Productizing Telephony and Audio in a GNU/Linux (Sailfish OS) Smartphone

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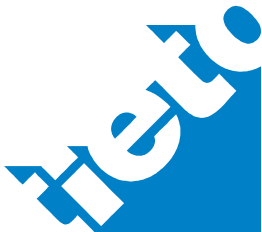
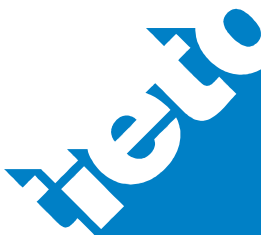


Agenda

- Hardware / software stack overview
- Audio
  - What we did and why
  - Some implementation details
- Telephony
  - What we did and why
  - Some implementation details

About the speaker

- Martti Piirainen
  - Cellular telephony expert (from modem to UI)
  - 15 years in SW development, Linux mobile devices since 2010
- Tieto Product Development Services
  - R&D in communications and embedded technologies
  - Part of Tieto, 14000 employees, headquarters in Finland
  - More at www.tieto.com/pds
- This presentation covers work done by Tieto for Jolla



Hardware Stack

- “**Jolla**” smartphone
- **Qualcomm** MSM8930 SoC
  (from “Snapdragon S4” family)
  - incl. dual-core Krait ARM CPU
  - incl. GSM/UMTS/LTE cellular modem
  - incl. multimedia accelerators

Software Stack

- **Sailfish** OS
- UI layer mostly done in **QML**
- Middleware based on **Nemo Mobile** project
- Based on **Mer** Linux distribution
- **Android™** BSP plus some **libhybris** magic

