Bluecoin - Voice and Music Over an Embedded BLE Platform

Voice communication: a key driver of innovation since 1800's

Voice Automation “in the things”: ***Voice Internet Assistant***

E-gadgets, Wearables

Play Music

Control Lighting, heating, …

News, sport, traffic, weather, …

Answer questions, create to-do lists, shopping lists, …

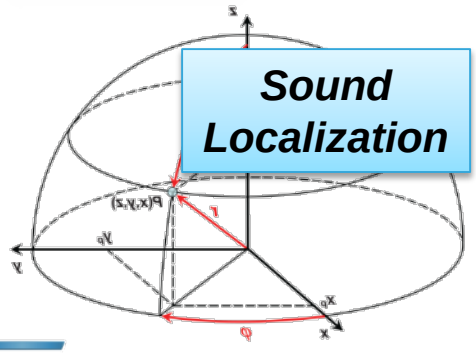
Place orders online, use other online services: taxi, pizza, …

BlueCoin: the Robotic Ear

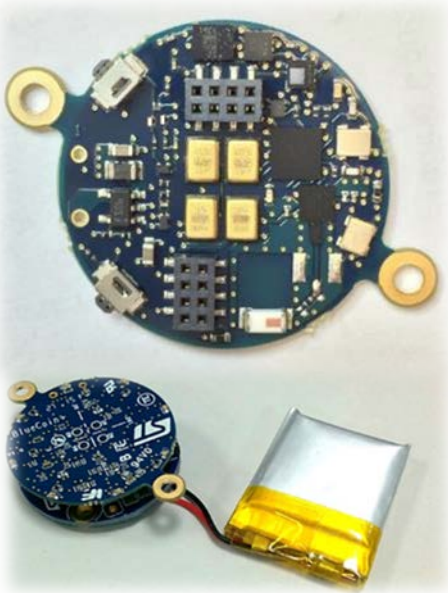
Augmented hearing and motion sensing

Motion, Activity and Balance

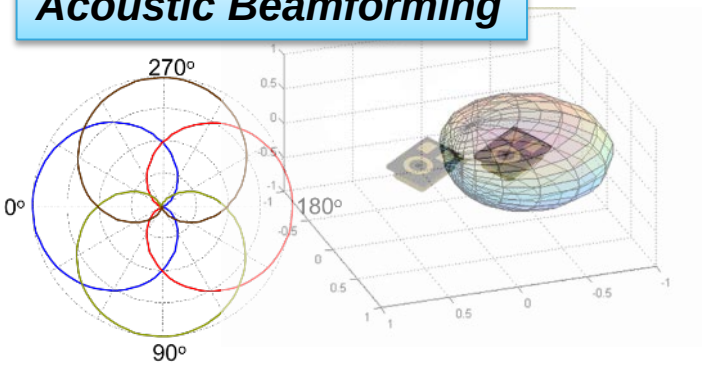
Bluetooth Low Energy



Sound Localization

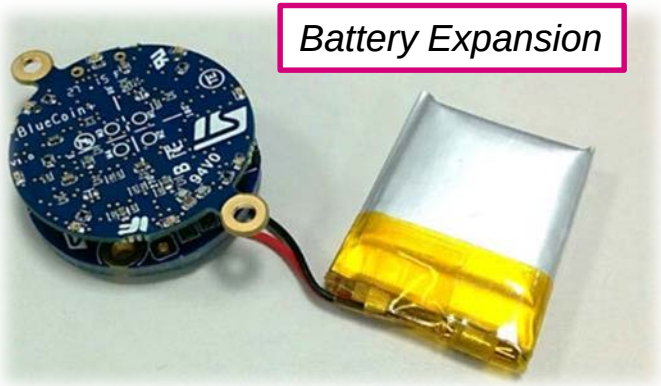


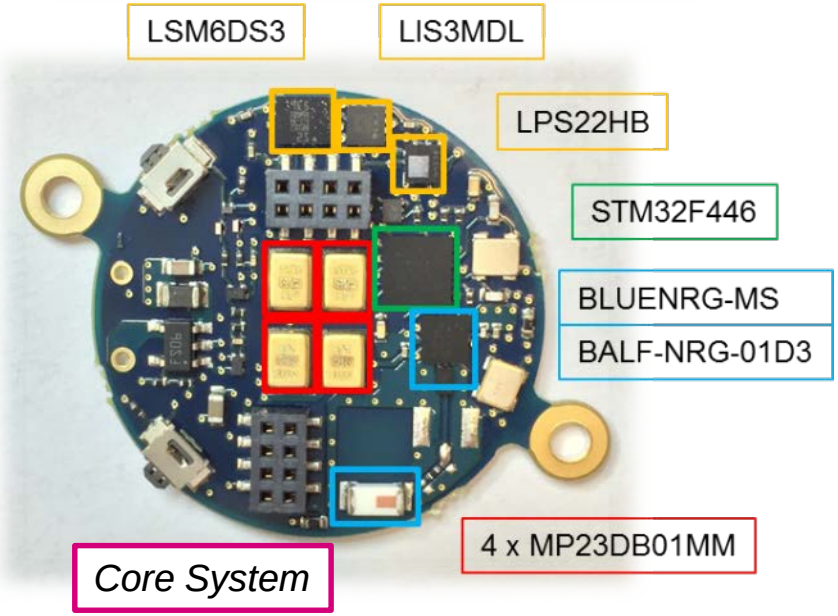
Acoustic Beamforming



Embedded Processing

BlueCoin – *Augmented hearing & Sensing*





- Microphone array processing
- Wide band audio over BLE (BlueVoice)
- Sensor fusion
- Complete development kit

Main components:

- ✓ STM32F446
  - ARM Cortex-M4F@180MHz - 128KB RAM
- ✓ u4 Microphone Array (4x MP23DB01MM)
- ✓ Bluetooth-Low-Energy radio (BlueNRG-MS)
  - Bluetooth 4.1, multiple role simultaneously
- ✓ 6+3 axis inertial module (LSM6DS3+LIS3MDL)
- ✓ Absolute pressure sensor (LPS22HB)

