The PulseAudio Sound Server

linux.conf.au 2007

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Who Am I?

Student (Computer Science) from Hamburg, Germany

Core Developer of PulseAudio, Avahi and a few other Free Software projects

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IRC: `mezcalero`

Introduction

Current State of Linux Audio

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OSS emulation is kludgy: `$LD_PRELOAD`! (`esddsp`, `artsdsp`, `aoss`)

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Amarok on Phonon on GStreamer on ALSA on PulseAudio on ALSA?

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- Doing "hot" switching of playback streams between devices on USB headset hotplug
- ...

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- but in different configuration (no dmix!)

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Low-latency kernel

Well defined, accepted APIs for pro audio, such as JACK for interconnection or LADSPA for plugins

Competition

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Microsoft ships a new userspace sound system with Windows Vista.

What can we do?

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We need to acknowledge that OSS is not going to go away

We need to agree on an API that people should standardize on

We should stop abstracting abstracted abstraction layers

Missing Pieces

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Play a little catch-up with Apple, Microsoft

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LGPL licensed (practically downgraded to GPL on the server side)

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It's basically a proxy for your sound device, that receives audio data from your applications, does simple, or more advanced operations on it, and passes it on to the device.

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It's also a proxy that recieves audio data from your sound device, does simple, or more advanced operations on it, and passes it on the your applications.

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What are those *simple, or more advanced operations*?

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- Adjust sample rate or format
- Do volume adjustments
- Apply other filters, echo cancellation
- Redirect or copy to another audio device or application, possibly over the network
- Reroute channels (e.g. Stereo to Surround)
- ...

Modular Design

Modular System, currently shipping with 34 modules:

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Toys: LIRC, multimedia keyboard (Linux evdev)

Desktop integration: X11 bell, X11 credentials

Modular Design II

Integration: JACK, EsounD

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Managing: Restore volumes, devices, move stream to other device if device vanishes

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Managing: Restore volumes, devices, move stream to other device if device vanishes

Plug'n'Play: simple device autodetection, HAL-based hotplug

Synchronize output on multiple sound devices

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Not just "Yet another audio API"!

Not a try to push yes another EsounD on the people!

Features

Supports up to 32 channels.

Wide range of sample formats (PCM, μLaw, aLaw)

Realtime scheduling

Network transparent sample cacheing

Current Status

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Lots of room for improvement

PulseAudio vs. ALSA dmix

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PulseAudio replaces the `libasound` plugin `dmix`, `plughw`, others

PulseAudio vs. EsounD

There is practically no reason left to use EsounD instead of PulseAudio

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At least on the desktop - not necessarily on embedded devices, due to lack of FPU.

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There is no “vs.”!

Different objectives - JACK: inter-application communication for pro audio

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JACK has some limitations that makes it unusable for desktop use: reliance on FP, the need to “start” it manually, high CPU load. Incompatibility with everything else.

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Future integration with PulseAudio?

PulseAudio vs. aRts

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PulseAudio vs. aRts

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aRts is officially dead.

Usage

Required Dependencies

`liboil`: Optimized inner loops

`libsamplerate`: Sample rate adjustments

`libsndfile`: Loading sound files

Optional Dependencies

ALSA: Hardware access

GLIB: Support for integration into the GLib event loop - no hard dependency

Avahi: for Zeroconf support

JACK: for JACK integration

X11: Hook into bell event, store authentication credentials

`liboil`: Asynchronous name resolution

TCPWRAP: access control

LIRC: remote control

Compatibility

Plugin for `libasound`: most ALSA applications can access PulseAudio like a local sound card

`$LD_PRELOAD` based OSS compatibility

Implementation of the EsounD protocol

Integration with JACK

Plugin for `libao`

Plugin for GStreamer (With nice tricks!)