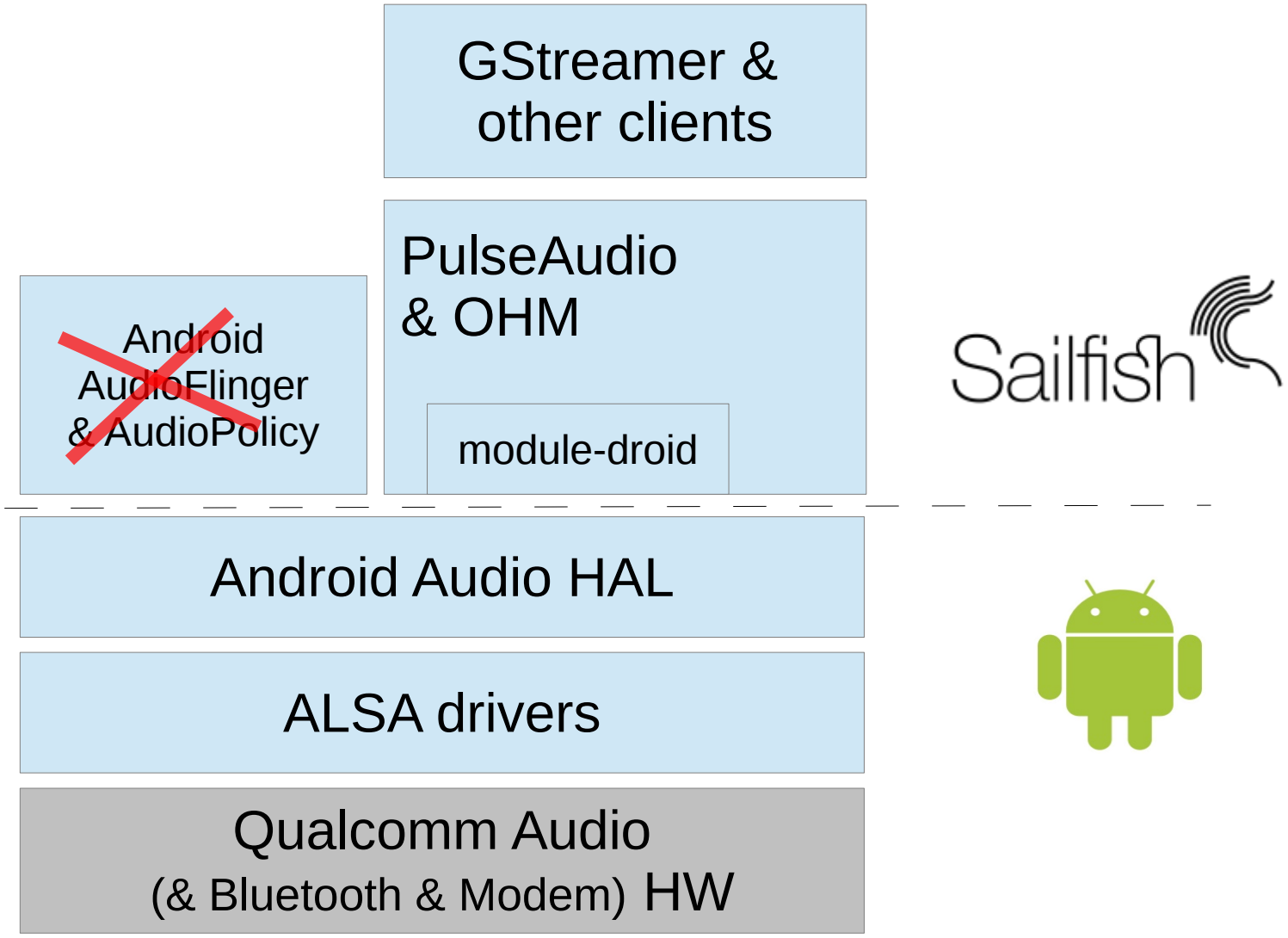
Audio Use Cases

- Play music, video, anything with sound in it
  - Media player, web browser, 3rd party apps, ...
- System / feedback sounds
- Cellular voice calls
  - Two-way speech
  - Ringtone
  - Generate various signalling sounds
- Volume control / muting

Audio Use Cases, cont'd

- Output devices
  - Speaker, earpiece, wired or Bluetooth headphones
- Input devices
  - Built-in microphone, wired or Bluetooth headset microphone
- Audio routing
  - Which sound input (software process or physical device) is connected to which sound output?
- Audio policy
  - Which apps / services are allowed to use which resource? *Example: Ringtone takes precedence over media player*
  - Also, automatic routing changes. *Example: Plug in headset ==> route audio to headset & adjust volume*

Audio Routing & Policy Stack



Some of our Work in Audio

- New PulseAudio modules
  - **module-droid-{card,source,sink,keepalive}**
  - Use Android HAL (via libhybris) for routing
  - Media audio routes through these streams
  - Cellular audio and Bluetooth audio streams stay in the SoC side ...
  - ... but we control routing, volume, muting, etc.

Some of our Work in Audio, cont'd

- Implement all resource policy in Sailfish
  - Based on Maemo / MeeGo legacy
- **Productize:**
  - Tune the configurations (e.g. volume levels, priorities)
  - Test, bugfix, rinse, repeat
- Alternative approach: We might have used PulseAudio ALSA-modules and ALSA Use Case Manager
  - Also a lot of work, esp. UCM porting
  - Less portable

PulseAudio and Audio HAL talk via C function calls

Initialization snippet from pulseaudio-modules-droid/src/droid/droid-util.c:

from libhybris (hardware.c)

```
hw_get_module_by_class(AUDIO_HARDWARE_MODULE_ID,
    module->name, (const hw_module_t**) &hwmod);
if (!hwmod) {
    pa_log("Failed to get hw module %s.",
        module->name);
    goto fail;
}
```

from Audio HAL (audio.h)

```
ret = audio_hw_device_open(hwmod, &device);
```

Audio routing example: Speaker during call

- During a voice call, enable the Integrated Hands-Free
  - i.e. change downlink speech audio routing from earpiece to speaker
- Sequence:
  Voicecall UI
  ==> OHM
  ==> Dependency Resolver
  ==> PulseAudio policy module
  ==> core PulseAudio
  ==> PulseAudio droid-sink module
  ==> Android Audio HAL

Audio routing example cont'd

Snippet from pulseaudio-modules-droid/src/droid/droid-sink.c:

```
pa_snprintf(tmp, sizeof(tmp), "%s=%u;",
    AUDIO_PARAMETER_STREAM_ROUTING, routing);
pa_log_debug("set_parameters(): %s (%#010x)",
    tmp, routing);
pa_droid_hw_module_lock(u->hw_module);
u->stream_out->common.set_parameters(
    &u->stream_out->common, tmp);
pa_droid_hw_module_unlock(u->hw_module);
```

from Audio HAL (audio.h)

Telephony

- The “phone” part of “smartphone”
- Everything around Cellular (GSM / WCDMA / LTE) connectivity
- Most visibly voice calls, text messaging, packet data ...
- ... but also many more obscure and “legacy” things
- The modem implements the “hard” protocol-level problems, but *modem interfaces* are still massive beasts

