Bluetooth et BLE : Support dans Linux

maxime.chevallier@openwide.fr

Open Wide Ingénierie

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Historique

- 1994 : Création (Ericsson)
- 1998 : SIG (Ericsson, Intel, Nokia, Toshiba)
- 1999 : v1.0
- 2004 : v2.0 : Basic Rate / Enhanced Data Rate
- 2010 : v4.0 Low Energy
- 2014 : v4.2

Logo Bluetooth

Historique

- 1994 : Création (Ericsson)
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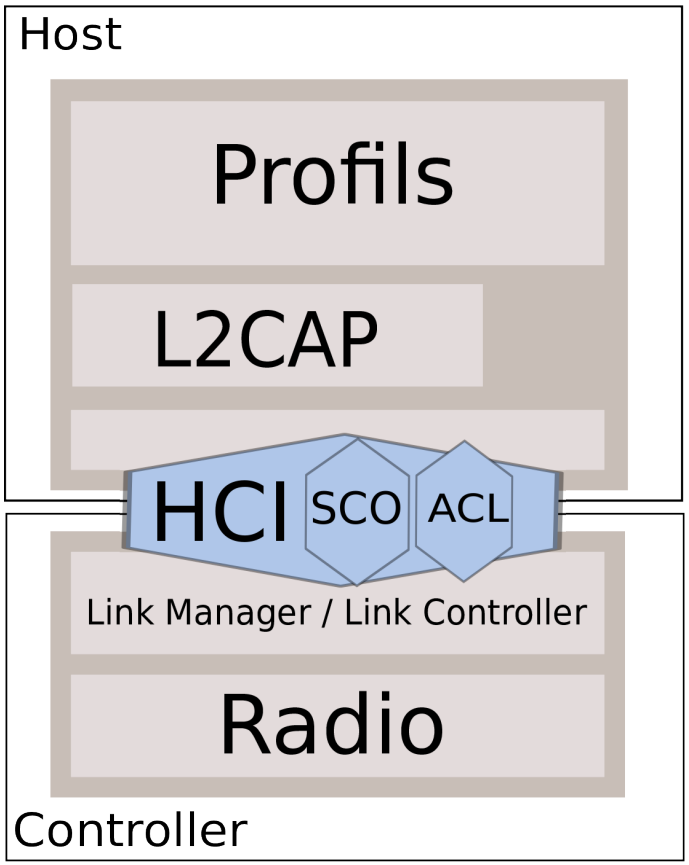
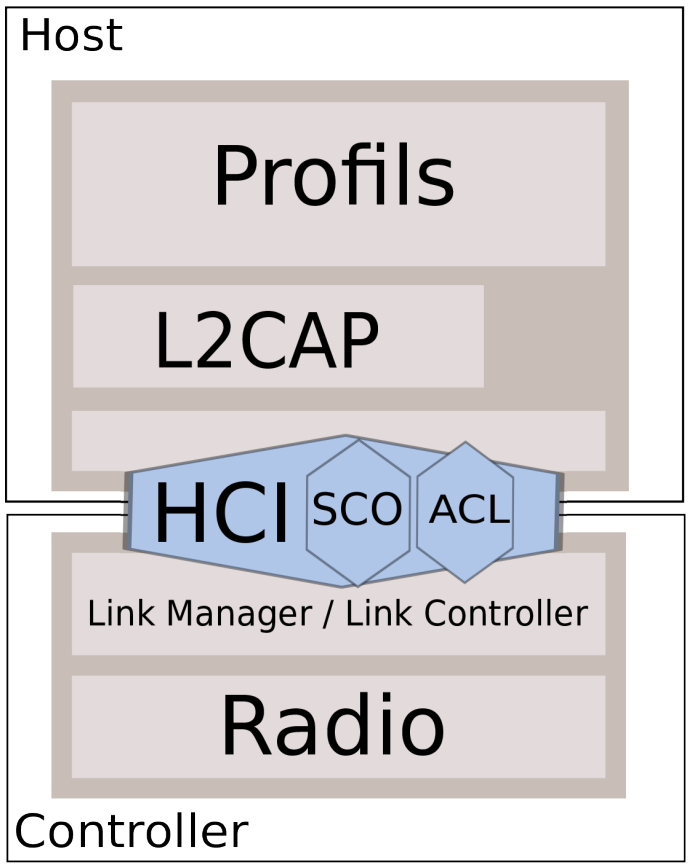
Caractéristiques physiques

- 2.4 GHz
- Max 24Mb/s
- 79 cannaux, AFH
- Conso : 1W



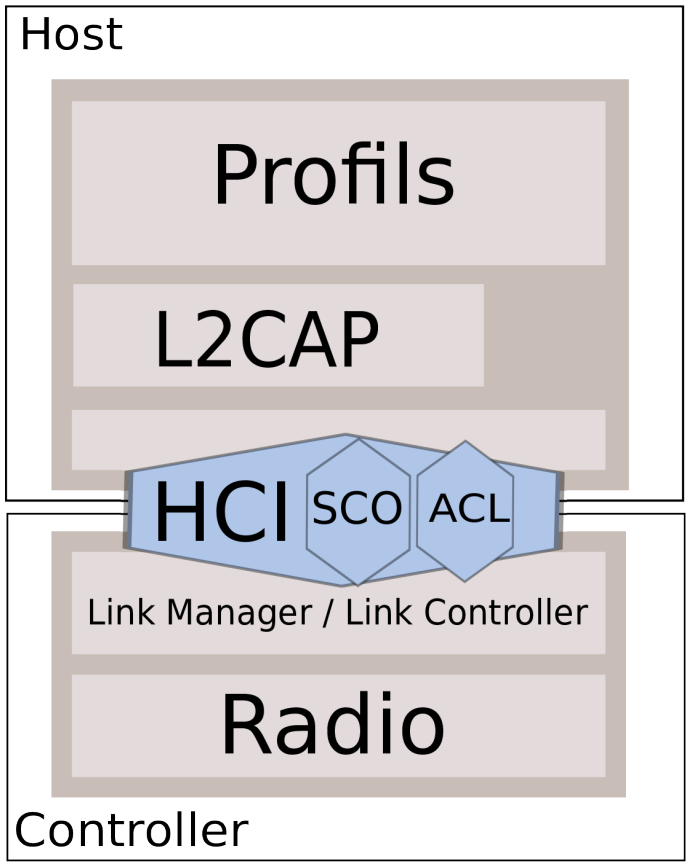
Bluetooth core



Bluetooth core

Host

- Logique Métier
- Scheduling
- Buffering



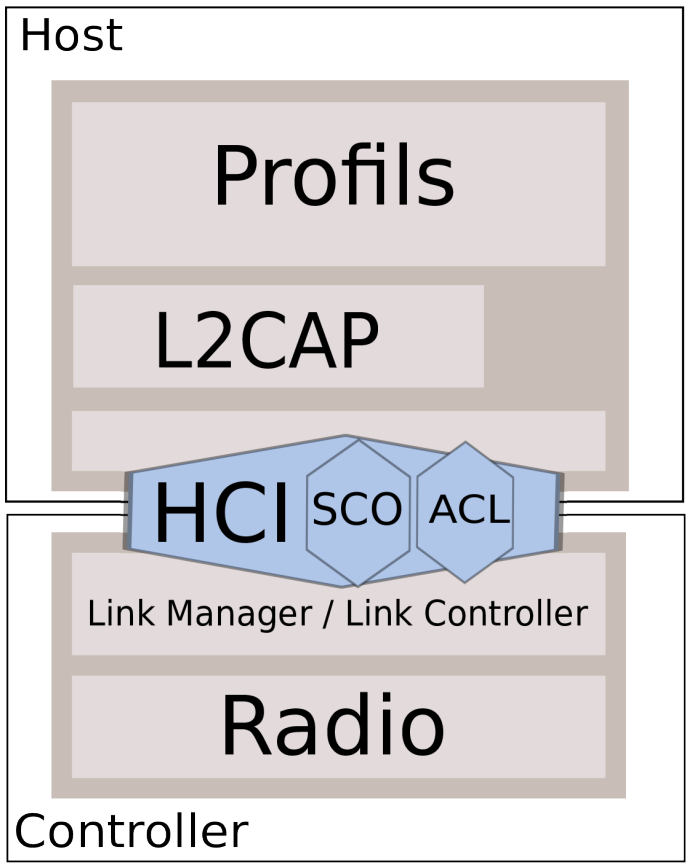
Bluetooth core

Host

- Logique Métier
- Scheduling
- Buffering

Host to Controller

- Host to Controller Interface
- Sychronous Connection-Oriented
- Asychronous Connection-Less