Compatibility II

Plugin for XMMS, Audacious

Driver for MPlayer, Xine

Driver for MPD

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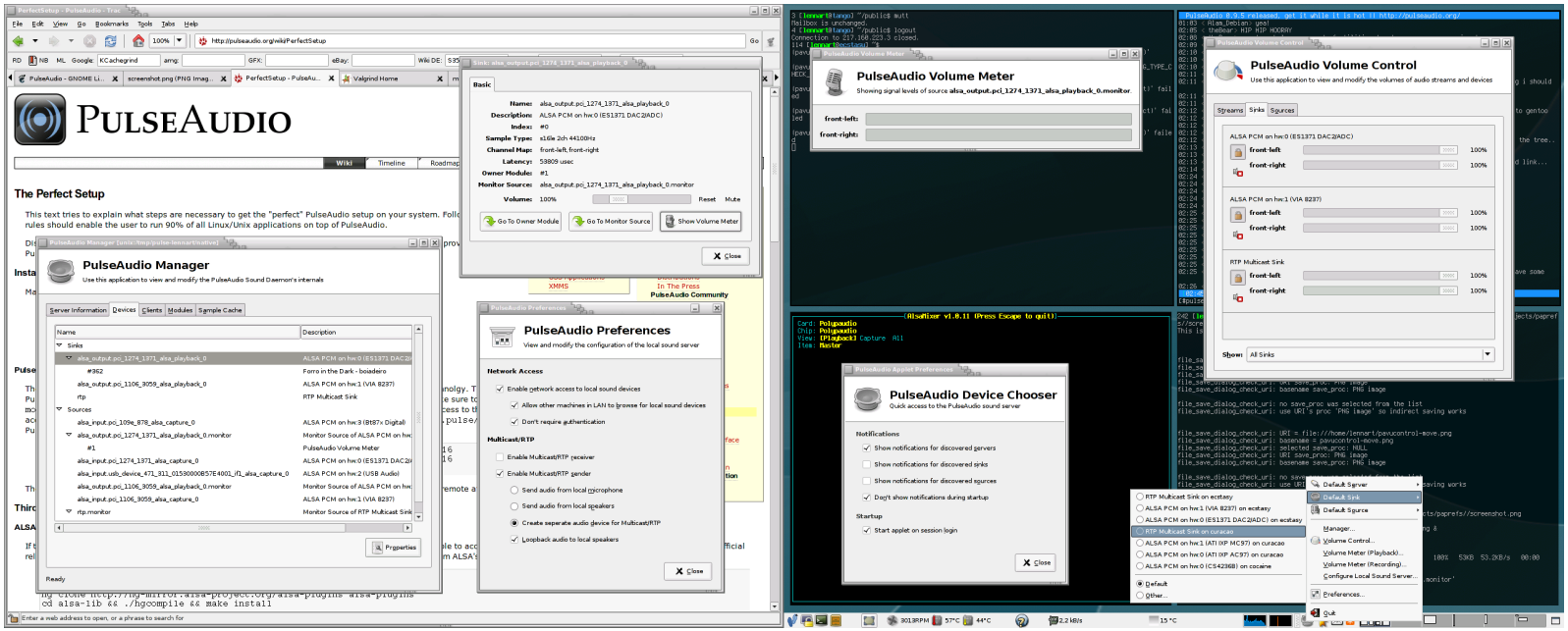
Driver for MPD

$>$ 90 % of all Linux audio applications should run on it.

`http://pulseaudio.org/wiki/PerfectSetup`

Screenshot


PULSEAUDIO
The Perfect Setup
PulseAudio Manager
PulseAudio Preferences
PulseAudio Volume Meter
PulseAudio Volume Control
PulseAudio Device Chooser