Full Embedded Sensing Software Development Kit

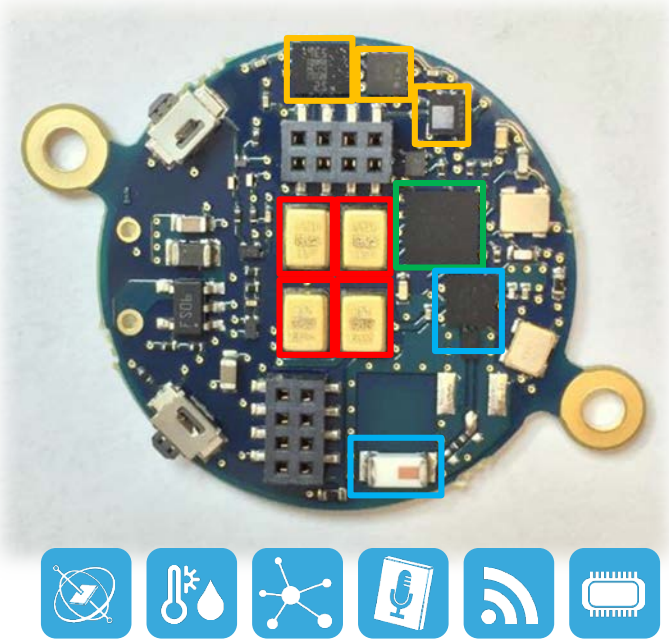
OSX OpenSoftwareX

open.AUDIO

open.MEMS

open.RF

STM32



STM32 Open Development Environment

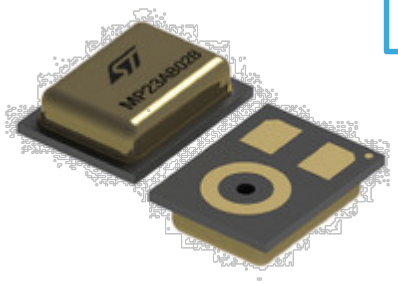
STM32 Cube

open.AUDIO	open.MEMS			open.RF	
4 x MP23DB01MM	LSM6DS3	LIS3MDL	LPS22HB	BLUENRG-MS	BALF-NRG-01D3

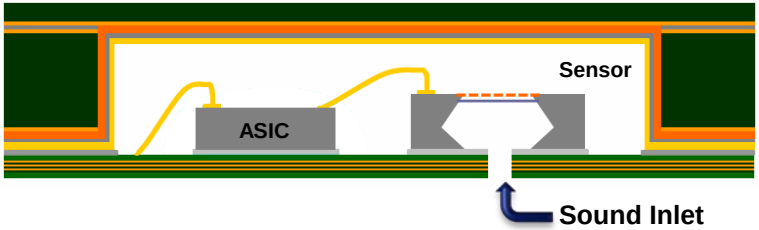
MEMS  Voice to Cloud: and Audio System quality

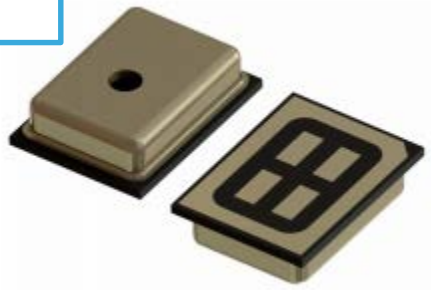
Digital MEMS Microphones

- Ultra compact, low power, omnidirectional
- System-in-package combines:
  - capacitive sensing MEMS element
  - ASIC interface



Bottom port





Top port

A/D and Digital i/f

PDM (Pulse Density Modulation) interface:

- 1 to 3 MHz
- 1-bit resolution
- Fully digital

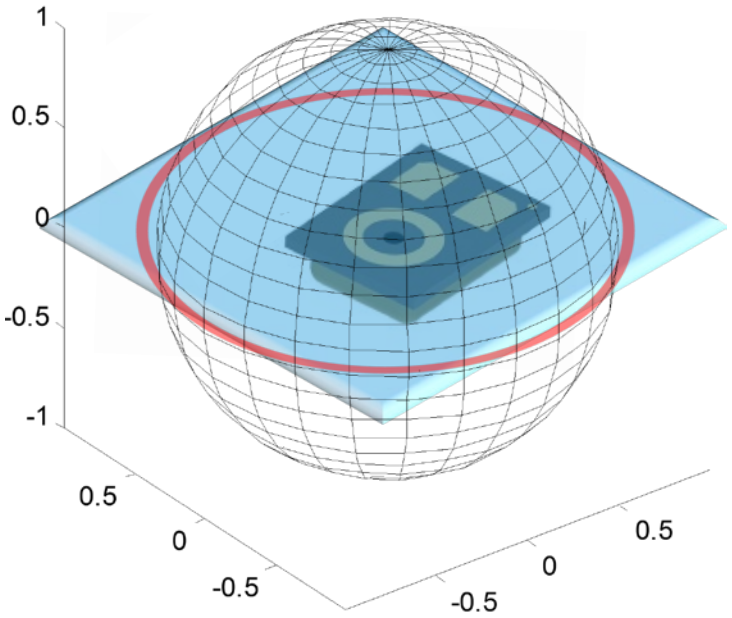
Sensing

- Capacitive membrane
- Omnidirectional
- Analog output

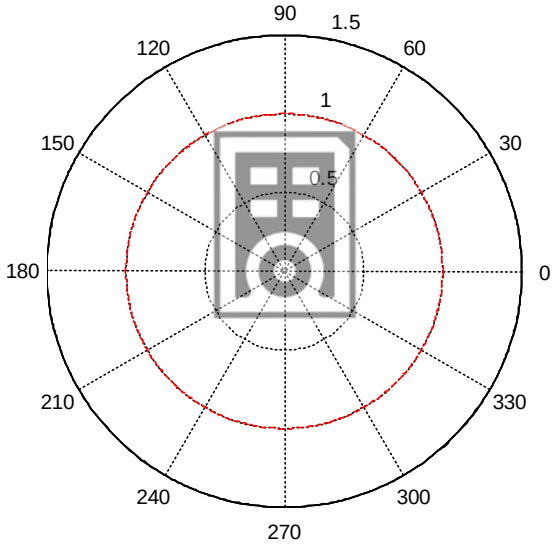
Omnidirectional MEMS microphone

Omnidirectional microphones *Sensitivity* is the same in all directions
Power of captured sound is independent from its Direction of Arrival.