Bluetooth core

Host

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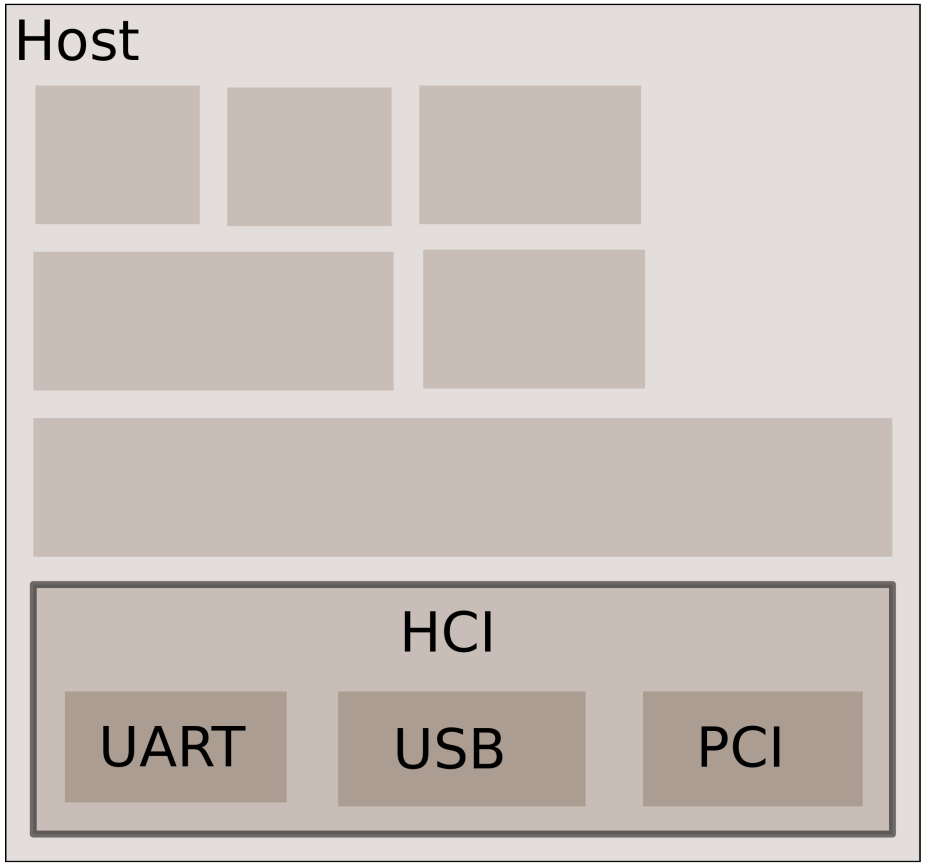
Controller

- Connexion
- Découverte



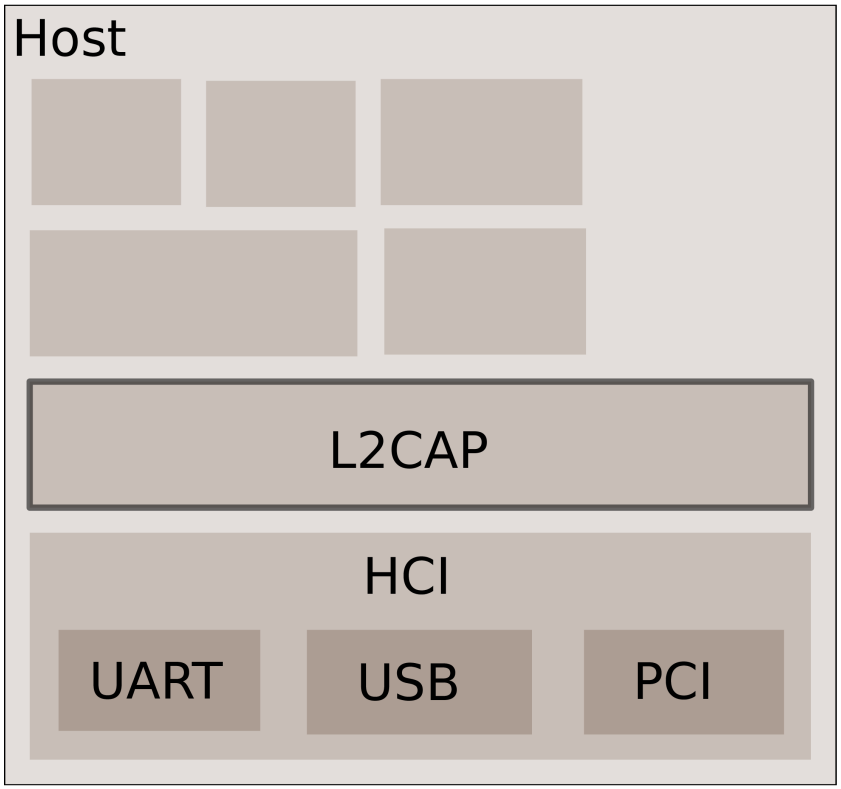
Host to Controller Interface

HCI

- Uniformisation
- Abstraction

Commandes :