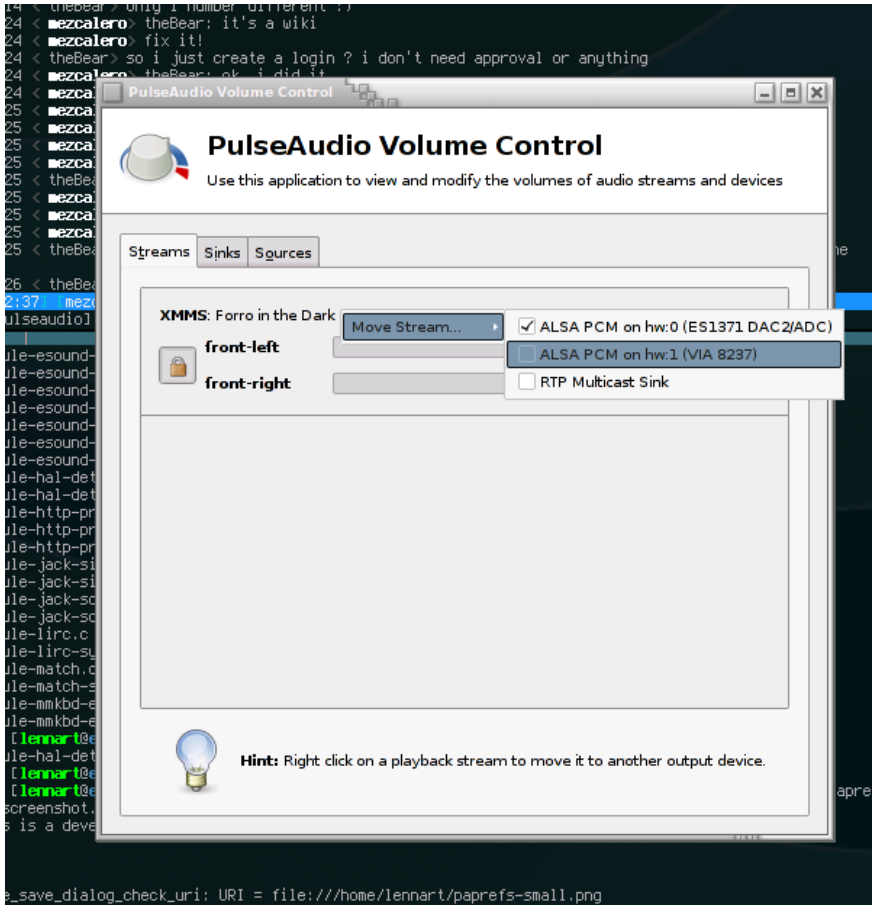
GStreamer Plugin

- Wraps playback, capturing, mixer, device enumeration
- Extracts song metadata from pipeline, uses it to name the stream in the PulseAudio server - independent from the application.
- Not yet part with upstream GStreamer, but will be

