Broadcom V3D 7.1.6, same VideoCore architecture
- Higher clock rate, up to 8 RTs, better support for subgroup operations, better instruction-level parallelism (but a bit more register pressure!), ...
- Driver code merged into existing v3d and v3dv drivers in Mesa 23.3 and Linux Kernel 6.8.
- Same high-level feature support as Raspberry Pi 4:
- Conformant OpenGL ES 3.1 and Vulkan 1.2.
- Non-Conformant OpenGL 3.1

# From OpenGL 2.1 to 3.1

- Important for users on Raspberry Pi platform.
  - Most apps target OpenGL instead of OpenGL ES.
- 35 new extensions
- Missing HW features, not fully conformant
  - 8 Render Targets (supported in Raspberry Pi 5)
  - Non-seamless cubemap filtering
  - Required RGBA16 render formats not supported

  ...but we can support everything else






# From Vulkan 1.0 to 1.2


- Exposed 80 new extensions
  - Subgroups
  - Geometry Shaders
- Improved performance mostly in the shader compiler.
  - It improves the v3d OpenGL driver too.
- Zink (OpenGL on Vulkan) works with v3dv
- Support for Android (thanks to Roman Stratiienko)



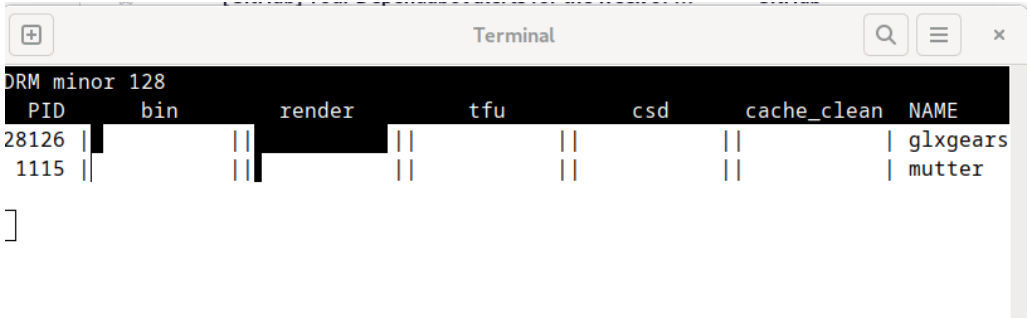
# Kernel CPU jobs

- For v3dv some Vulkan commands cannot be performed by the GPU alone.
  - Timestamp queries, performance queries, indirect CSD jobs.
- This was initially implemented in user space (Mesa) stalling the GPU job submissions.
- Moving CPU jobs to kernel space, allows DRM schedule to queue, not stalling the submission, providing more efficient usage of the GPU.