- Données
- Configuration
- Évènements

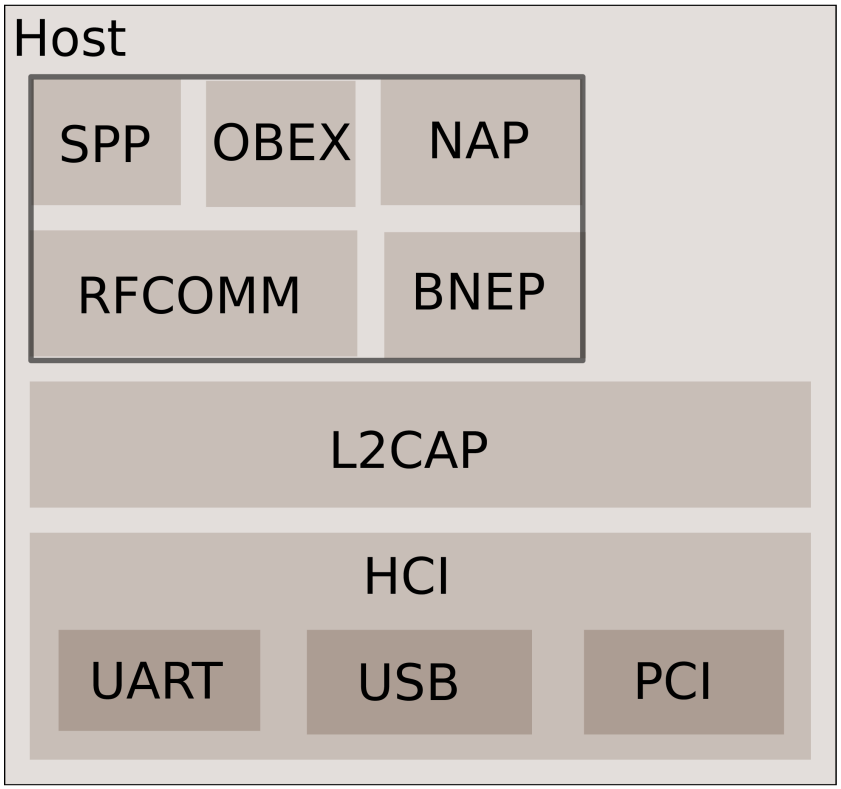


Logical Link Control and Adaptation Protocol

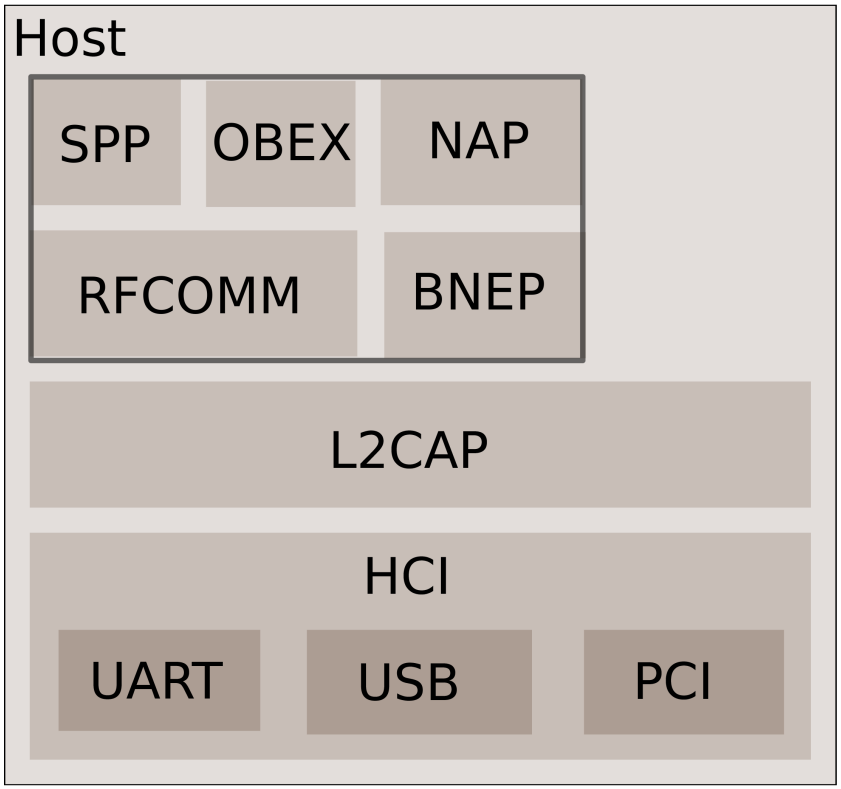
L2CAP

Socle pour de nombreux profils :

- Multiplexage
- Buffering
- QoS
- Scheduling



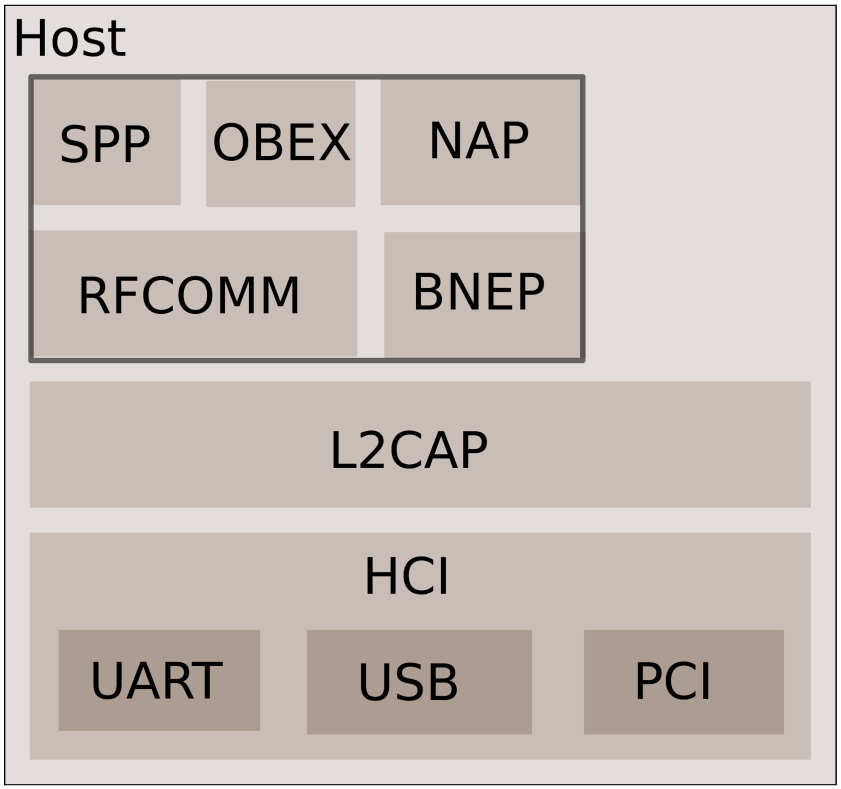
Profils



Profils

Protocoles

- RFCOMM
- BNEP
- AVCTP (controle A/V)
- AVDTP (transport A/V)



Profils

Protocoles

- RFCOMM
- BNEP
- AVCTP (controle A/V)
- AVDTP (transport A/V)

Profils

- Serial Port Profile
- Human Interface Device
- Personnal Area Network
- Phone Book Access Profile

Découverte

1. Inquiry
2. Paging
3. Connexion

Découverte

1. Inquiry
2. Paging
3. Connexion

Appairage

- Connexion automatique,
- sécurisée,
- authentifiée,
- adaptée à l'appareil.

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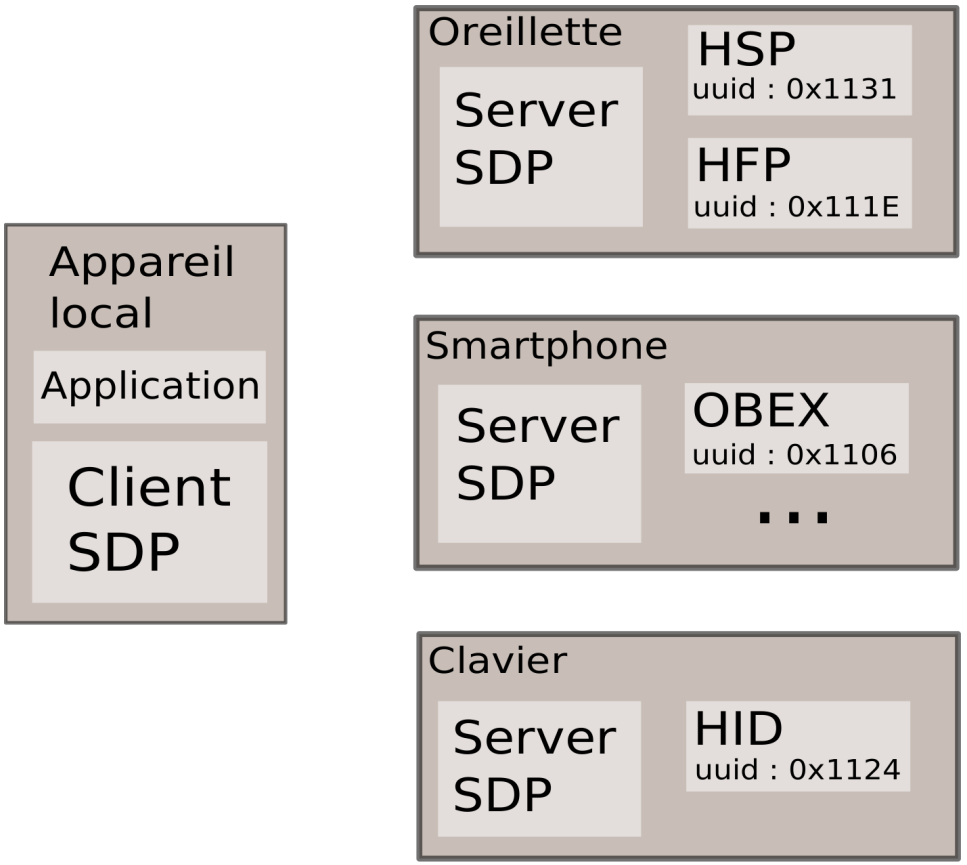

UUID

Identifient des :

- Profils
- Protocoles
- Attributs GATT

Service Discovery Protocol

Liste : https ://www.bluetooth.com/specifications/assigned-numbers/service-discovery