3-D Polar Pattern

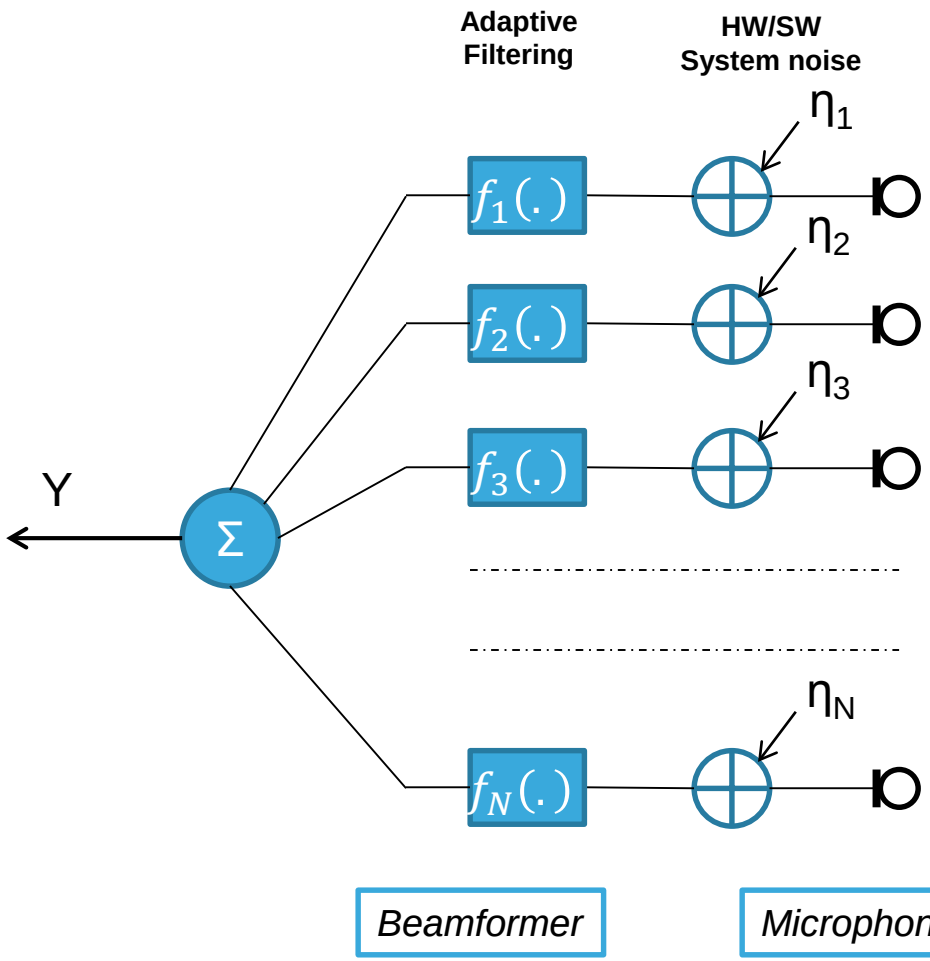


2-D Polar Pattern



open.AUDIO Software Building Blocks: MEMS-microphones.*augmented*

Acoustic Beamforming algorithms

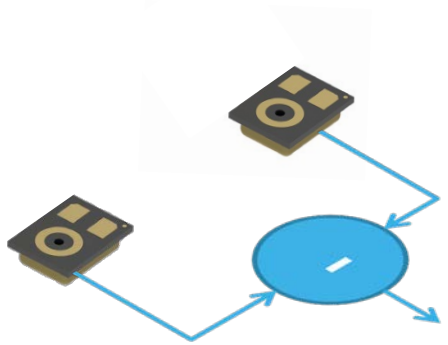


First Order Directional Beam Patterns

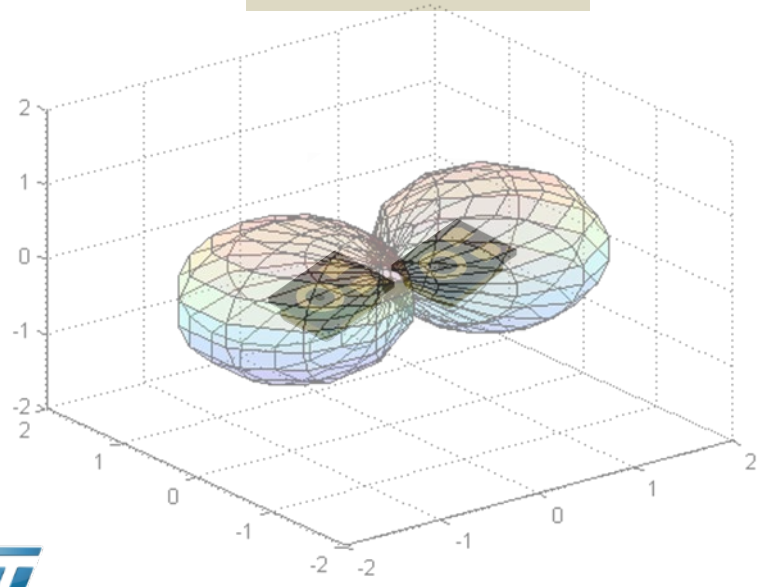
- Directionality is achieved by combining two microphones and by processing their synchronized audio output.