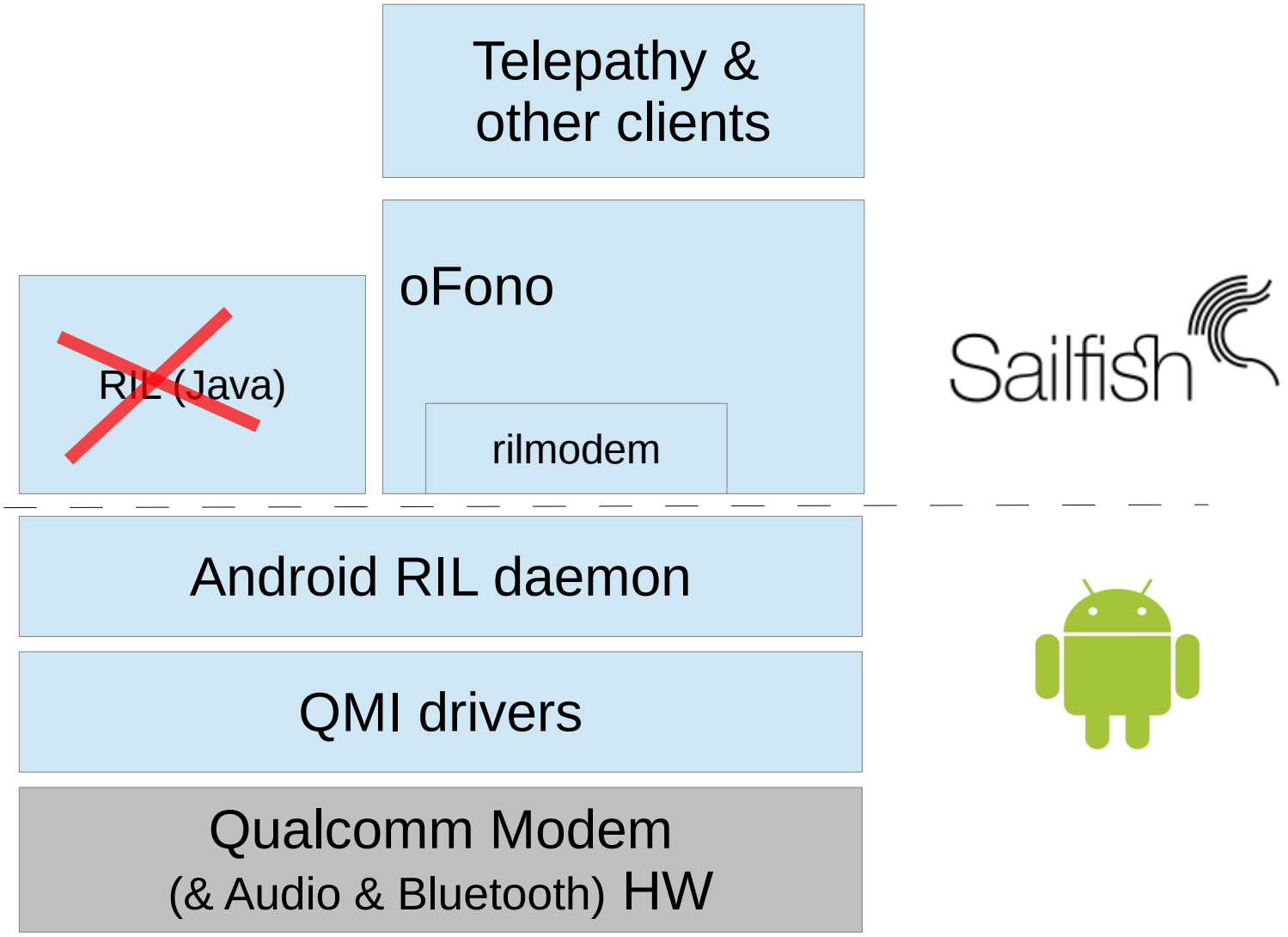
Telephony, cont'd

- Linux Telephony daemon: **oFono**
  - Design principle: hide unnecessary complexity from the phone UI
  - Happy 5th Birthday, oFono!

```
piiramar@ul001130:~/git/ofono$ git log --reverse
commit 2c5ddf34d8c4b6a87710245ac10f8addee6b223d
Author: Marcel Holtmann <marcel.holtmann@intel.com>
Date:   Sun Apr 26 20:31:15 2009 +0200

    Initial revision
```