Bluetooth Smart

- 2006 : Wibree (Nokia)
- 2010 : Bluetooth 4.0

Logos Bluetooth Low Energy

Bluetooth Smart

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Logos Bluetooth Low Energy

Bluetooth Smart

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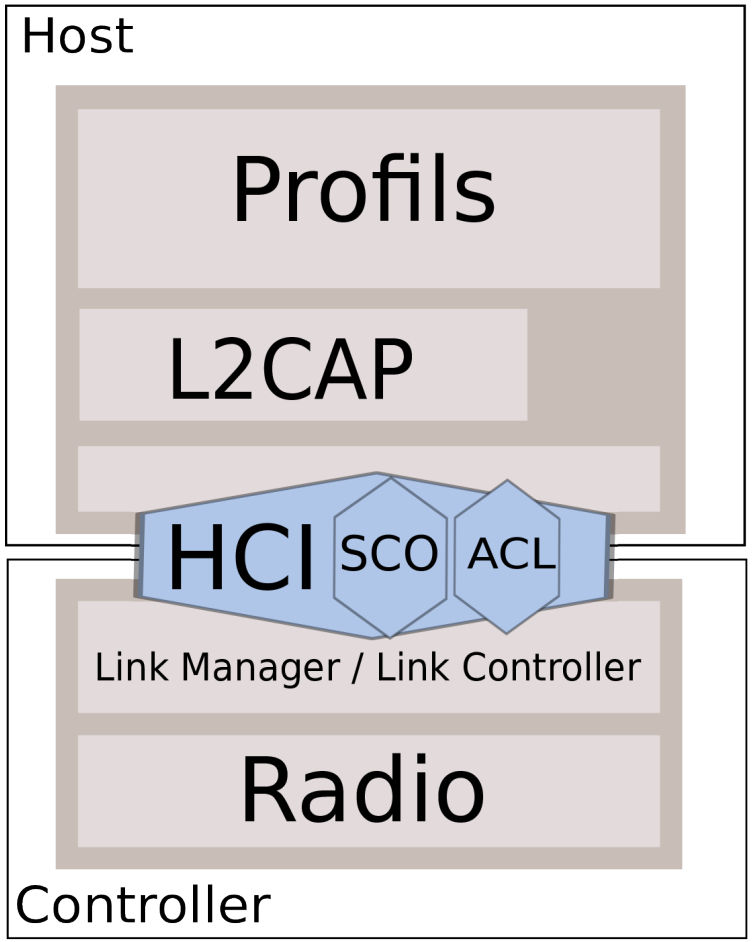
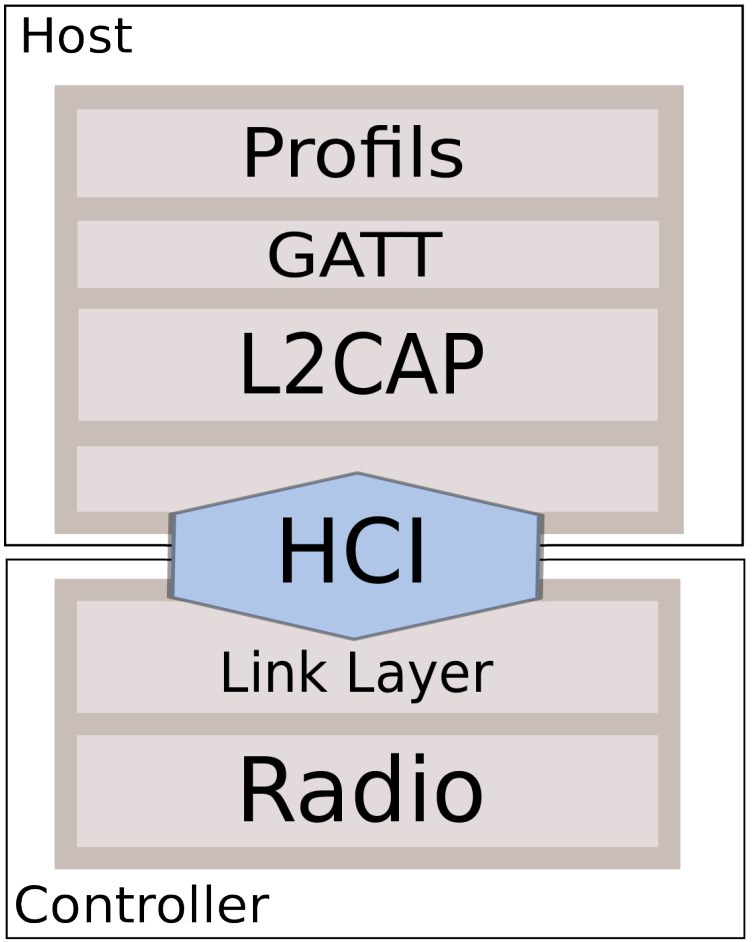
Caractéristiques

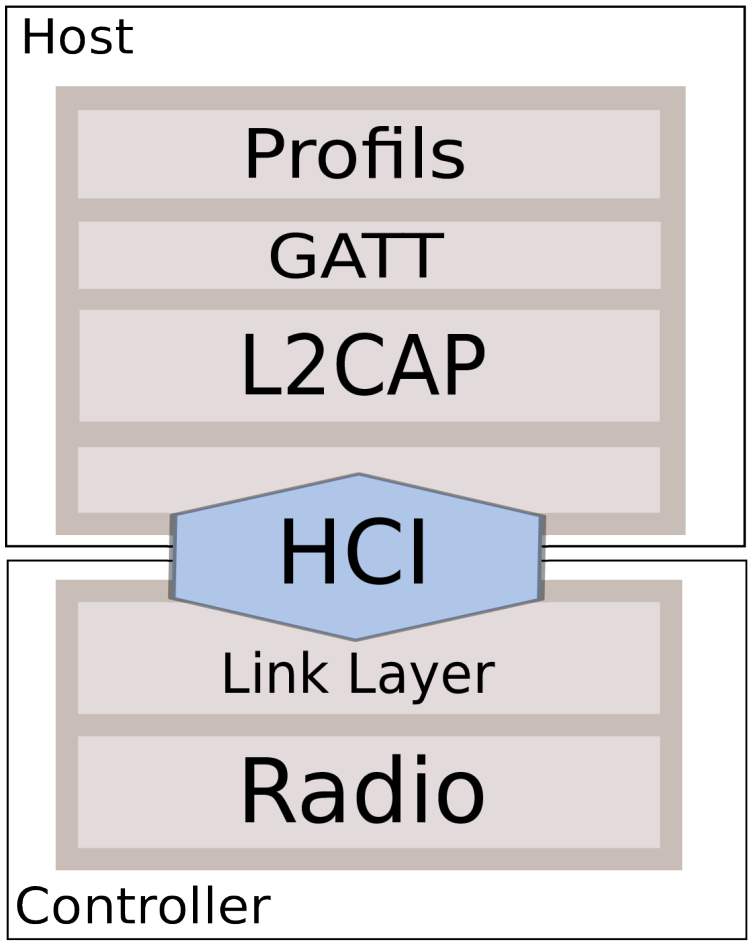
- 2.4 GHz
- 40 cannaux
- 1 Mbit/s
- Conso entre 0.01W et 0.5W