Example:

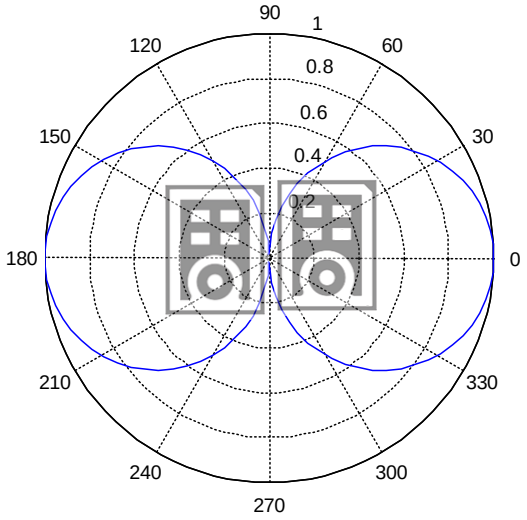
*"**Figure of 8**" beamforming is achieved by subtraction of 2 microphones signals*



3-D Polar Pattern



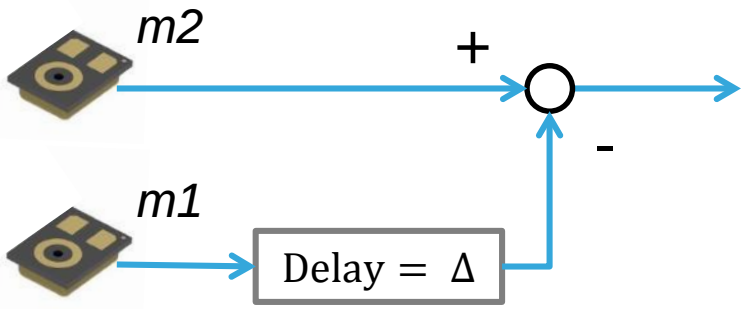
2-D Polar Pattern



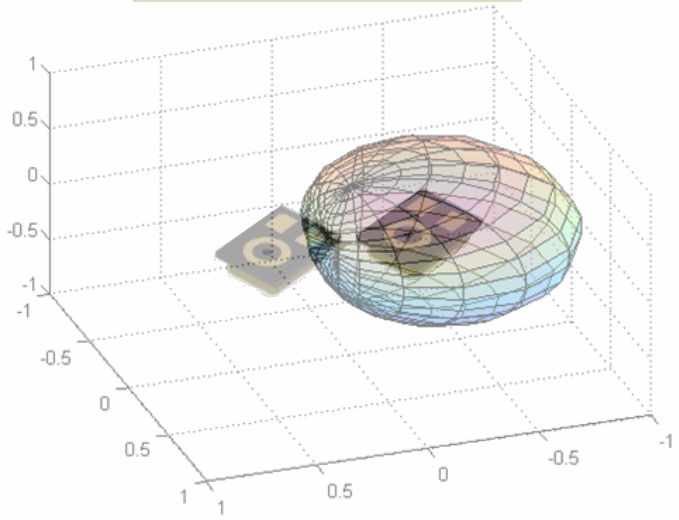
Cardioid beamforming

- Cardioid beam pattern implements single-sided Audio capture

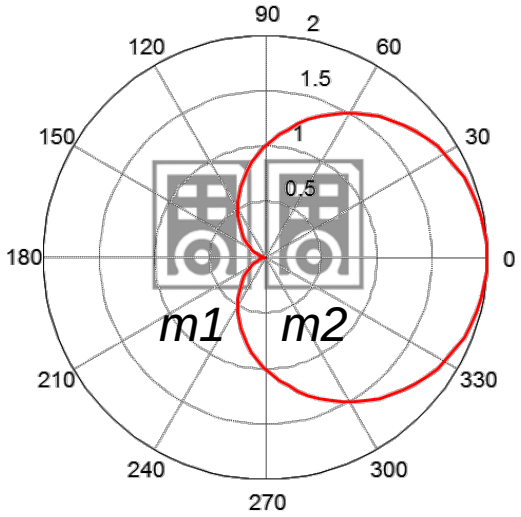
Cardioid Beamforming Basic Scheme



3-D Polar Pattern



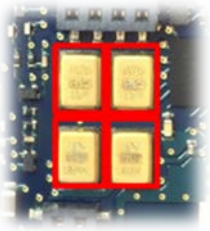
2-D Polar Pattern

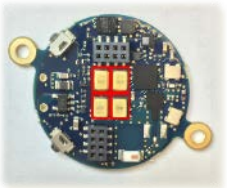


libBeamforming100: Strong Cardioid

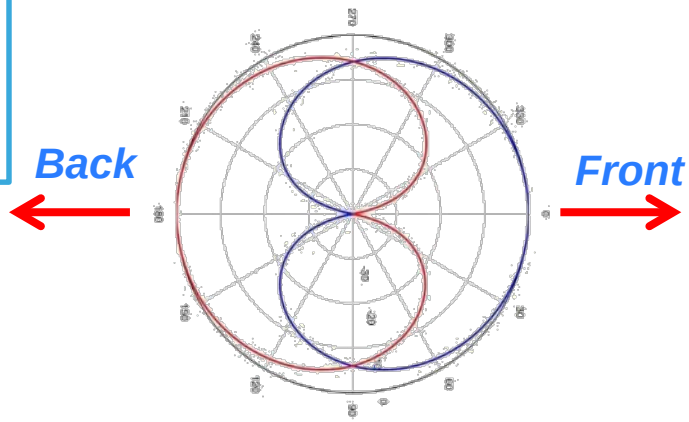
2 DMA cardioids in "back to back" configuration

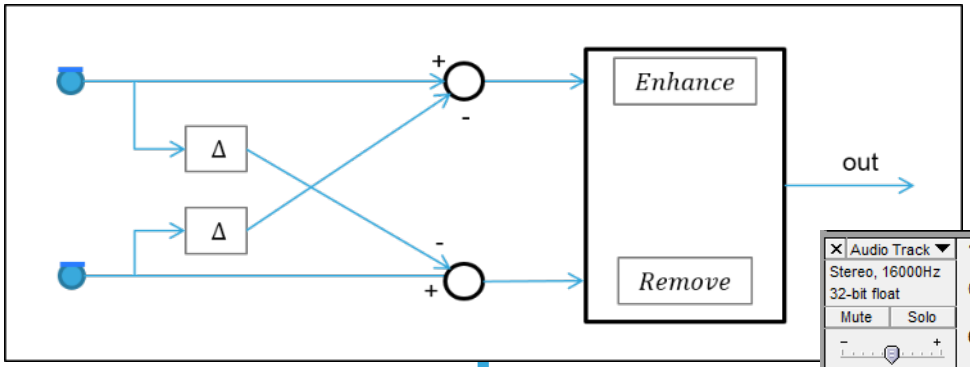
µ4 array: MEMS microphone side by side; the smallest array you can build