XMMS Plugin

- Wraps playback, mixer
- Uses song name to name stream in PulseAudio

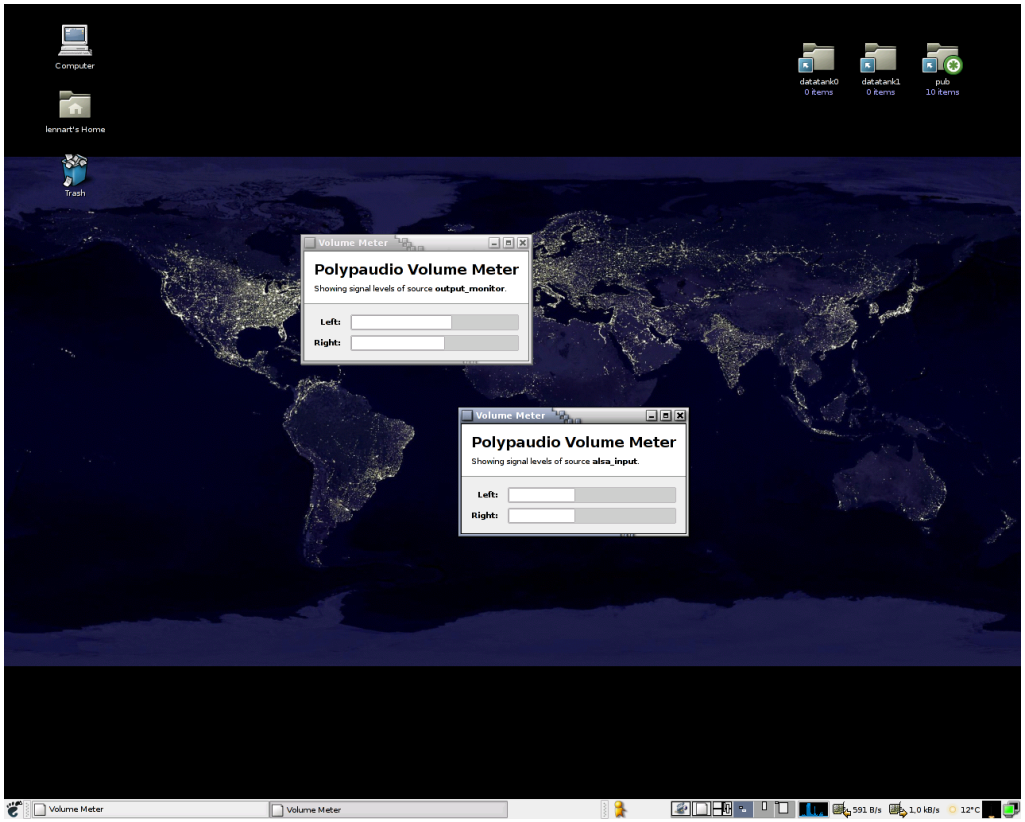
GUI: Volume Control



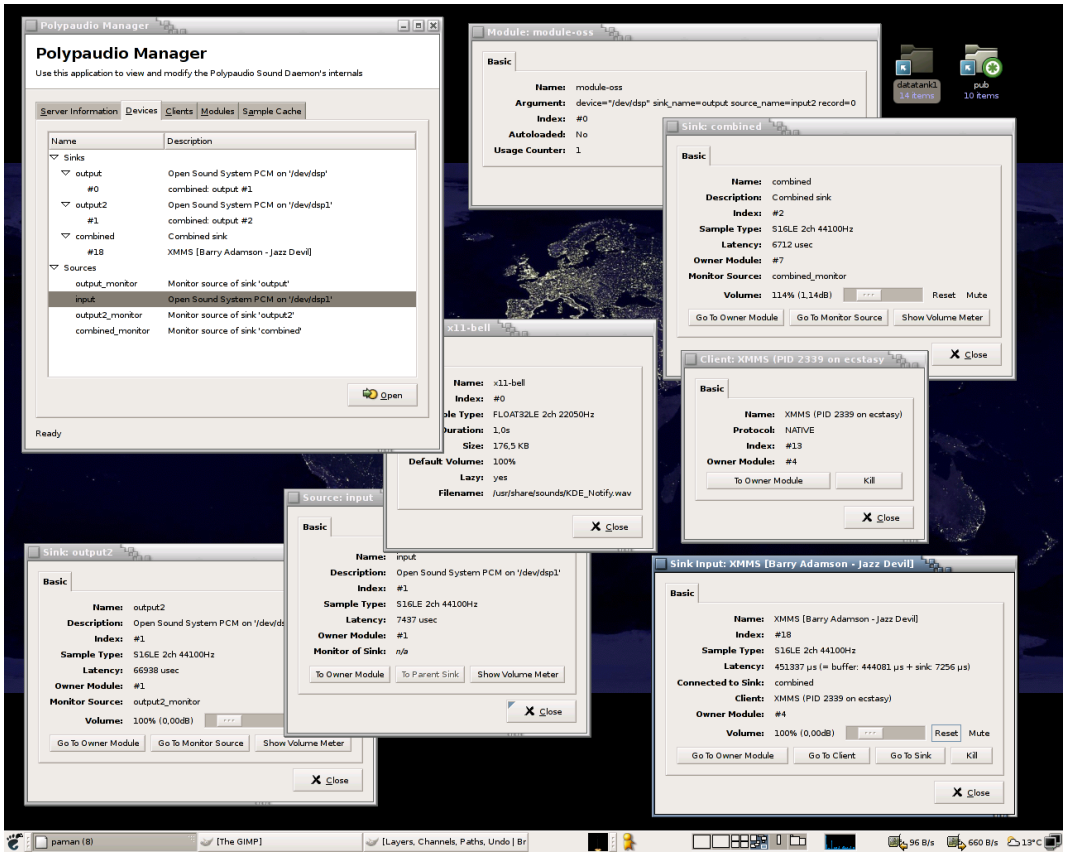
GUI: Volume Control II

- Shows streams, sinks, sources
- Allows volume changing for each channel separately
- Shows song name for each stream (that's why sliders are horizontal!)
- Allows to move stream from one sink to another without interrupting playback

