The PipeWire multimedia framework and its potential in AGL

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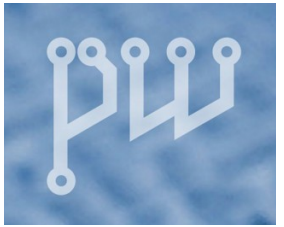
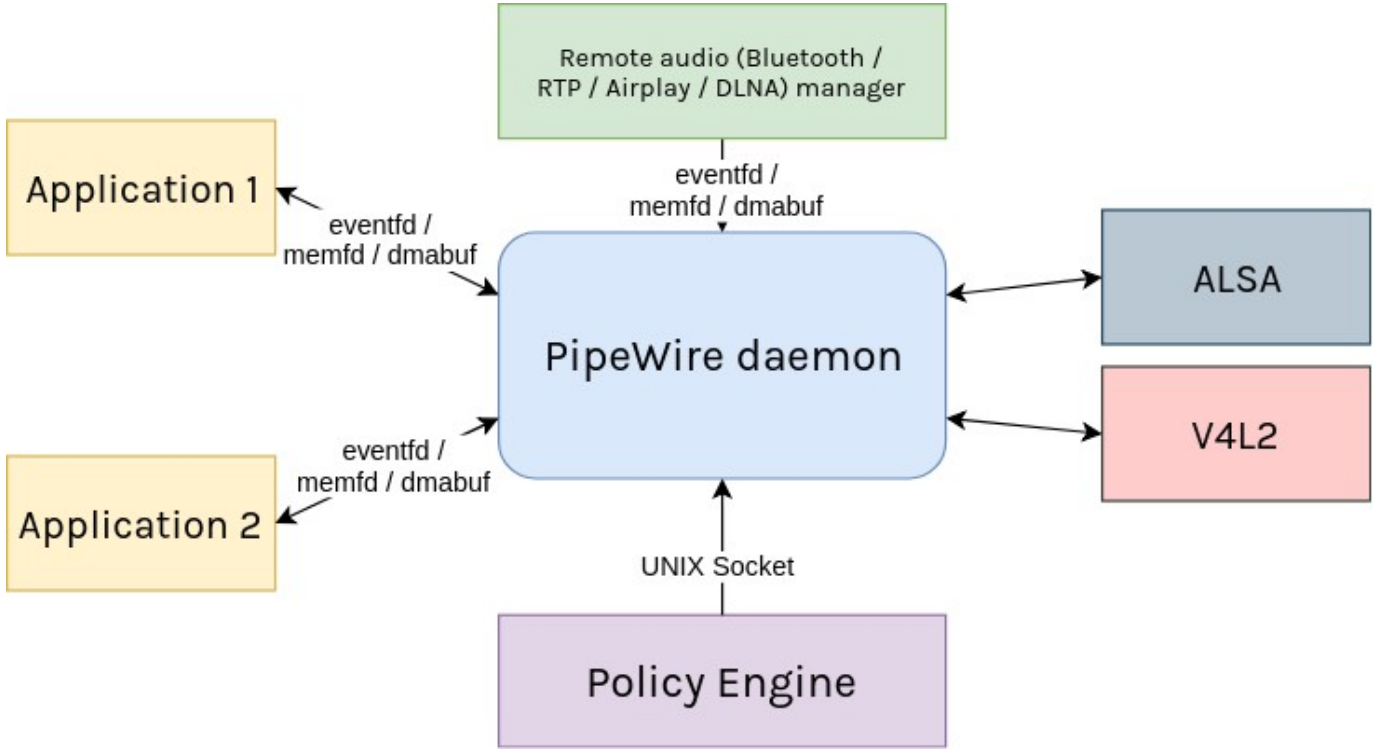
What is PipeWire



- Initial idea: PulseAudio for video
- Now: generic multimedia daemon
  - Video capture server
    - Camera and other video sources (ex. gnome-shell screencast)
  - PulseAudio and Jack (pro-audio) replacement
    - Borrowing ideas also from CoreAudio, AudioFlinger, and others...