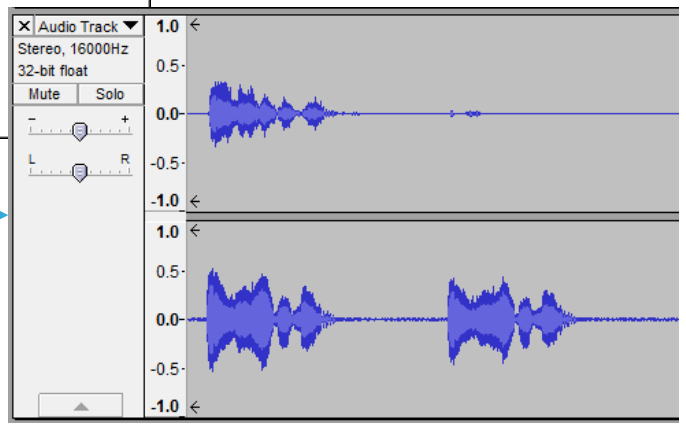




4 x MP23DB01MM





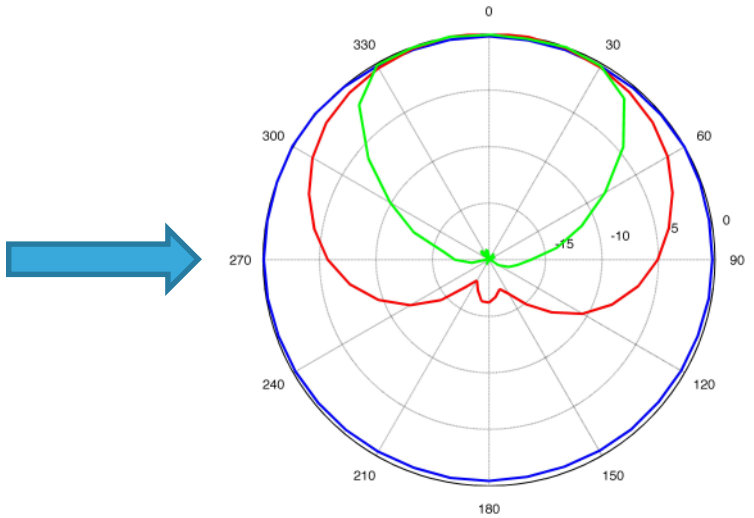


Polar pattern tests

Test setup:

- Microphone Array mounted on a rotating support
- Inter-microphone distance: 4mm
- Rotation in steps of 10 degrees
- Gaussian White Noise played by high quality loudspeaker

- Resulting beampattern
  - Blue: omnidirectional microphone
  - Red: «Basic cardioid» mode
  - Green: «Strong» mode



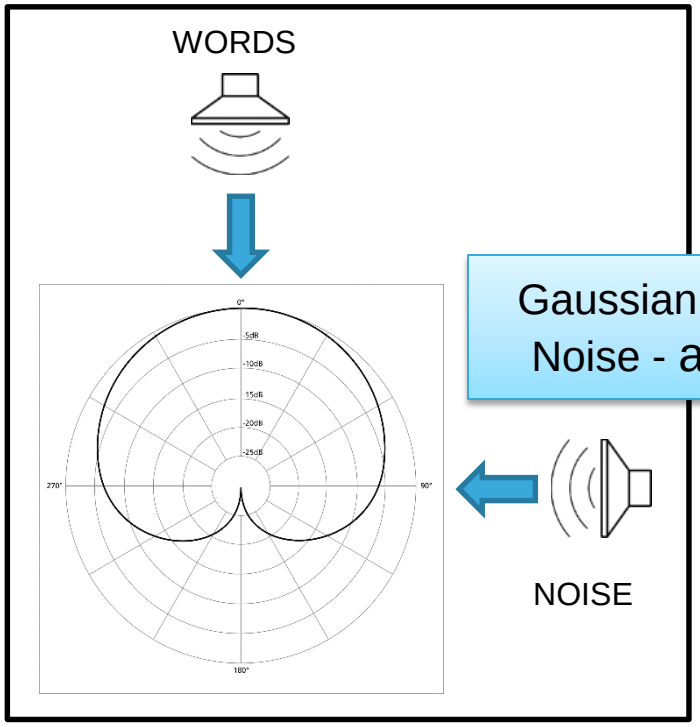
Beamforming: ASR Test

Test setup:

Inputs

Output

Male and female spoken words - at 0°



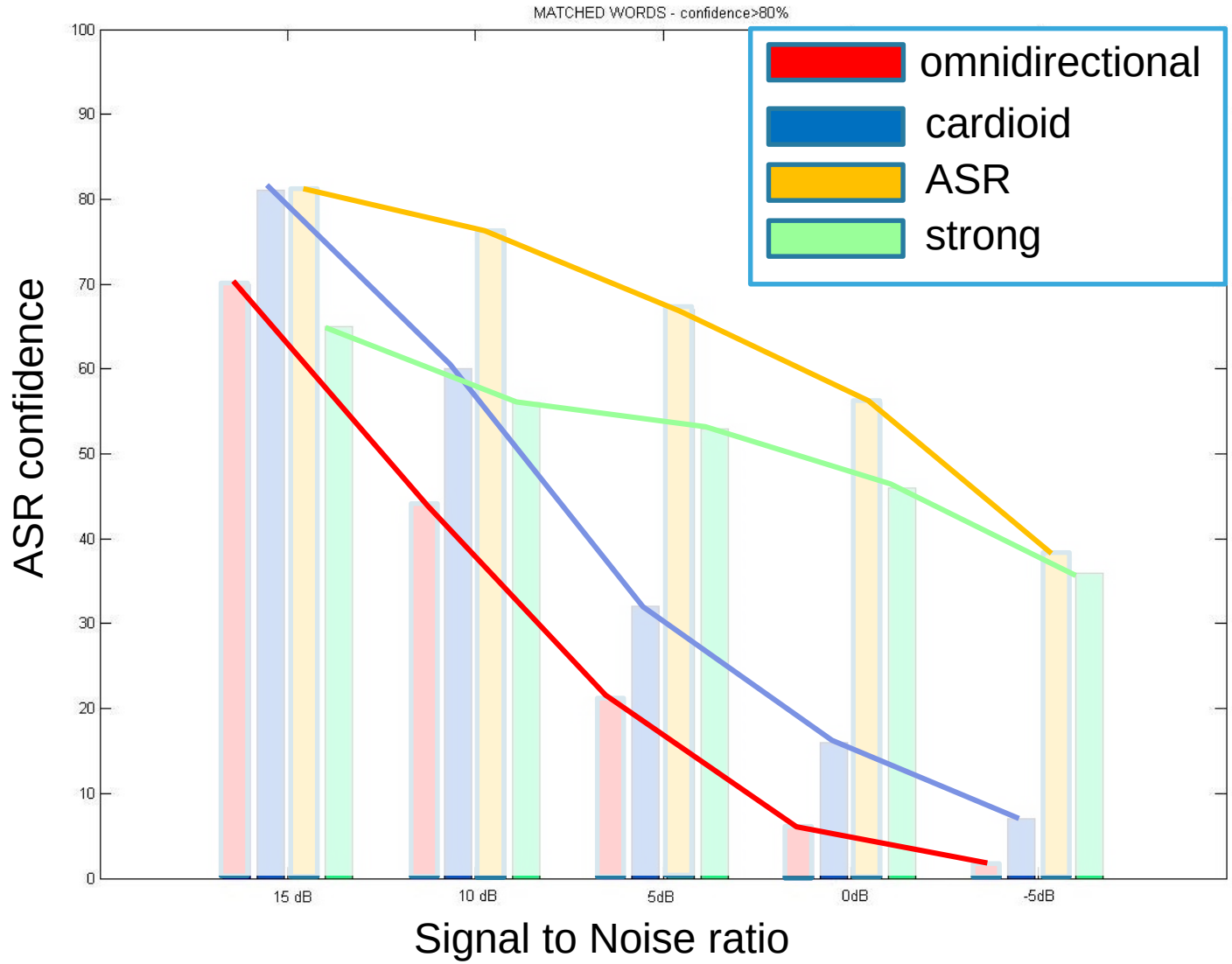
Gaussian White Noise - at 90°

4 synchronous output channels :

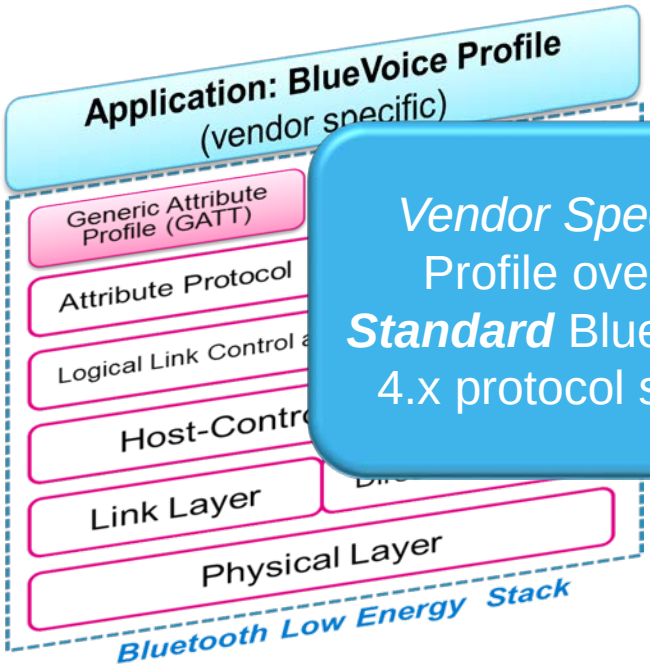
- Omnidirectional microphone
- Basic Cardioid
- ASR Ready
- Strong Cardioid