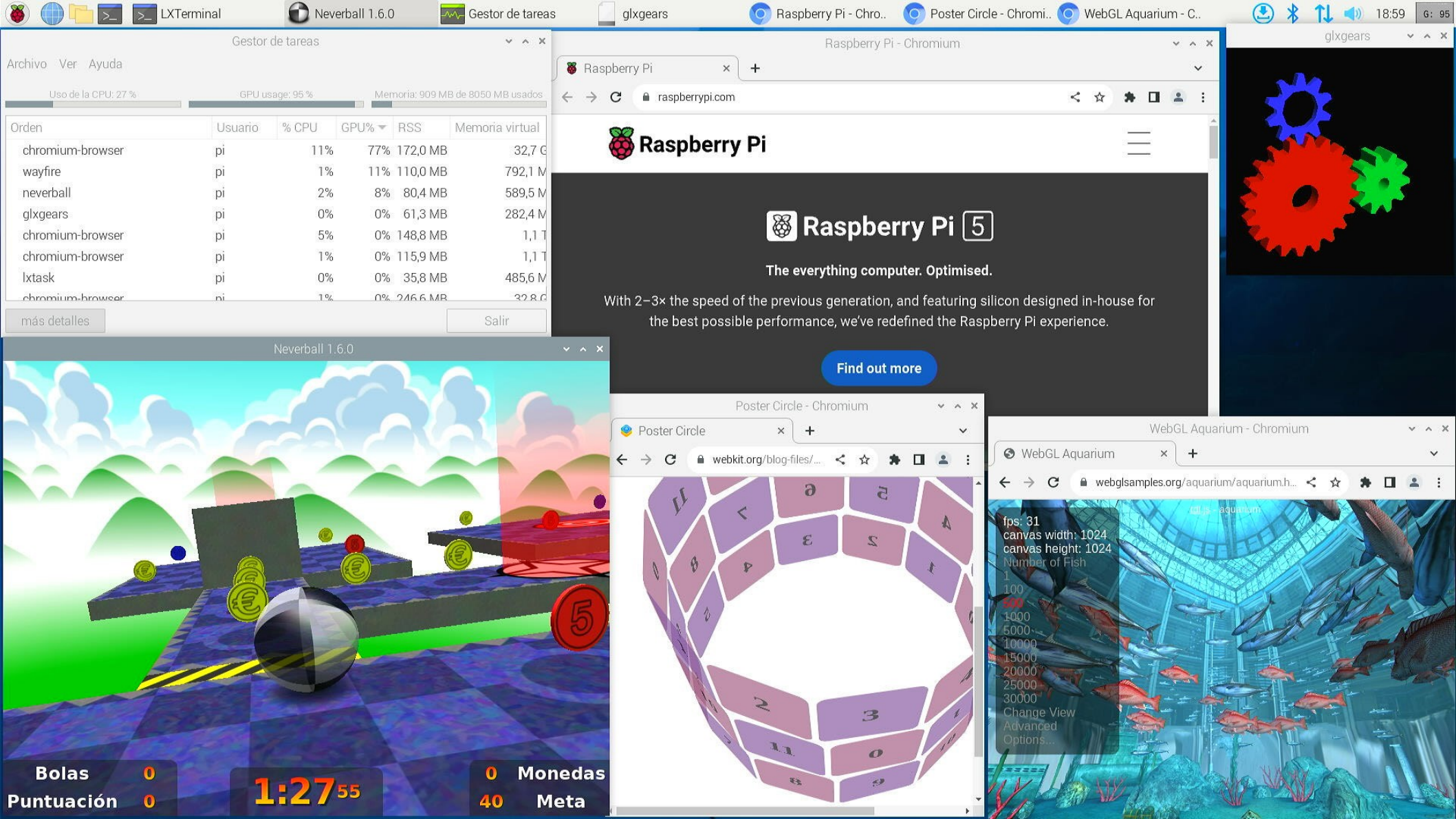
# Kernel GPU stats

- Expose the GPU usage stats per process and global.
- Per process stats uses standard DRM client usage stats (gputop)




- Global stats are exposed using sysfs.
- We measure the accumulated amount of GPU usage using submit and finish timestamps of GPU jobs.




LXTerminal
Neverball 1.6.0
Gestor de tareas
glxgears
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Poster Circle - Chromi..
WebGL Aquarium - C..
18:59
Gestor de tareas
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GPU usage: 95 %
Memoria: 909 MB de 8050 MB usados
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wayfire pi 1% 11% 110,0 MB 792,1 M
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# From Xserver to Wayland