GUI: Volume Meter



GUI: Manager


Polypaudio Manager
Polypaudio Manager
Use this application to view and modify the Polypaudio Sound Daemon's internals
Server Information
Devices
Clients
Modules
Sample Cache
Name
Description
Sinks
output
Open Sound System PCM on '/dev/dsp'
#0
combined: output #1
output2
Open Sound System PCM on '/dev/dsp1'
#1
combined: output #2
combined
Combined sink
#18
XMMS [Barry Adamson - Jazz Devil]
Sources
output_monitor
Monitor source of sink 'output'
input
Open Sound System PCM on '/dev/dsp1'
output2_monitor
Monitor source of sink 'output2'
combined_monitor
Monitor source of sink 'combined'
Open
Ready
Module: module-oss
Basic
Name: module-oss
Argument: device="/dev/dsp" sink_name=output source_name=input2 record=0
Index: #0
Autoloaded: No
Usage Counter: 1
Sink: combined
Basic
Name: combined
Description: Combined sink
Index: #2
Sample Type: S16LE 2ch 44100Hz
Latency: 6712 usec
Owner Module: #7
Monitor Source: combined_monitor
Volume: 114% (1,14dB)
Reset
Mute
Go To Owner Module
Go To Monitor Source
Show Volume Meter
Close
x11-bell
Name: x11-bell
Index: #0
Default Volume: 100%
Lazy: yes
Filename: /usr/share/sounds/KDE_Notify.wav
Close
Client: XMMS (PID 2339 on ecstasy
Basic
Name: XMMS (PID 2339 on ecstasy)
Protocol: NATIVE
Index: #13
Owner Module: #4
To Owner Module
Kill
Close
Source: input
Basic
Name: input
Description: Open Sound System PCM on '/dev/dsp1'
Index: #1
Sample Type: S16LE 2ch 44100Hz
Latency: 7437 usec
Owner Module: #1
Monitor of Sink: n/a
To Owner Module
To Parent Sink
Show Volume Meter
Close
Sink: output2
Basic
Name: output2
Description: Open Sound System PCM on '/dev/ds
Index: #1
Sample Type: S16LE 2ch 44100Hz
Latency: 66938 usec
Owner Module: #1
Monitor Source: output2_monitor
Volume: 100% (0,00dB)
Go To Owner Module
Go To Monitor Source
Show Volume Meter
Close
Sink Input: XMMS [Barry Adamson - Jazz Devil]
Basic
Name: XMMS [Barry Adamson - Jazz Devil]
Index: #18
Sample Type: S16LE 2ch 44100Hz
Latency: 451337 µs (= buffer: 444081 µs + sink: 7256 µs)
Connected to Sink: combined
Client: XMMS (PID 2339 on ecstasy)
Owner Module: #4
Volume: 100% (0,00dB)
Reset
Mute
Go To Owner Module
Go To Client
Go To Sink
Kill
Close
datatank1
14 items
pub
10 items
paman (8)
[The GIMP]
[Layers, Channels, Paths, Undo | Br
96 B/s
660 B/s
13°C

GUI: Manager II

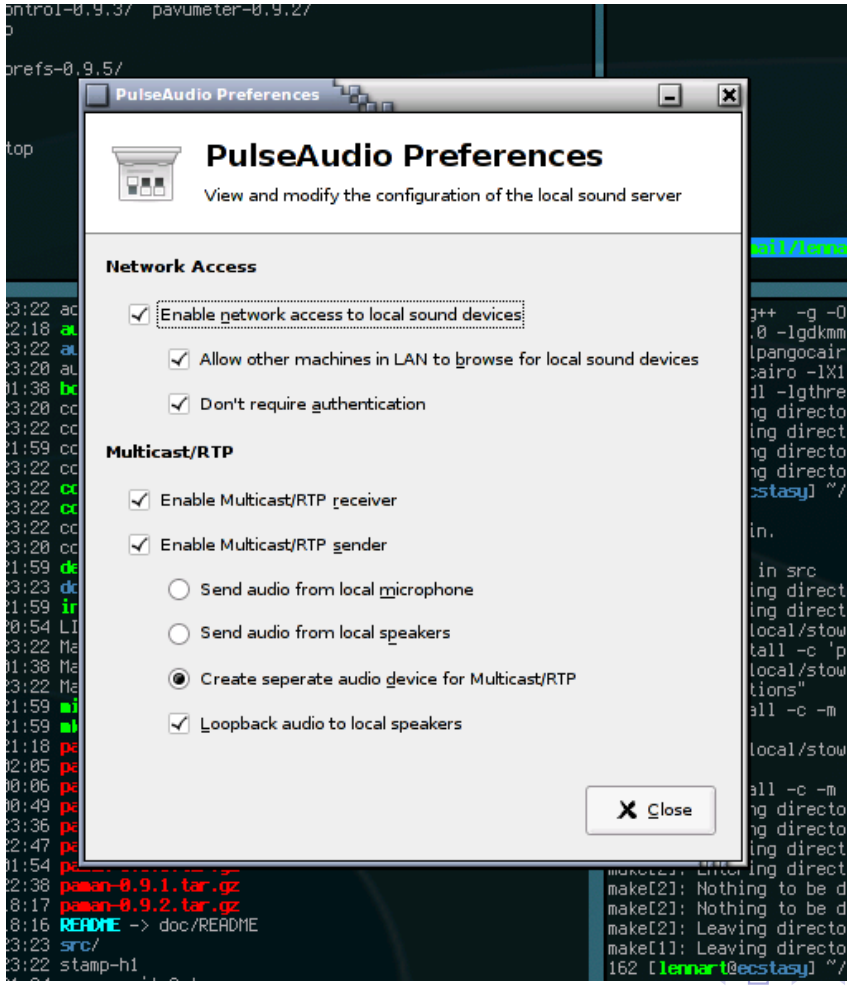
- Shows internals of a PulseAudio server
- Not for the regular user