Core BR/EDR



Core BLE



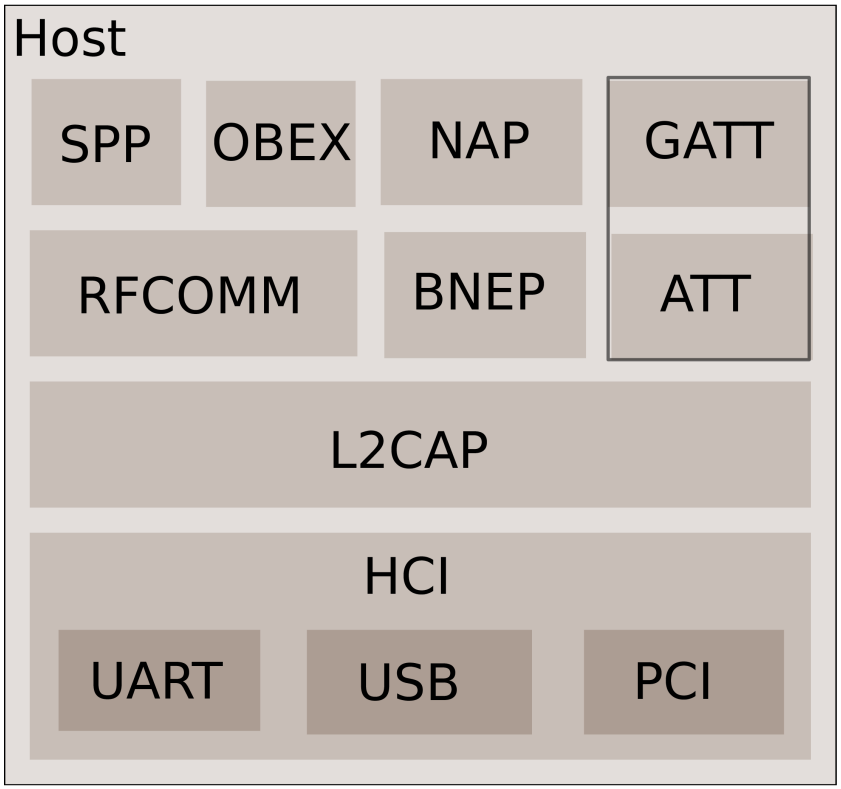
Core BLE

Link Layer

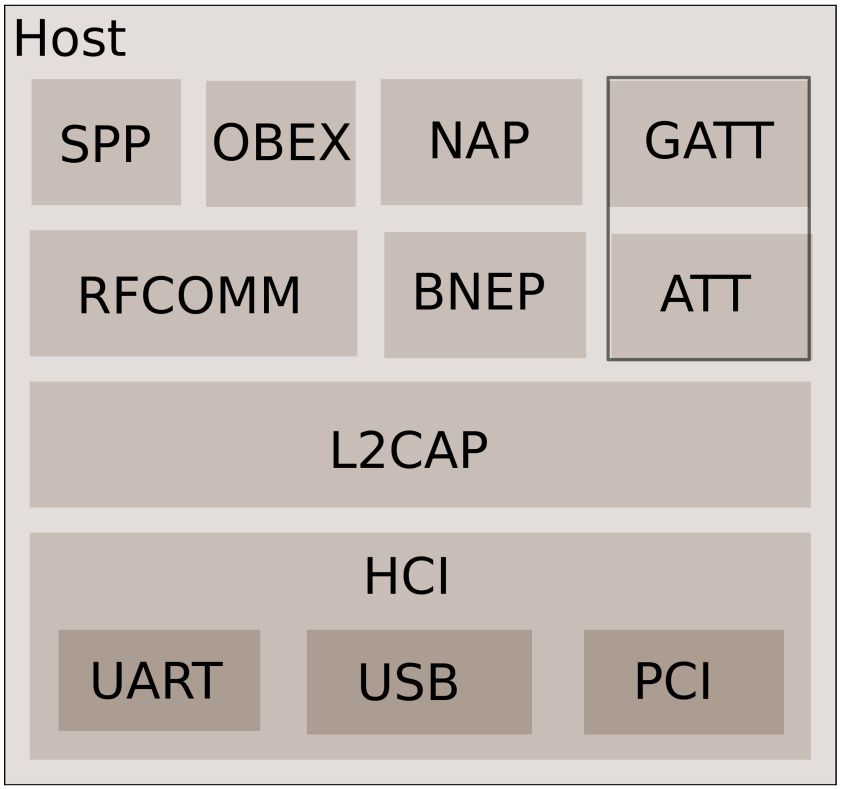
- Advertising
- Scanning
- Connected

Sécurité

- Clé côté Host
- AES 128
- Adresses :
  - Publique
  - Aléatoire



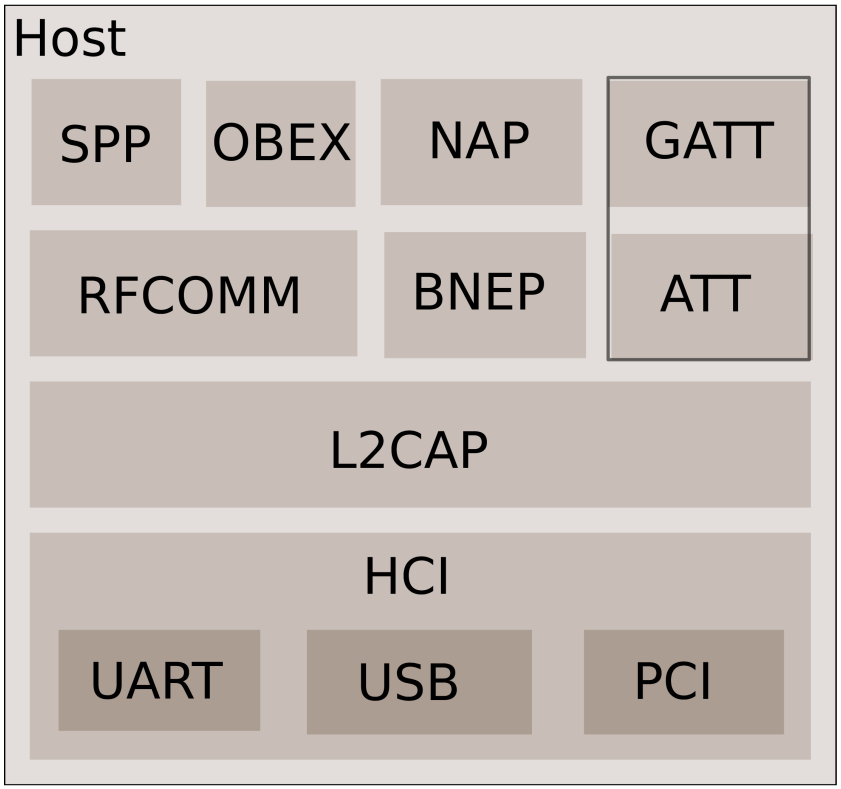
ATTributes / Generic ATTributes



ATT

- Protocole
- Transport d'attributs

ATTributes / Generic ATTributes



ATTributes / Generic ATTributes

ATT

- Protocole
- Transport d'attributs

GATT

Profil BLE

- Client
- Serveur

GATT

GATT

Attribut

- Type : UUID
- Permissions :
  - R/W
  - Encryption
  - Autorisation
- Valeur
- Handle : Adresse

GATT

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- Type : UUID
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Services

GATT

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Regroupe des :

Caractéristiques

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Regroupe des :

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- Déclaration
- Valeur

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Regroupe des :

Caractéristiques

- Déclaration
- Valeur
- Et parfois :

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Services

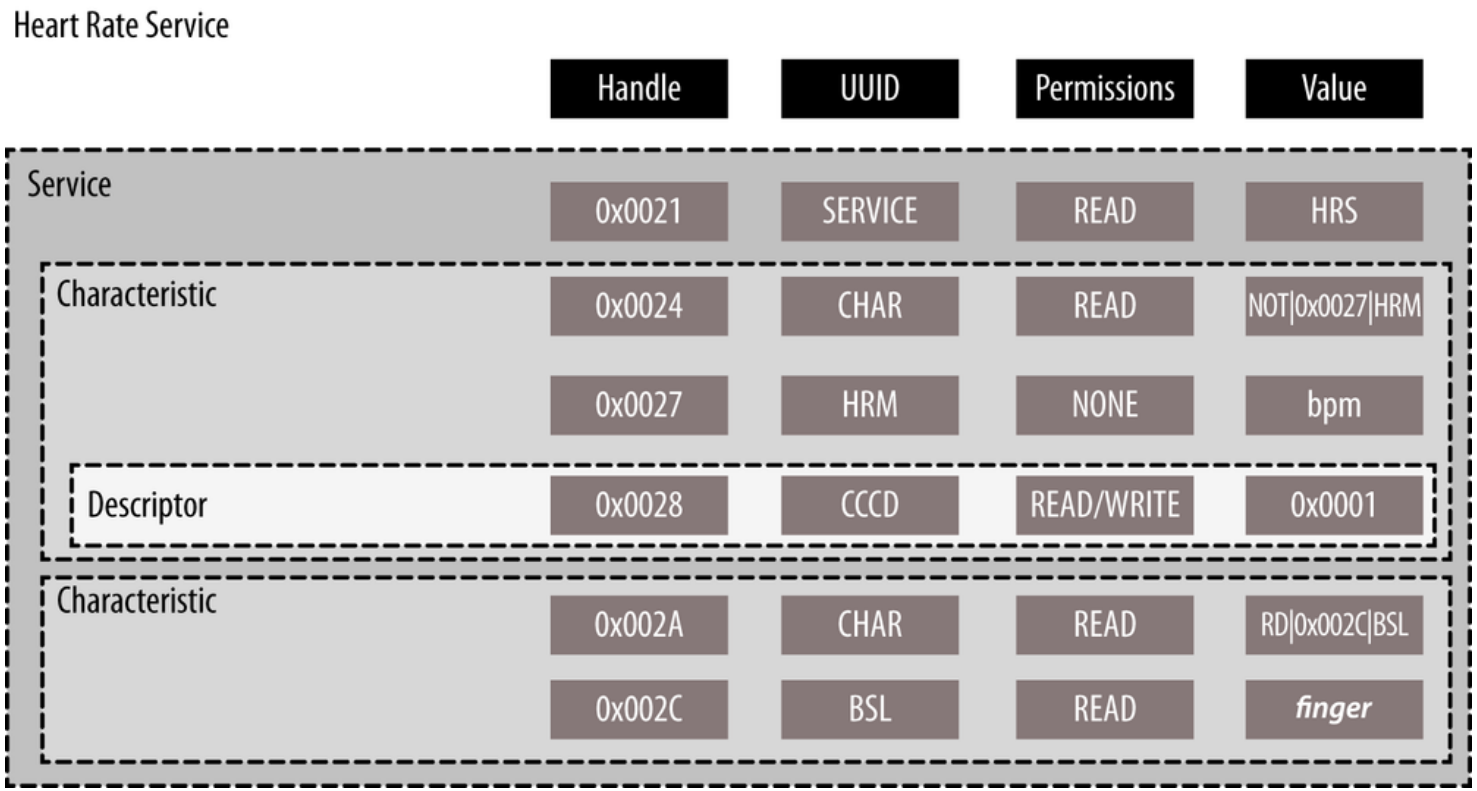
Regroupe des :