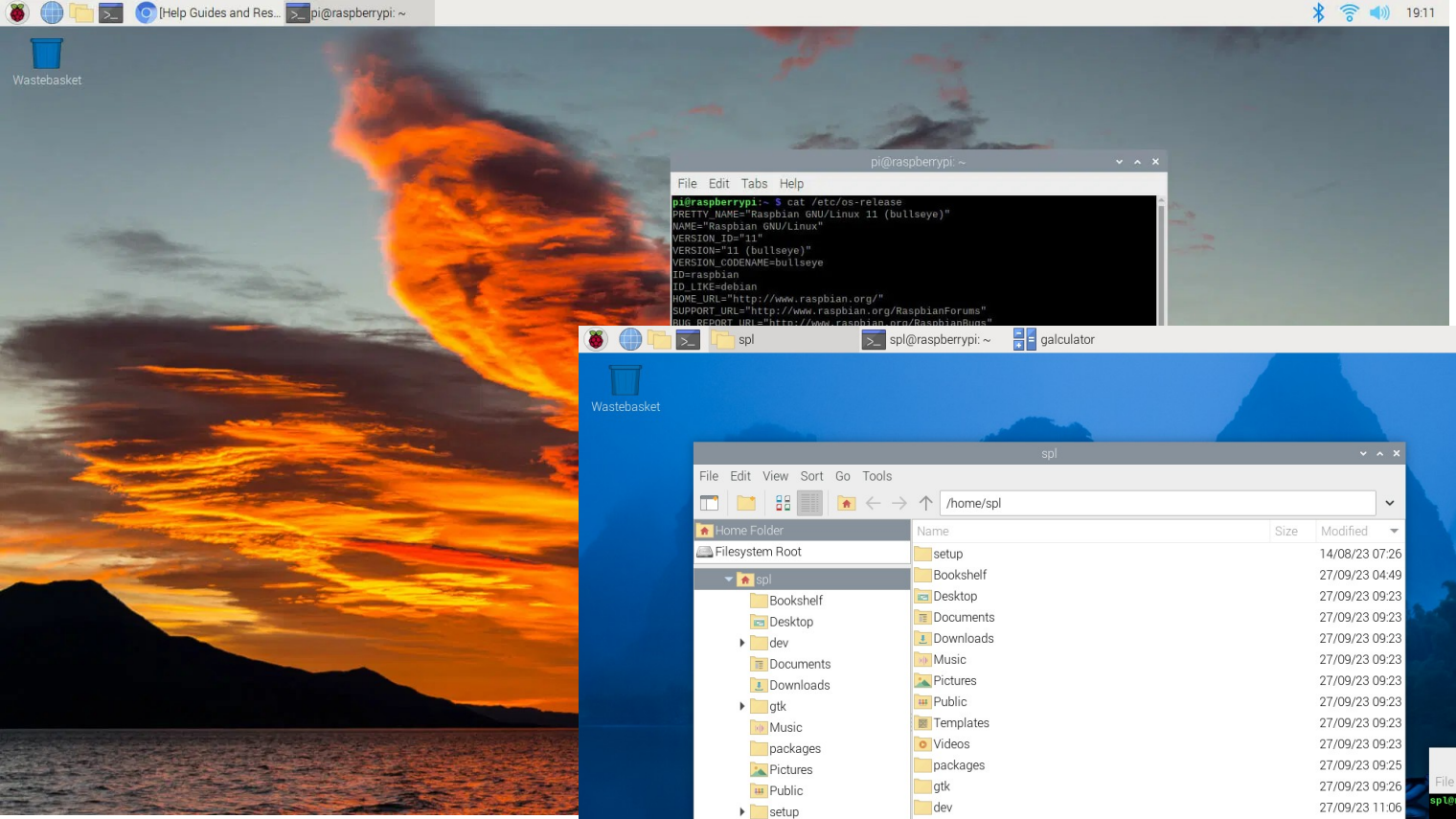
- On Bullseye Raspberry Pi OS desktop was running Xserver with Mutter on the Raspberry Pi 4.
  - Openbox was used for previous HW generations.
- When bookworm was released Wayfire became the default wayland compositor on Raspberry Pi 4 & 5 devices.
  - On previous generations, Raspberry Pi [123] Xserver & Openbox is still the default desktop experience.



# Wayland on Raspberry Pi 4/5

- Wayfire uses OpenGL wlroots backend and OpenGL for the plugins.
- Wayland desktop **environment looks the same** than bullseye desktop that used Mutter. (Huge effort, thanks to Simon Long)