Architecture



Architecture

- Multi-process, graph based processing
- External session/policy management (unlike PulseAudio)
  - *Nothing* happens automatically inside the daemon
  - Per-desktop/distro implementations can exist
- External applications can be device providers
- Real-time ultra low-latency (pro-audio) and standard high latency (typical desktop)

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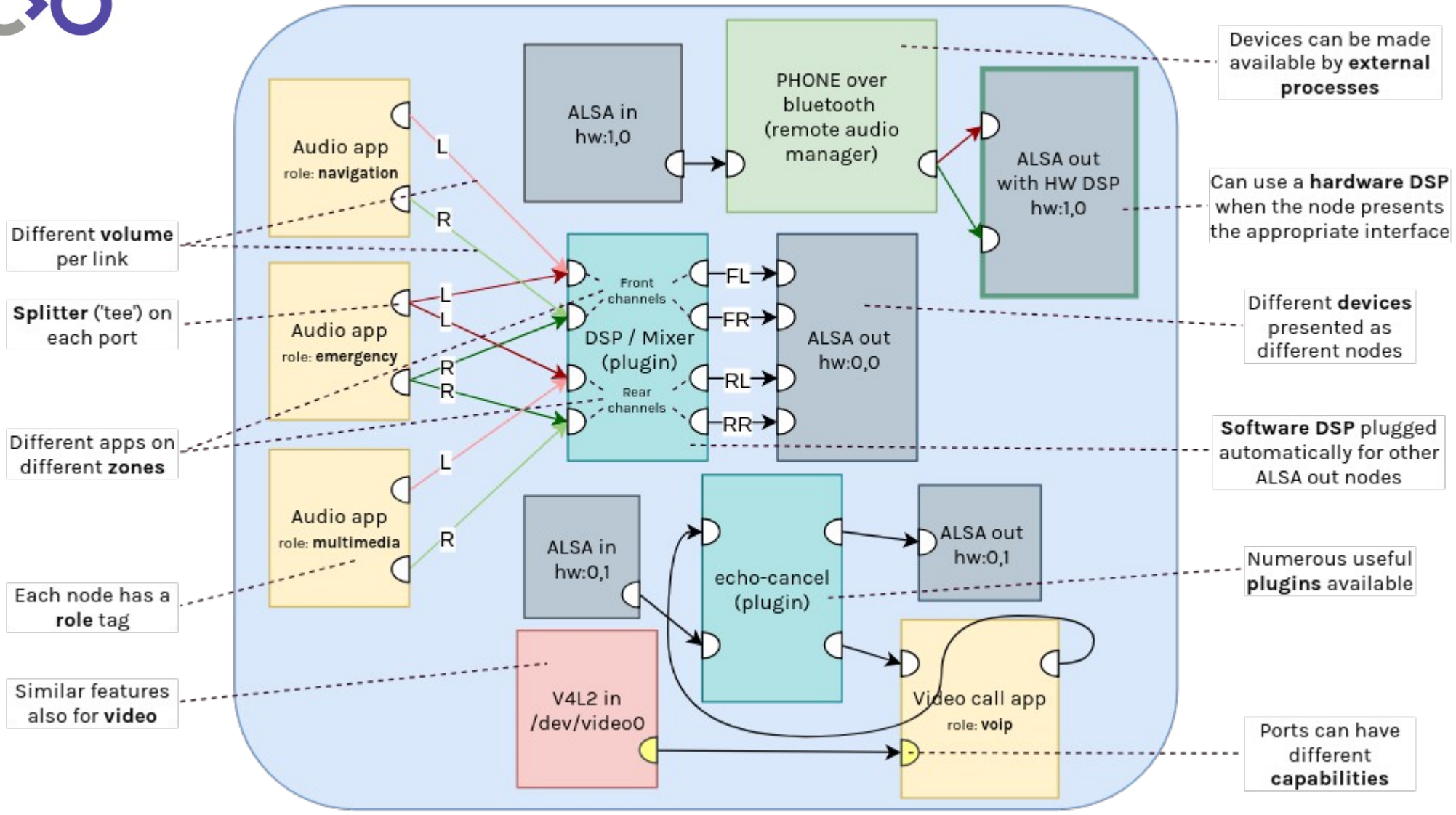
PipeWire daemon



