AUTOMOTIVE BLUETOOTH TELEPHONY.
COMBINING BlueZ AND THE MODERN VEHICLE.

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AUTOMOTIVE BLUETOOTH TELEPHONY. WHY ARE WE DOING THIS?

Building Open Source IVI Stack for Bluetooth Use Cases

using BlueZ, oFono and PulseAudio

feeding back APIs and architectural decisions into the GENIVI Alliance
BLUETOOTH BASICS.
DATA TRANSPORT ARCHITECTURE.

- L2CAP Layer
  - L2CAP Channels
- Logical Layer
  - Logical Links
  - Logical Transports
- Physical Layer
  - Physical Links
  - Physical Channel

BLUETOOTH BASICS.
PHYSICAL LAYER.

Physical Channel

- Frequency Hopping Sequence
- Access Code
- Packet Timing

Physical Link

represents a connection between Bluetooth devices

(see. [2] Core System Package, p. 71ff and 96ff)
BLUETOOTH BASICS.
LOGICAL LAYER.

Logical Transport
defines a communication channel with a set of characteristics:

- Flow control
- Acknowledgment and repeat mechanisms
- Sequence numbering
- Scheduling behaviour

Logical Link
associated with a logical transport
supports applications with
different transport requirements

(see. [1] Architecture & Terminology Overview, p. 61)
BLUETOOTH BASICS.
LOGICAL TRANSPORTS.

**ACL** (Asynchronous Connection-Oriented)
Packet-switched communication

**SCO** (Synchronous Connection-Oriented)
Circuit-switched communication
BLUETOOTH BASICS.
LOGICAL LINK CONTROL AND ADAPTATION PROTOCOL LAYER.

L2CAP Channel

used for connection-oriented and connectionless data services

offers

• Segmentation and reassembly of packets
• Flow Control
• Error Control and retransmission

(see. [3] Core System Package, p. 30ff)
HANDS-FREE PROFILE (HFP).

ROLES.

Handset

Cellular connection

Hands-free car kit

Bluetooth connection

Hands-Free Unit (HF)

Audio Gateway (AG)

Cellular Network

Cellular connection

(c.f. [4] Hands-Free Profile 1.6, p. 14)
HANDS-FREE PROFILE (HFP). STRUCTURE.
HANDS-FREE PROFILE (HFP).
STRUCTURE.

(cf. [4] Hands-Free Profile 1.6, p. 10)
HANDS-FREE PROFILE (HFP). STRUCTURE.

(SCO and eSCO (Audio)

SCO Socket

Generic Access Profile (GAP)

RFCOMM

Logical Link and Adaption Layer (L2CAP)

Service Discovery Profile (SDP)

Host Controller Interface (HCI)

Controller(s)

Hands-Free Profile (HFP)

Serial Port Profile (SPP)

RFCOMM Socket

SCO Socket

AT CMD

(cfr. [4] Hands-Free Profile 1.6, p. 10)
ARCHITECTURE.
CORE COMPONENTS AND APIs.

- oFono
- D-Bus API → BlueZ
- BlueZ
- D-Bus API → Pulseaudio
- RFCOMM Socket
- Management Socket
- SCO Socket
- Kernel
- Host Controller Interface (HCI)
- Bluetooth Hardware
ARCHITECTURE.
CORE COMPONENTS AND APIs.

User Interface (Human Machine Interface)

- oFono
- BlueZ
- Pulseaudio

Handsfree API
- Handle Connections
- Handover RFCOMM

Media API
- Handle audio streams
- Suspend and resume
- Echo cancellation and noise reduction
ARCHITECTURE.
CORE COMPONENTS AND APIs.

User Interface (Human Machine Interface)

Telephony Control
- Dialing
- Call Handling (Accept, Reject, Hold)
- Multiparty Call Handling

Bluetooth Device Control
- Device Inquiry
- Device Pairing
- Profile Activation
- Priority Handling

Audio Control
- Microphone Mute
- Echo Cancellation / Noise Reduction
- Policy Handling

oFono

BlueZ

Pulseaudio
ARCHITECTURE.
HUMAN MACHINE INTERFACE.