Telephony Stack



Some of our Work in Telephony

- Extend existing oFono rilmodem driver
  - https://github.com/rilmodem/ofono , used by **Ubuntu Touch**
  - Basic use cases of voice call / SMS / packet data were already implemented by Canonical
- Fix what's broken and add what's missing
  - https://github.com/nemomobile-packages/ofono , used by **Sailfish OS**
  - Examples following:
- **SIM**-related things
  - Security handling (PIN, PUK), phonebook access
  - SIM Toolkit. “Legacy” but requested by operators. *Example: A mobile authentication service*

Some of our Work in Telephony, cont'd

- Advanced **call handling**
  - Hold/resume, multiparty
  - Emergency calls always possible. *Regulatory requirement in some markets.*
  - Signalling tones
- **SMS** improvements
  - Delivery report handling
  - Text encodings. *Example: SMS containing advanced Unicode (emoticons as surrogate pairs)*
- **Network** handling
  - Operator selection (automatic / manual), roaming behaviour, user preferences
  - Show network name / Service Provider name. *Important for operators' branding.*
  - Flight mode

Some of our Work in Telephony, cont'd

- **Supplementary Services**
  - Call Forwarding / Waiting / Barring
  - CLIR (show / hide my number), USSD
- Settings **provisioning**
  - Packet data and MMS. Pre-configured and Over-The-Air
- Modem **power management** based on system activity state
- “OEM Raw” **extension API** for proprietary modem requests
- Fixes in **telepathy-ring**, the port from csd to oFono was somewhat unfinished

Some of our Work in Telephony, cont'd

- **Productize**:
  - Prioritize requirements from product mgmt, operators, end users (*we just couldn't do everything at once*)
  - Don't just do the “happy cases”. *Example: Many requests can be rejected by the network and/or SIM*
  - Test, bugfix, rinse, repeat
  - Including surprises from field testing
  - Utilizing network and SIM card simulators
- Alternative approach: We might have extended oFono's QMI driver
  - RIL API is on a slightly higher level of abstraction, increases portability, hides modem-specific quirks
  - RIL implementation is ”battle-hardened” in Android devices

oFono and RIL talk via UNIX socket and messages

Initialization snippet from ofono/gril/gril.c:

```
#define RILD_CMD_SOCKET "/dev/socket/rild"
addr.sun_family = AF_UNIX;
strncpy(addr.sun_path, RILD_CMD_SOCKET,
    sizeof(addr.sun_path) - 1);
if (connect(sk, (struct sockaddr *) &addr,
    sizeof(addr)) < 0) { ... }
```

oFono example: Call Waiting status

- Set / Query the status of the “Call Waiting” supplementary service (a.k.a. “knocking”) to / from the network
- Client calls oFono via D-Bus:
  - Object path `/ril_0`
  - Set the “call waiting” status:
    Method `org.ofono.CallSettings.SetProperty`,
    arguments `(string:"VoiceCallWaiting",`
    `variant:string:"enabled")`
  - Get the “call waiting” status:
    Method `org.ofono.CallSettings.GetProperties`

oFono example cont'd, oFono behavior

- The D-Bus request is handled by oFono's call-settings atom
  - checks if busy with a pending request, and argument validity
  - checks availability of a modem driver implementing this
- Request is forwarded to rilmodem call-settings driver
  - Driver constructs a request message
  - gril plug-in sends it to RIL
    - which does the actual modem and network request
  - Driver parses the response message
  - Callback to oFono core, reply to D-Bus client

oFono example cont'd, RIL messages

Request message, oFono ==> RIL

00000010230000000e8010000010000000000000000

service class “all”

RIL_REQUEST_QUERY_CALL_WAITING, from ril.h

msg length

serial number

“enabled” ... for “voice”

00000018000000000e80100000000000000200000001000000010000000

Response message, RIL ==> oFono

Achievements Summary

- Using Android HAL and RIL was **speeding up** our product development
  - From first hacks on target hardware to commercial launch in a few months
  - CE and Bluetooth HFP certified
  - A beautiful phone with happy users

Acknowledgements

- Warm thanks to:
  - Everyone at Jolla
  - Canonical rilmodem team
  - oFono, PulseAudio, libhybris maintainers and contributors

Repositories in GitHub.com

mer-packages/pulseaudio
mer-hybris/pulseaudio-modules-droid
nemomobile/pulseaudio-modules-nemo
nemomobile/pulseaudio-policy-enforcement
nemomobile/ohm
nemomobile/ohm-plugins-misc
nemomobile/libdres-ohm
nemomobile/ohm-rule-engine
nemomobile/policy-settings-common
nemomobile/tone-generator
nemomobile/telepathy-ring
nemomobile/provisioning-service
nemomobile-packages/ofono