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pi@raspberrypi: ~
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pi@raspberrypi:~ $ cat /etc/os-release
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NAME="Raspbian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
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ID_LIKE=debian
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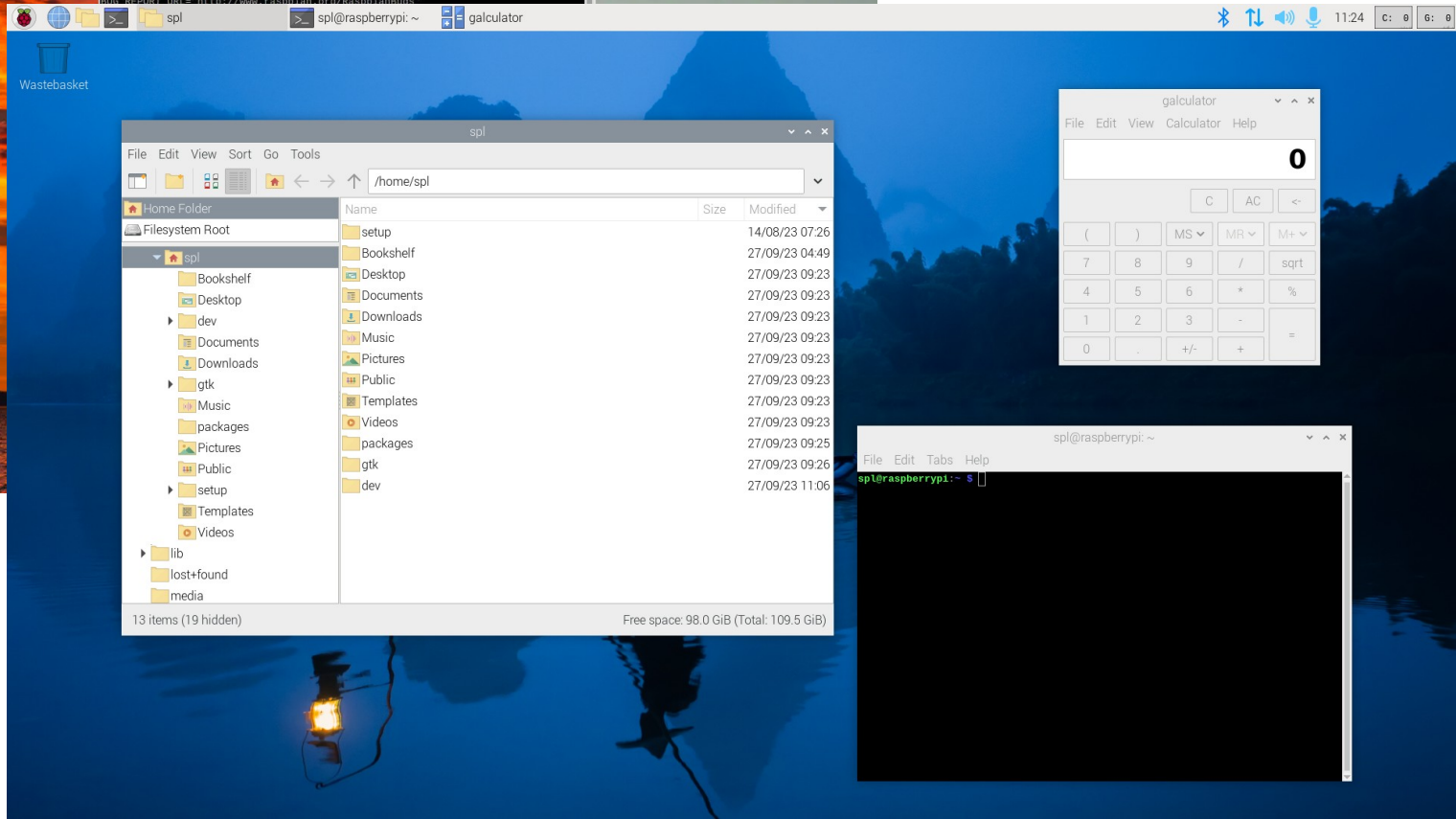
SUPPORT_URL="http://www.raspbian.org/RaspbianForums"
BUG_REPORT_URL="http://www.raspbian.org/RaspbianBugs"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Templates 27/09/23 09:23
Videos 27/09/23 09:23
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spl@raspberrypi:~ $