User Interface (Human Machine Interface)

Please use your Bluetooth device to start search for Bluetooth devices. The vehicle will identify itself as:

BMW 12345

Please refer to the owner's handbook for your Bluetooth device. For more information on compatible functions and special features, please see:

Functions of the device K800i:

- Telephone
- Audio

Source: Vehicle memory

oFono
BlueZ
Pulseaudio
BLUETOOTH BASICS.
OTHER RELEVANT AUDIO PROFILES.

A2DP (Advanced Audio Distribution Profile)
- Setup, Control and manipulate streaming of compressed audio
- Stream high-quality Audio over ACL-Link

AVRCP (Audio/Video Remote Control Profile)
- Control a media player and retrieve current status
- Browse and Search library of a media player

HSP (Headset Profile)
- Full-duplex audio connection over SCO-Link
- Minimal device control
SINGLE PHONE USE CASES.
PUTTING CALLS ON HOLD.

- Active call
- Put call on hold
- Hold call
- Activate held call
- Activate call

- Bluetooth connection
- Call active
- Call on hold
- Audio connection (HFP)
SINGLE PHONE USE CASES. PRIVATE MODE (ACTIVE CALL).

Enter private mode → Disconnect Audio

Leave private mode → Connect Audio
SINGLE PHONE USE CASES. PRIVATE MODE (INCOMING CALL).

Answer call

Ringing

Active call

Connect Audio

Leave private mode

[Diagram showing the connection between a mobile phone and a car, with labels for Bluetooth connection, call active, call on hold, and audio connection (HFP).]
SINGLE PHONE USE CASES.
AUDIO PRIORITIES.

- Ringing
- Active call
- Answer call
- Hang up call
SINGLE PHONE USE CASES.
AUDIO PRIORITIES.

Answer call

Hang up call

Ringing

Active call

Hang up call

Audio connection (HFP)

Call active

Call on hold

Audio stream (A2DP)

Bluetooth connection
SINGLE PHONE USE CASES.
AUDIO PRIORITIES – UNDER THE HOOD.

- Bluetooth connection
- Call active
- Call on hold
- Audio connection (HFP)
- Audio stream (A2DP)

Diagram:
- +CIEV
- SCO connect
- ATA
- OK
- Stop audio
- new_call()
- PropertyChanged()
- Acquire()
- SCO Socket
- Ringing
- call_answer()
- PropertyChanged(call active)
- Notify
- Answer
- OK
MULTI-PHONE USE CASES.
HOLD AND ANSWER.

- Bluetooth connection
- Call active
- Call on hold
- Audio connection (HFP)

1. Call active
2. Call on hold
3. Audio connection (HFP)
4. Hold and Answer
5. Put call on hold
6. Active call
7. Answer call
8. Ringing

Automotive Bluetooth Telephony, BMW Car IT GmbH
MULTI-PHONE USE CASES.
SWAPPING CALLS.

Activate held call

Bluetooth connection
Call active
Call on hold
Audio connection (HFP)

Call on hold
Active call
Swap calls

Activate held call
Put call on hold

2
1

1
2
MULTI-PHONE USE CASES. AUTOMATIC REJECT.

- Bluetooth connection
- Call active
- Call on hold
- Audio connection (HFP)
THE ROAD AHEAD.

• Wide band speech
• Transition to BlueZ 5.0
• Audio Routing
• IOP Testing

Used Versions:

BlueZ: dbd9c3109e77088dc3d7e35dec78524ba73d1ad4

oFono: ce79121d27555d8ad43b5db49a35db83a01a0b8

PulseAudio: a423ee0f3d36b98baff64cc31558632e738b402d
RESOURCES.

www.bluetooth.org  www.bluez.org
www.genivi.org  www.ofono.org


Soundtrack of the Demo: http://freemusicarchive.org/music/Life_In_A_Blender
HAN D S - F R E E P R O F I L E 1 . 6 .
INTRO DUCING W ID E B AND SPEE C H

What’s new?

• Extended SCO is used for audio streams
• Audio Codecs are used to stream high quality audio

Codec Negotiation

oFono

Handsfree API

Pulseaudio

Media API

BlueZ
MULTI-PHONE USE CASES.
DIALING.

Diagram showing the process of dialing and selecting between multiple phones, with symbols for Bluetooth connection, call active, call on hold, and audio connection (HFP).