Recorded words are sent to Google ASR and recognition data are collected

libBeamforming100: ASR test results

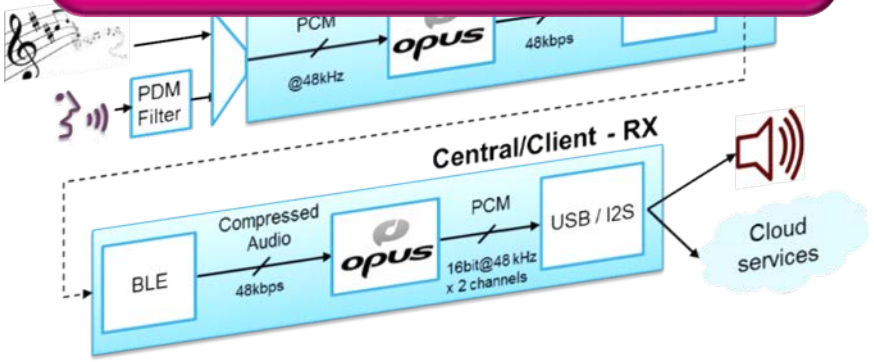


BlueVoice: augmenting Bluetooth Smart with Audio

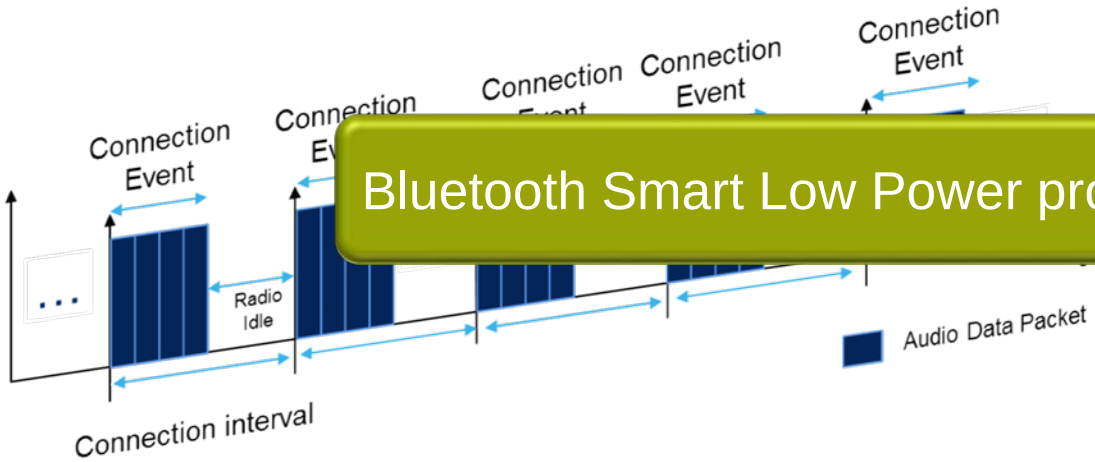


Vendor Specific Profile over a ***Standard*** BlueTooth 4.x protocol stack

Advanced Audio Compression and streaming architecture



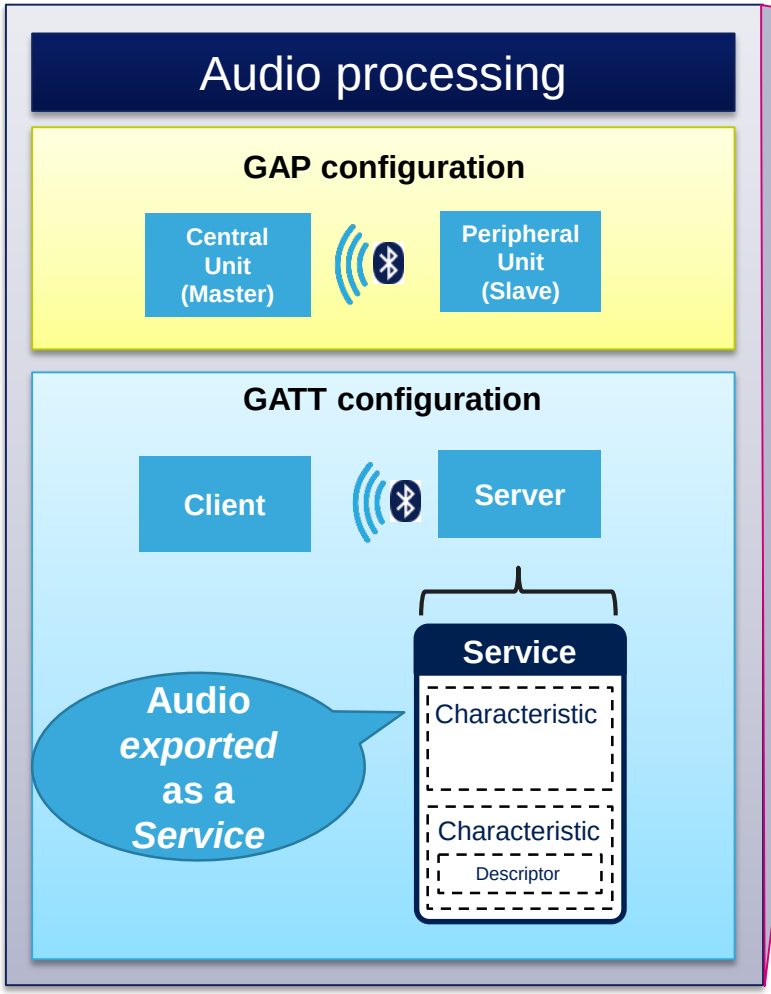
Bluetooth Smart Low Power protocol design



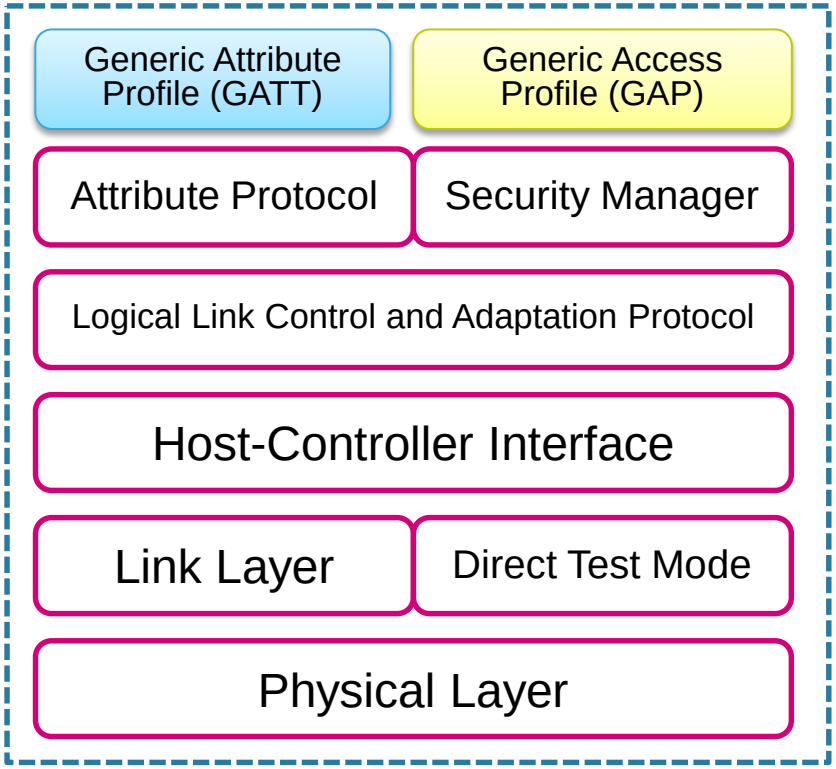
life.augmented

BlueVoice mapping over standard Bluetooth 4.0 protocol stack

BlueVoice Vendor Specific Profile

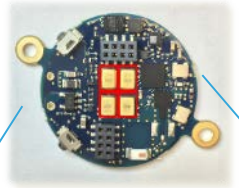


Application: BlueVoice Profile
(vendor specific)



Bluetooth Low Energy Stack

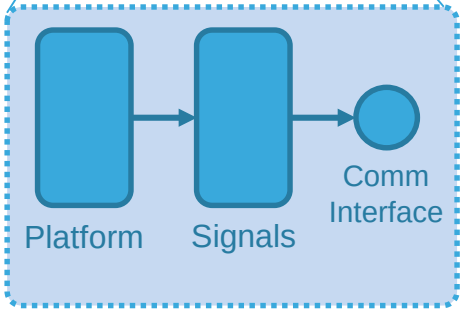
BlueVoice: embedded-to-Cloud communication