GUI: Device Chooser

GUI: Device Chooser II

- Sits in the notification area
- Allows easy changing of the input/output device/server
- Avahi support
- Easy access to the utility programs

GUI: Preferences



GUI: Preferences II

- Easy access to selected configuration options
- Communicates over GConf with PulseAudio
- Instant apply
- Requires `module-gconf` loaded into the server
- Current options: Remote access, Authentication, Zeroconf, RTP multicast receive, send

Internals

Nomenclatura

Sink - A clocked output device PA writes data to (e.g. ALSA sound card)

Source - A clocked input device PA reads data from (e.g. ALSA sound card)

Monitor Source - Implicitly attached to every sink for monitoring what is currently being played

Nomenclatura

Sink - A clocked output device PA writes data to (e.g. ALSA sound card)

Source - A clocked input device PA reads data from (e.g. ALSA sound card)

Monitor Source - Implicitly attached to every sink for monitoring what is currently being played

Sink Input - An output stream whose data PA sends on to a sink; not clocked! (e.g. a client application such as Rhythmbox)

Source Output - An input stream where PA sends to data from a source; not clocked! (e.g. a client application such as Ekiga)

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PulseAudio does not know the notion of "pipelines"!

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Client - A local or networked client which cann allocate any number of inputs or outputs.

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Client - A local or networked client which cann allocate any number of inputs or outputs.

Sinks and sources can be identified by a short string such as `dsp1` or `dsp1.monitor`. Name is generated automatically from the underlying device name - or may configured manually.

Internals

Zero-Copy memory management

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Shared-Memory data transfer

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Powerful playback model

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Embeddable core

Supports multiple sinks/sources in a single daemon

Asynchronous Client API

Fully configurable during runtime

Zero-Copy Memory Management

We never copy memory around if not really necessary

Instead of queueing samples, we queue pointers to reference counted memory data blocks

Location of those memory data blocks is flexible: dynamic memory, SHM from other process, DMA buffer of sound card, mapped file

Advantages: low memory usage, low-latency

Shared-Memory data transfer

Audio data between local clients and server is transferred via shared memory

The server and each client allocates one shared memory segment and allocates its audio buffers from it. Indexes into this segment are passed between clients and between client and server.

RW access only to local segment, RO access to other process' segments

Playback Model

Playback buffer is a linked list of pointers to audio data blocks and their indexes

Monotonically advancing read index

Freely seekable write index: `SEEK_RELATIVE`, `SEEK_ABSOLUTE`, `SEEK_RELATIVE_ON_READ`, `SEEK_RELATIVE_END`

If data is written "left" of the current read pointer, it is immediately dropped

If due to seeking the buffer contains "holes" silence is automatically inserted.