# Desktop on Raspberry Pi 1-3

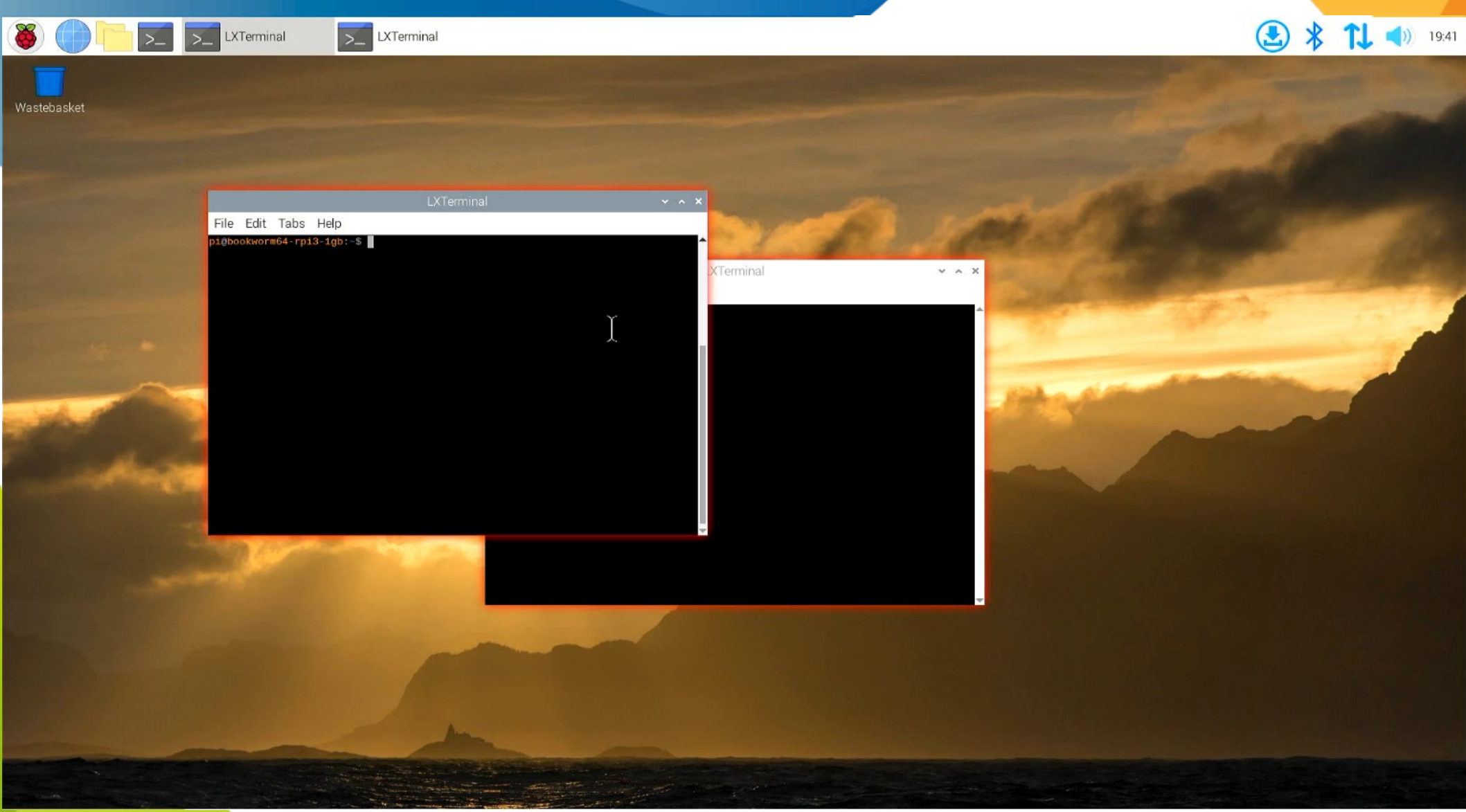
- Xserver+Openbox is still default desktop on bookworm.
- In bullseye initial release, desktop software rendering was used
  - Glamor off
  - No HW accelerated OpenGL/ES applications
- During the bullseye cycle
  - We enabled HW accelerated applications.
  - msdri3: We implemented Xserver DRI3 without Glamor.
  - No more desktop crashes due GPU memory (CMA) exhaustion.



# Wayland on Raspberry Pi 1-3?

- For wayland we need software rendering composition that allows HW accelerated applications.
- Wayfire uses OpenGL through wlroots backend or directly (plugins)
  - wlroots already has a pixman backend. → Use it.
  - Reimplemented Wayfire plugins using pixman rendering logic.
  - Enabled non-coherent kernel buffers → Faster CPU blending.
- For HW accelerated apps we enabled dmabufs with modifiers in wlroots pixman backend.




LXTerminal
LXTerminal
19:41
Wastebasket
LXTerminal
File Edit Tabs Help
pi@bookworm64-rpi3-1gb:~$
LXTerminal

# Questions ?

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