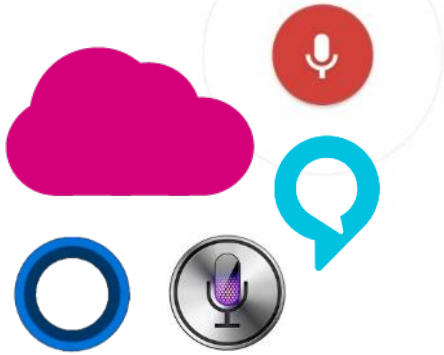
Augmented Audio Terminal

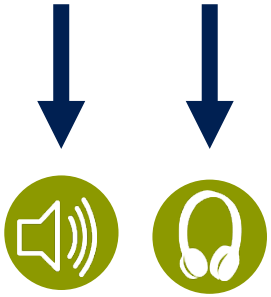
Mobile Device

Cloud-based Services

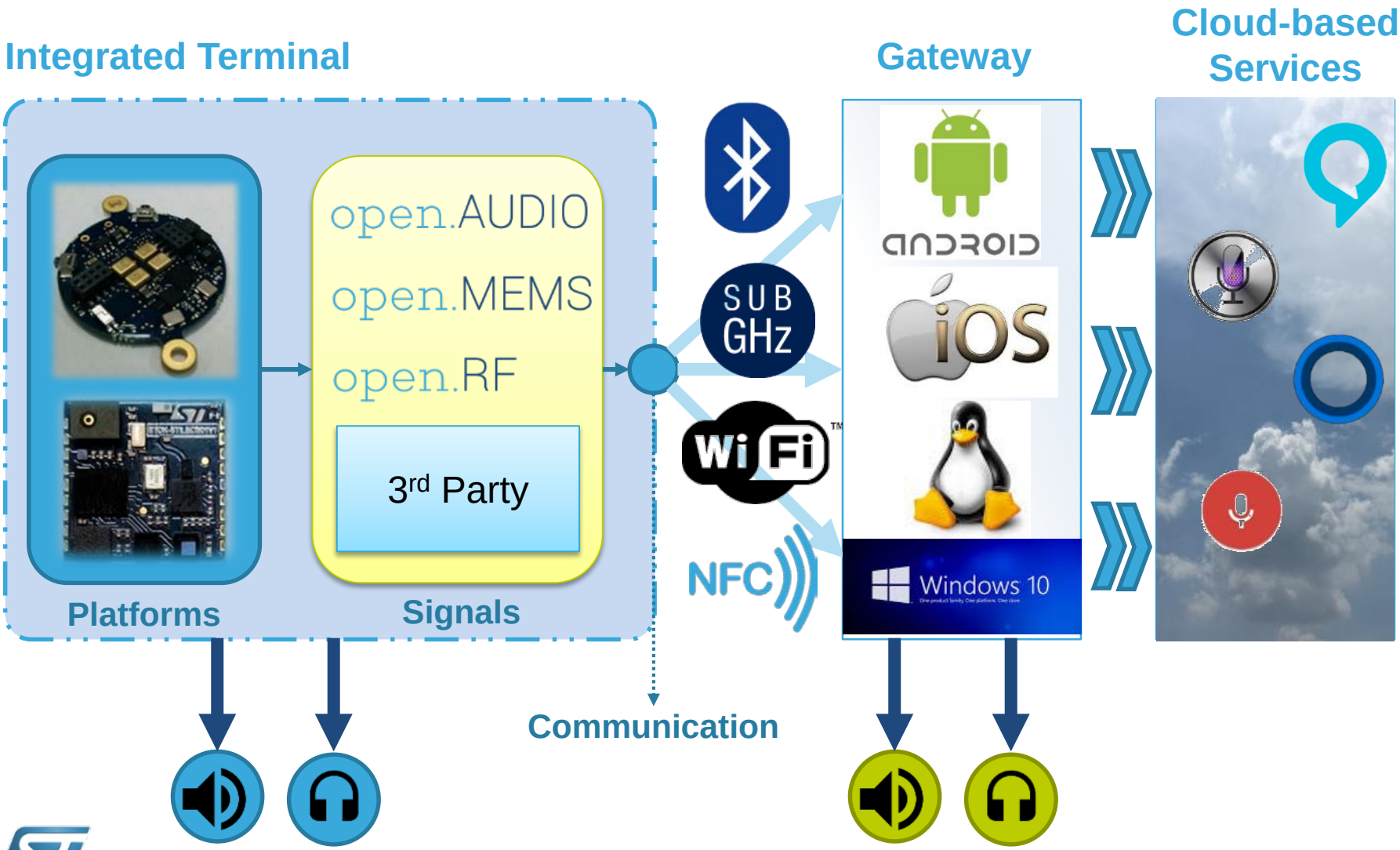


smart





Sensors to Cloud architecture



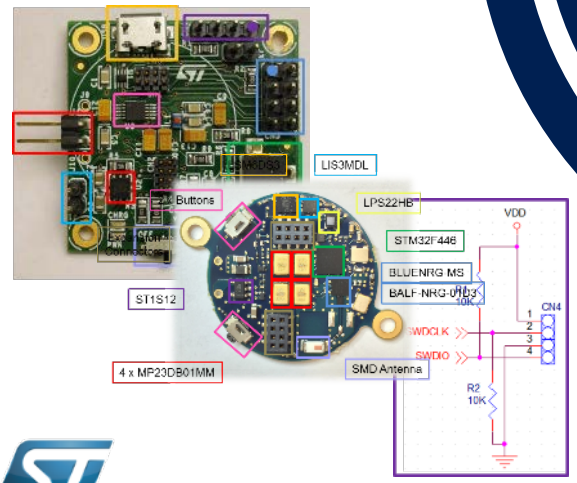
ST Development Kits for IoT: Integrated & Modular Design environment

Evaluation, tracking & monitoring

Fast Prototyping

Reference Design

System Software Development



open.AUDIO

open.MEMS

open.RF

STM32 Open Development Environment


2016: it's about time to make
a new dream come true...
life.augmented
Let's talk with the cloud(s)!!