Processing Efficiency

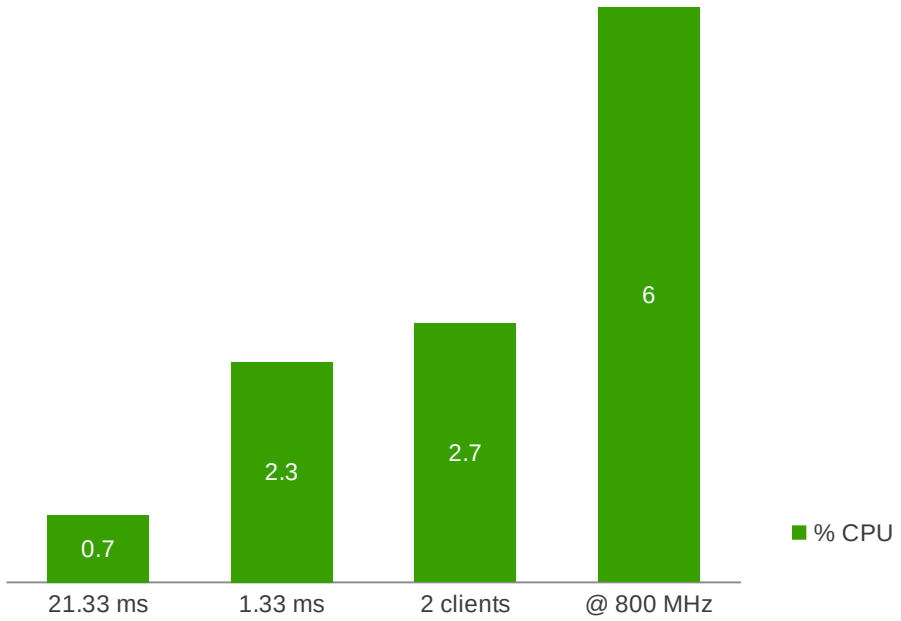
- Zero-copy with modern linux kernel APIs (memfd, dmabuf)
  - Buffers passed around with file descriptors
  - **memfd**: shared CPU buffer
    - Kernel ensures only the destination process can modify the buffer
  - **dmabuf**: shared hardware (GPU/VPU) buffer
    - Processing happens in dedicated hardware, the CPU does not need to copy data on the CPU-accessible RAM

Processing Efficiency (continued...)

- Plugins based on SPA (Simple Plugin API)
  - **Header-only** C library with **zero dependencies**
  - Extremely lightweight data structures
  - “Like GStreamer, but not so heavy!” - Wim Taymans
- Much lower CPU usage than PulseAudio
  - PulseAudio CPU skyrockets on low latency, even on a powerful i7
  - PipeWire CPU will happily stay low at any latency and any load

CPU Usage Statistics

Playback of a 24bit 96kHz 5.1 channel file, downmixed to 3.1 and resampled to 48kHz



- Measurements:
  - 21.33 ms (1024 samples / buffer)
  - 1.33 ms (64 samples / buffer)
  - 1.33 ms with 2 clients
  - 1.33 ms with CPU pinned @ 800 MHz
- Measurements on Intel(R) Core(TM) i7-4770 CPU @ 3.40GHz
- Comparatively, on 1.33 ms, PulseAudio uses 100% CPU and fails (underruns)

Power Efficiency

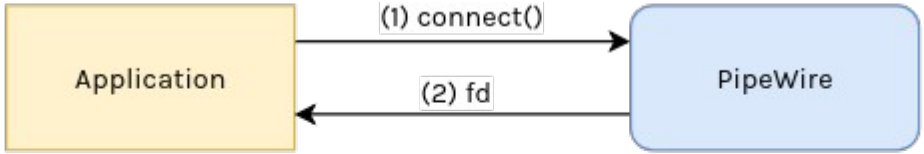
- **eventfd** to wake up the processes and schedule the graph
- Devices can be put to *sleep* when unused
  - Like PulseAudio does
  - Unlike ALSA or Jack