Caractéristiques

- Déclaration
- Valeur
- Et parfois :

Descripteurs

Métadonnées sur la caractéristique

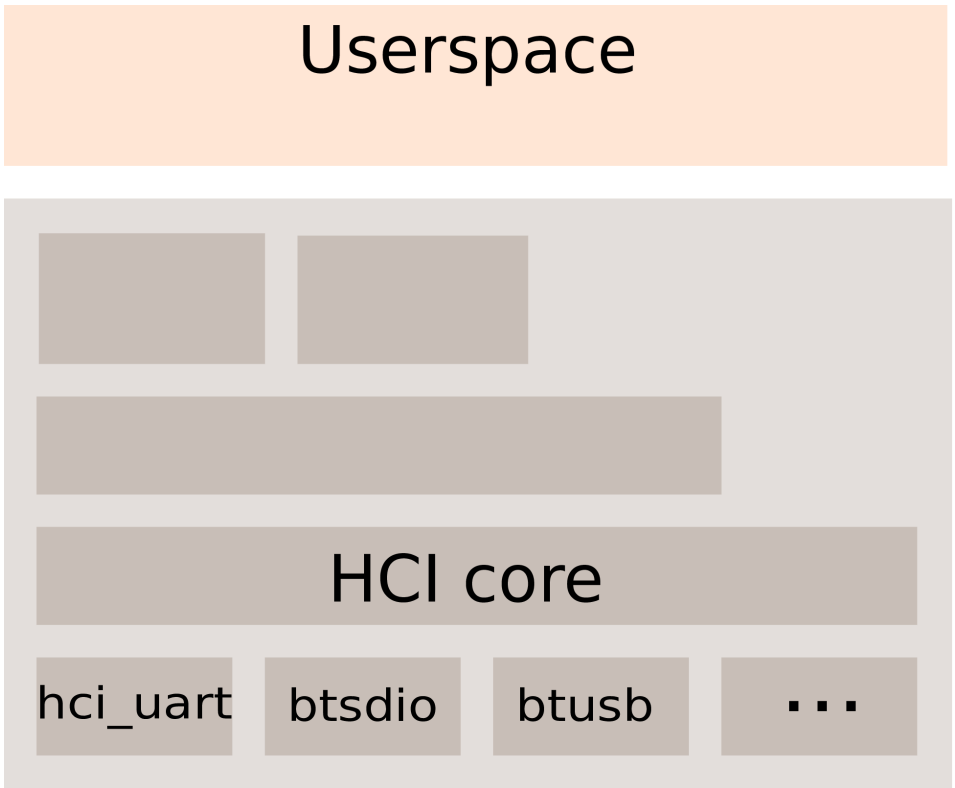


Exemple de service GATT

"Getting started with bluetooth low energy", R.Davidson, Akiba, Carles Cufí, Kevin Townsend, O'Reilly

BlueZ

- 2001 : Max Krasnyansky (Qualcomm)
  Kernel 2.4.6
- 2004 : Marcel Holtmann (Intel)
  Kernel 2.6
- 2012 : Low Energy (BlueZ 5.0)
  Kernel 3.5
- 2016 : BlueZ 5.37



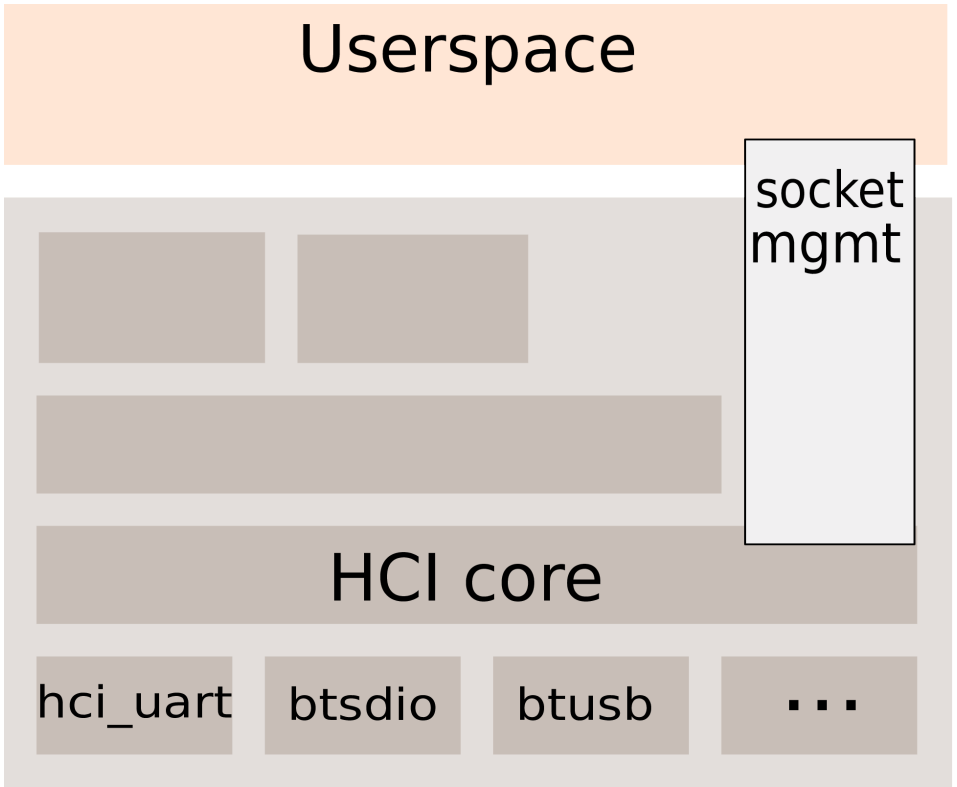
Host to Controller Interface

HCI

- Queueing
- Ordonnancement

Transport :