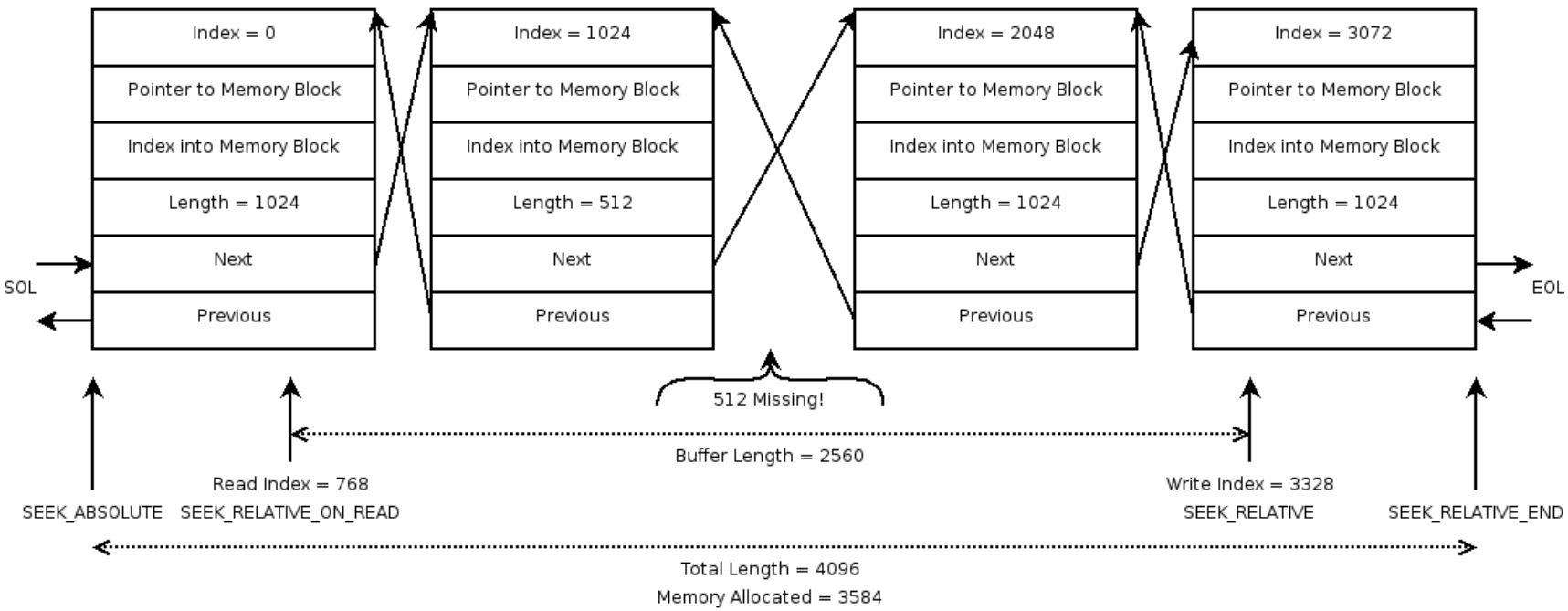
Playback Model II

Multiple streams can be synced together, read indexes will never deviate if enabled.

If buffer fill level becomes 0, an UNDERRUN event is sent to the client. If buffer fill level becomes smaller than a specified lower watermark a REQUEST event is sent to the client. If a specified maximum buffer length is reached an OVERRUN event is sent to the client.

Advantages: large buffers with quick reaction possible - useful especially over the network; easy to write RTP receivers; low memory usage

Playback Model III



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Two different modes supported:

- Playback stops on underrun, starts again if “prebuf” level is reached.

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- Playback stops on underrun, starts again if “prebuf” level is reached.
- Playback never stops, read index advances monotonically, and drops enough samples so that the time the underrun lasted is compensated.

Emulating OSS

Difficult, because kernel interfaces cannot easily be emulated from userspace

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It's slow and it's ugly.

DMA practically impossible.

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Quake2 - What about DMA?

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Possible solution: FUSD - emulating character devices from userspace.

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DMA still a problem?

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Probably more applications around that run exclusively on aRts than run exclusively on EsounD

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Remote: Cookie, IP ACL, X11 root window

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No encryption - no challenge response

Recipes

CLI - Command Line Language

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Ineteresting Commands:

```
load-module module-oss device="/dev/dsp"
sink_name=output source_name=input channels=1
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```

```
load-sample x11-bell /usr/share/sounds/notify.wav
```

Recipe: RTP Multicast “Radio” Receiver

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```
load-module module-rtp-recv
```

Recipe: RTP Multicast “Radio” Sender

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```
load-module module-null-sink sink_name=rtp
```

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```
load-module module-null-sink sink_name=rtp
load-module module-rtp-send source=rtp.monitor
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Recipe: RTP Multicast "Radio" Sender

```
load-module module-null-sink sink_name=rtp
load-module module-rtp-send source=rtp.monitor
set-default-sink rtp
```

Recipe: Output audio on two soundcards simultaneously

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load-module module-combine sink_name=combined
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```

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set-sink-default combined
```

Recipe: Combine two Stereo devices into a virtual 4-channel Surround device

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channels=2
```

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channels=4
```

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set-sink-default combined
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Outlook

Current Work

Move to a more threaded design

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Best possible OSS compatibility

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New abstracted sound API?

Future Work

Better integration with JACK

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`http://pulseaudio.org/browser/trunk/todo`

That's all, folks.

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Any questions?

PulseAudio

http://pulseaudio.org/

https://tango.0pointer.de/mailman/listinfo/pulseaudio-discuss

#pulseaudio on irc.freenode.org