Security

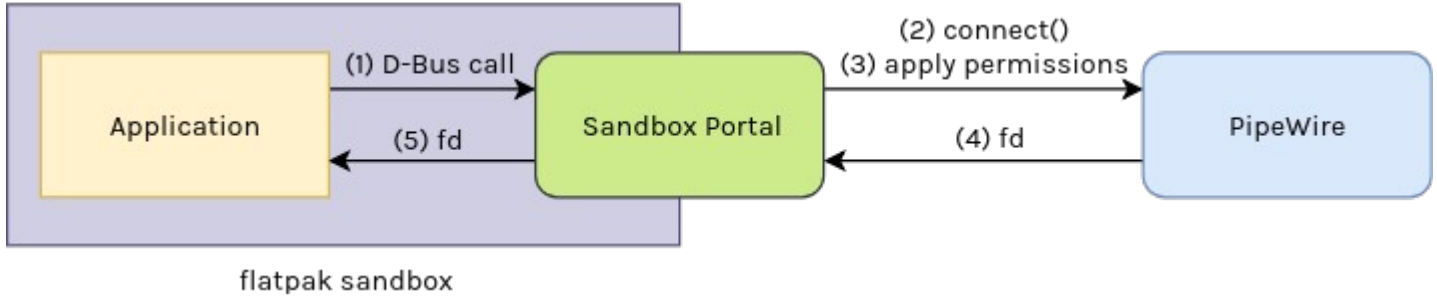
- Fine-grained access controls per client
  - Clients are not able to list other nodes or connect to them until the session manager approves
  - Each client can be made to “see” an entirely different graph
- Sandbox / Container support (flatpak, …)
  - Sandbox portal requests a fd from PipeWire and asks the session manager for specific permissions

Security

Standard Desktop:



With sandbox:



Compatibility

- Provides replacement compatibility libraries for:
  - PulseAudio (libpulse.so.0)
  - Jack (libjack.so.0)
  - Pulse & Jack applications can natively work with PW without recompilation
- ALSA plugin for ALSA-only clients
- LADSPA & LV2 plugins supported, apart from SPA
- Native API via UNIX Socket (D-Bus available; extensible)

Behavior

- PulseAudio is nasty with crash handling
  - Restarts automatically
- PipeWire doesn’t inherit this behavior
  - The service is meant to be started & restarted by systemd, using socket activation
  - It is up to the session/policy manager to restore connections, if necessary

ALSA UCM

- PipeWire wants to use ALSA UCM (Use Case Manager) to configure sound cards
  - Allows dynamic reconfiguration of ports
  - Allows power on/off on parts of the sound hardware
  - Hides ALSA controls complexity
- Open to discussion on improving it or making it optional
- Currently not implemented (in TODO list)

Who is behind this

- Author: Wim Taymans
  - Well-known old GStreamer developer (since the very early days) & ex-maintainer
  - Sponsored by: Red Hat
- Embraced by PulseAudio developers
  - Seen as the next generation of PulseAudio
  - PulseAudio will eventually be phased out
- Welcomed by ALSA and Jack developers

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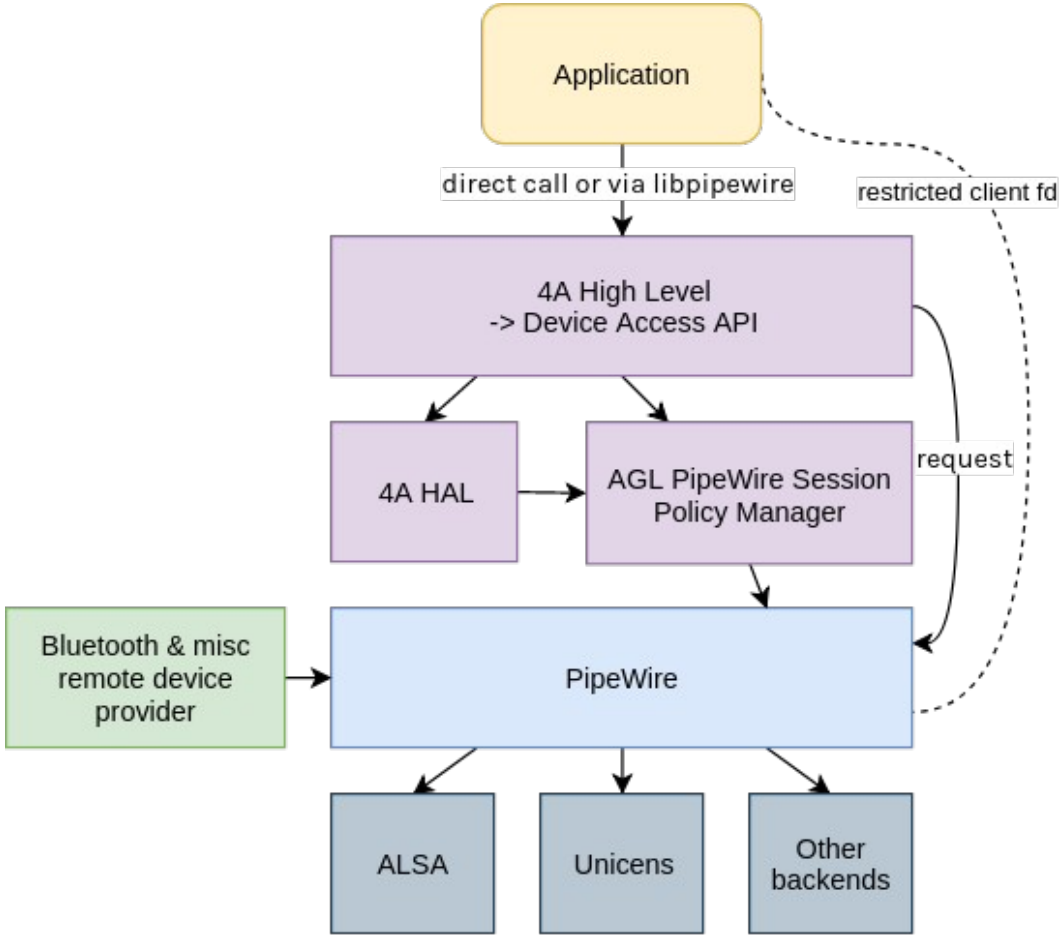
PipeWire in AGL