- USB
- UART
- PCI
- SDIO
- PCMCIA



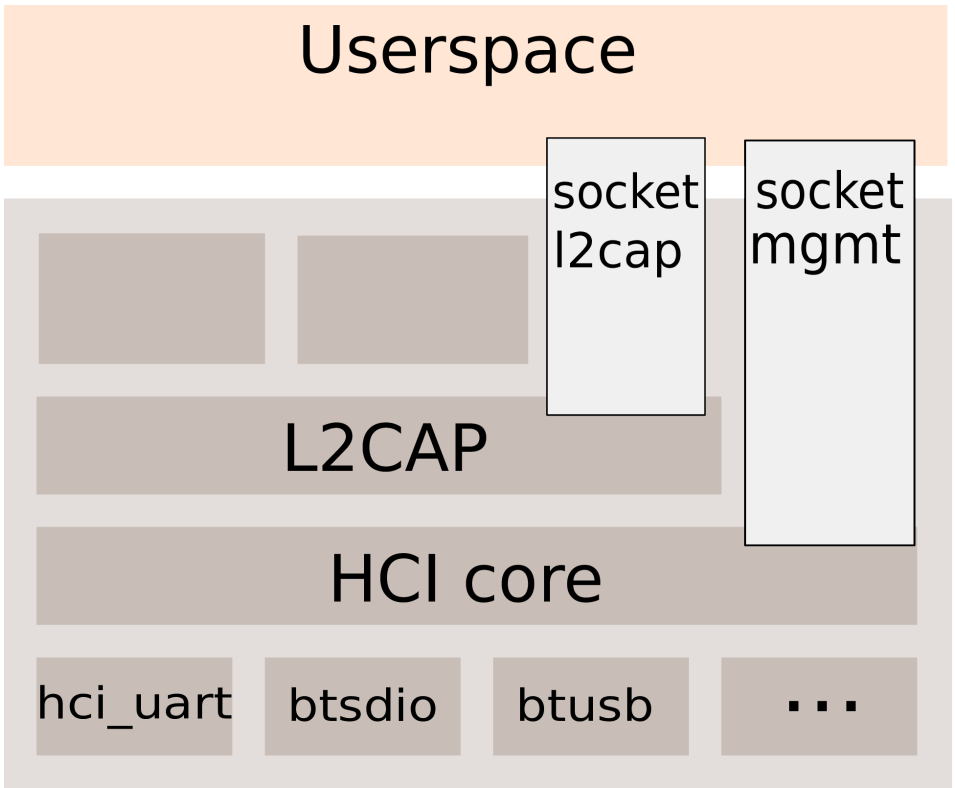
Management interface

mgmt socket

- HCI pour userspace
- Remplace hci sockets

Paramètres

```
- PF_BLUETOOTH
- BTPROTO_HCI
struct sockaddr_hci
 - .hci_family = AF_BLUETOOTH
 - .hci_dev = HCI_DEV_NONE
 - .hci_channel = HCI_CHANNEL_CONTROL
```



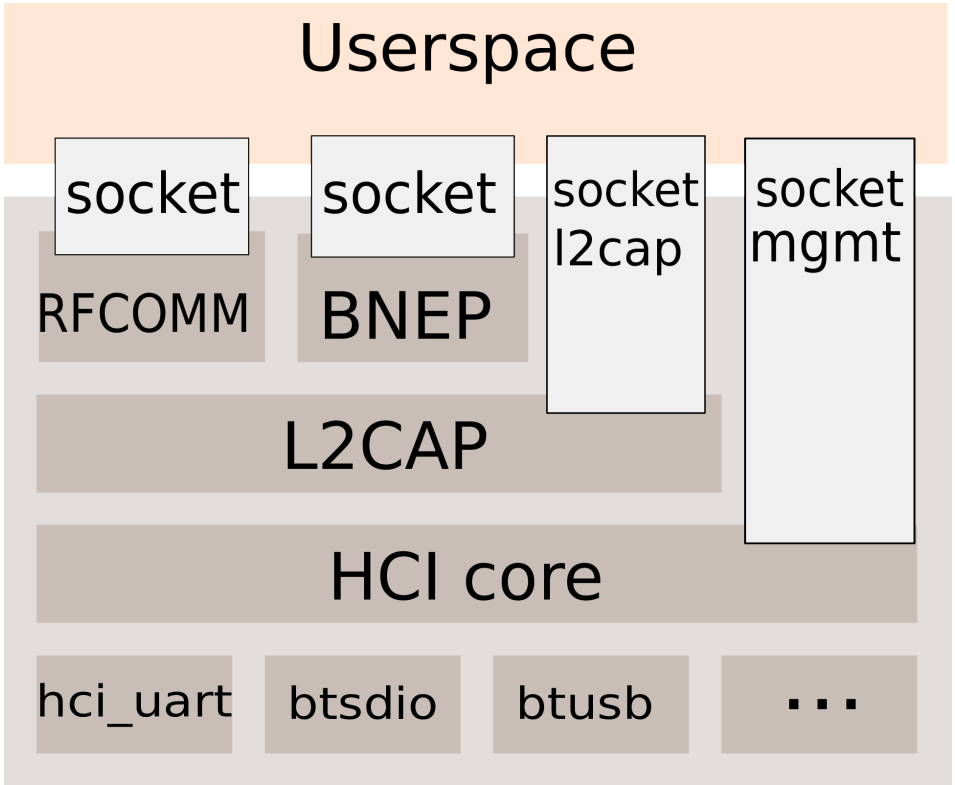
L2CAP

l2cap socket

- API Socket
- - Adresse
- - PSM

Paramètres

```
- AF_BLUETOOTH
- BTPROTO_L2CAP
struct sockaddr_l2
 - .l2_family = AF_BLUETOOTH
 - .l2_bdaddr = *BDADDR_ANY
 - .l2_psm = htobs(0x1001);
```



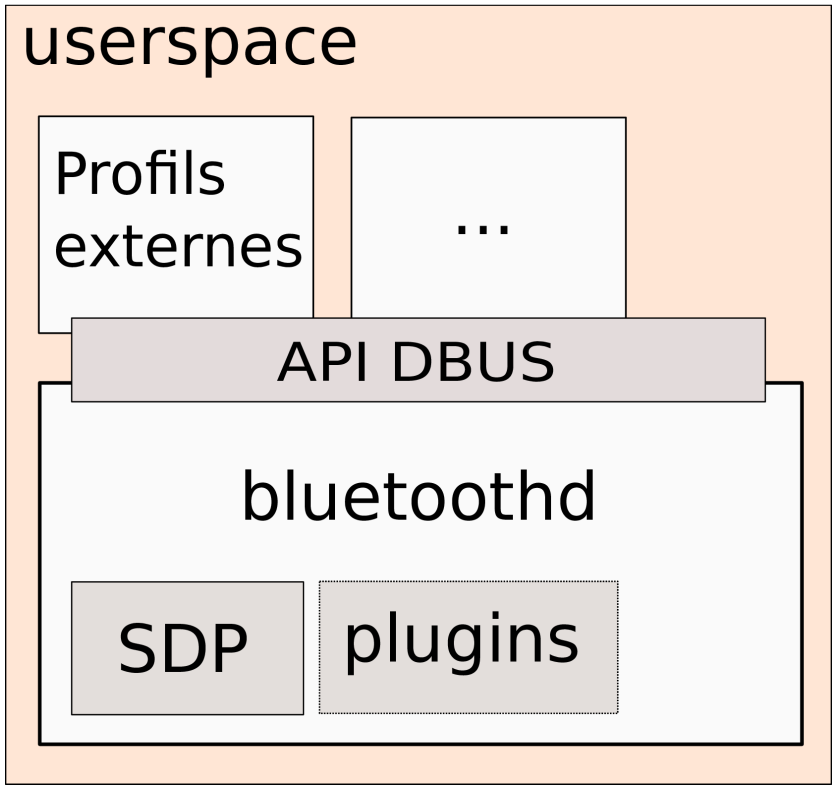
RFCOMM, BNEP, etc.

rfcomm socket

- API Socket
- - Adresse
- - Canal

Paramètres

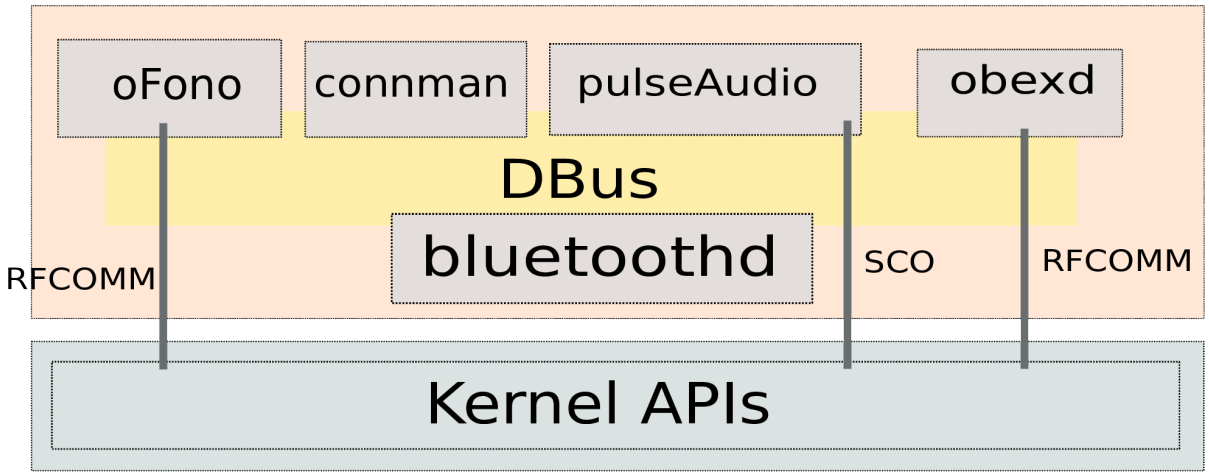
```
- AF_BLUETOOTH
- BTPROTO_RFCOMM
struct sockaddr_l2
 - .rc_family = AF_BLUETOOTH
 - .rc_channel = 1
 - .rc_braddr = *BRADDR_ANY;
```



bluetoothd

Démon bluetoothd

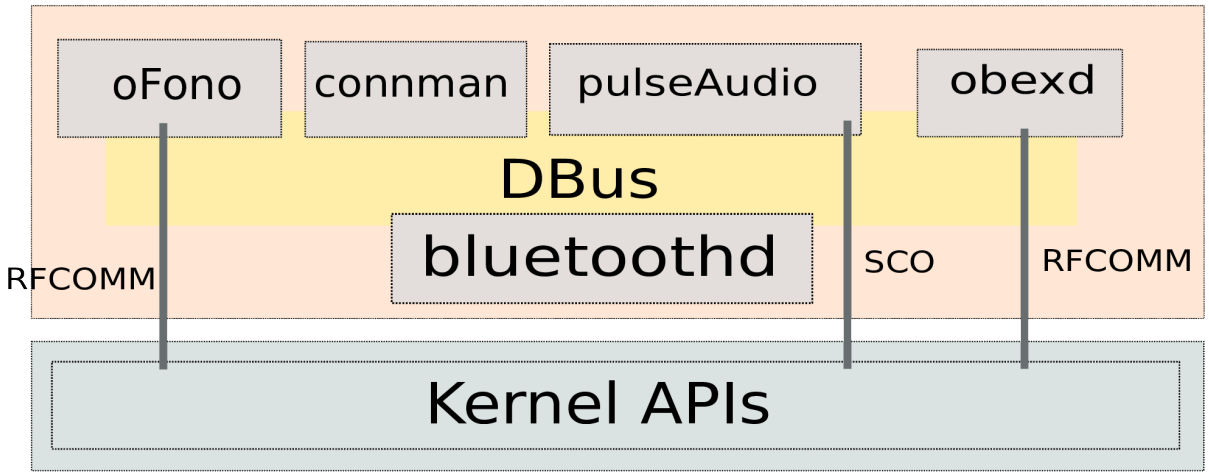
- Serveur SDP
- Gestion sockets
- Plugins
- Agents d'appairage
- API DBus



Profils Externes

oFono

- Gestion Téléphonie
- HFP / HSP



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oFono

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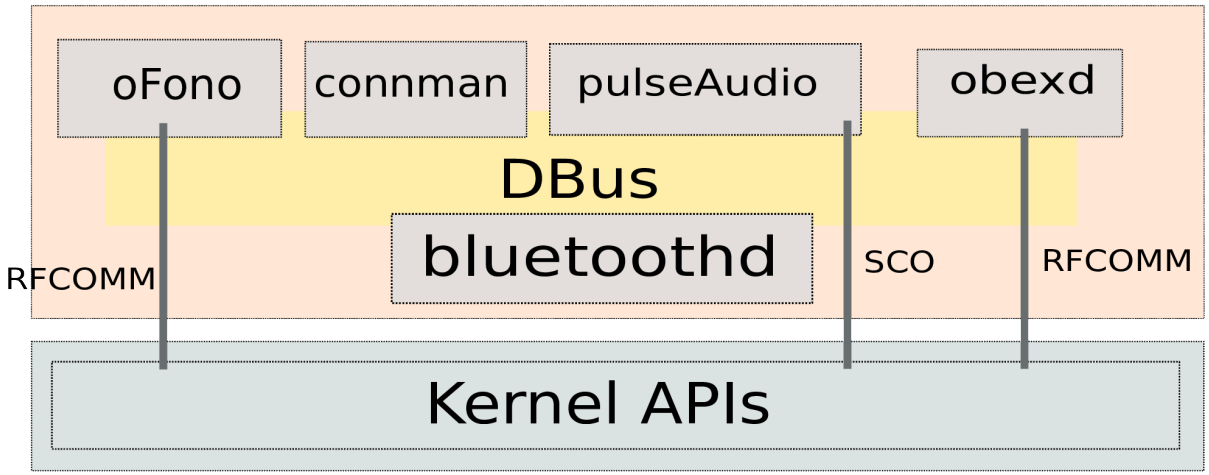
connman

- PAN (NAP)



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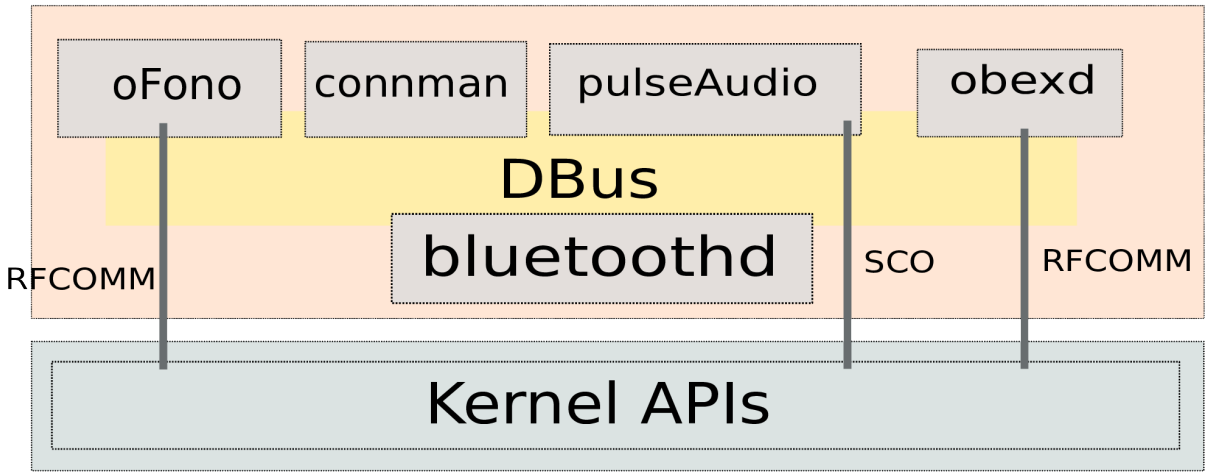

Profils Externes

oFono

- Gestion Téléphonie
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- PAN (NAP)

obexd

- OBEX, OPP

pulse audio

- AD2P
- Gateway HFP

Outils

bluetoothctl

- Appairage
- SDP

Outils

bluetoothctl

- Appairage
- SDP

obexctl

- OBEX
- FTP

Outils

bluetoothctl

- Appairage
- SDP

btmgmt

- mgmt API
- Configuration

obexctl

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Outils

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obexctl

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hcitool / hciconfig

- HCI brut
- Configuration

Outils

hcidump

- Log HCI
- Filtrage protocoles

Outils

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btmon

- Log HCI
- Log bluetoothd
- Dump btsnoop (wireshark)

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- **hciattach**

  `hci over UART`

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- **l2ping**
  `test L2CAP`

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  `gestion RFCOMM / SPP`

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  `test L2CAP`
- **rfcomm**
  `gestion RFCOMM / SPP`
- **sdptool**
  `gestion SDP`

Outils GATT

btgatt-client

- Connexion GATT
- Notifications
- Découverte services

Outils GATT

btgatt-client

- Connexion GATT
- Notifications
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gatttool

- Connexion GATT
- Découverte services
- Remplacé par btgatt-client

Outils GATT

btgatt-client

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- Notifications
- Découverte services

gatttool

- Connexion GATT
- Découverte services
- Remplacé par btgatt-client

btgatt-server

- Test GATT
- Intéractif

HCI lib

- Accès HCI
- Langage C, userspace
- Configuration précise :
  - Advertising LE
  - Commandes constructeur
- Utilisateurs avertis

Merci !

https ://github.com/minimaxwell/docs/tree/master/bluetooth/meetup