The idea


Application
direct call or via libpipewire
restricted client fd
4A High Level
-> Device Access API
4A HAL
AGL PipeWire Session
Policy Manager
request
Bluetooth & misc
remote device
provider
PipeWire
ALSA
Unicens
Other
backends

Why ?

- Stick to a (to-be) widely used & widely tested audio system
  - Implemented, maintained and supported by PulseAudio & GStreamer experts
- Provide flexibility for vendors to implement certain processing in hardware
  - by SPA plugins or external device providers
  - without having to implement a full-blown replacement for the 4A softmixer
  - without writing AGL-specific software

Why ?

- Provide more advanced capabilities for free
  - Advanced mixing configurations
  - Dynamic audio routing
  - Lower latency for applications that require it
  - Software effect plugins (echo canceler, equalizer, you name it…)
  - Standard Linux Bluetooth audio implementation (from PulseAudio)
  - Airplay, DLNA
  - RTP streaming to other car nodes with synchronization

Why ?

- Extend device arbitration to non-audio devices
  - Video capture devices (ex. camera for video calls)
  - Hardware encoders / decoders
  - Media-based sensors (ex. camera for AI)

Why ?

- Zero-copy, processing & power efficiency
  - Current 4A softmixer requires copying buffers back and forth through the kernel:

    app → ALSA loop device → softmixer → real ALSA device
  - AVIRT solves that, but unnecessarily introduces AGL-specific kernel code

Why ?

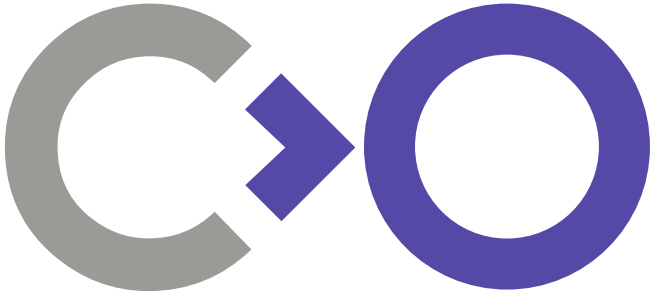
- Better security on the audio connection
  - Currently applications can just open an ALSA device without asking the 4A HL
  - SMACK will allow it if the application is labeled to be capable of opening this device (ex. multimedia application opening the “multimedia” sound device)
  - In PipeWire, the session/policy manager will be the one to make the final decision
  - We can arbitrate access to the socket via a binding-like mechanism
    - Also solves the problem of media frameworks not being aware of the AGL security mechanisms and 4A

Why ?

- Avoid using complicated ALSA plugins
  - Old, ugly codebase
  - Hard to use and therefore hard to maintain a “softmixer” that works well
  - Limited functionality
  - Not as efficient

Proposal

- Do a minimal demo
  - The least modifications required to get PipeWire to provide the audio backend
- Work with upstream
  - Provide missing bits in PipeWire
  - Decouple functionality from PulseAudio and make it available
  - Ensure that all AGL specific requirements are supported as early as possible



Thank you!