



Unique DSP Based Platform for Multiple IoT Domains

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www.ceva-dsp.com

Not All IoT Devices Are Born The Same ...

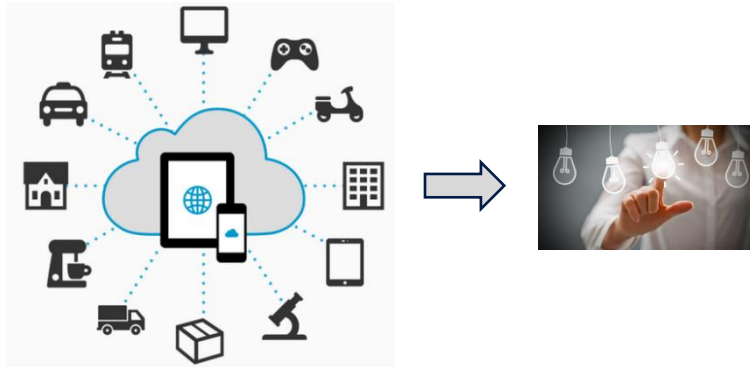


Connected



Vs.

Smart



- HD Camera
- Microphone
- Night Vision
- Motion Detection
- Temperature
- Air Quality
- Humidity



smart home security device

DSP enables the creation of **smart** IoT devices !

IoT Layers – Connected vs. Smart

► Example: a truly smart home controller would ...

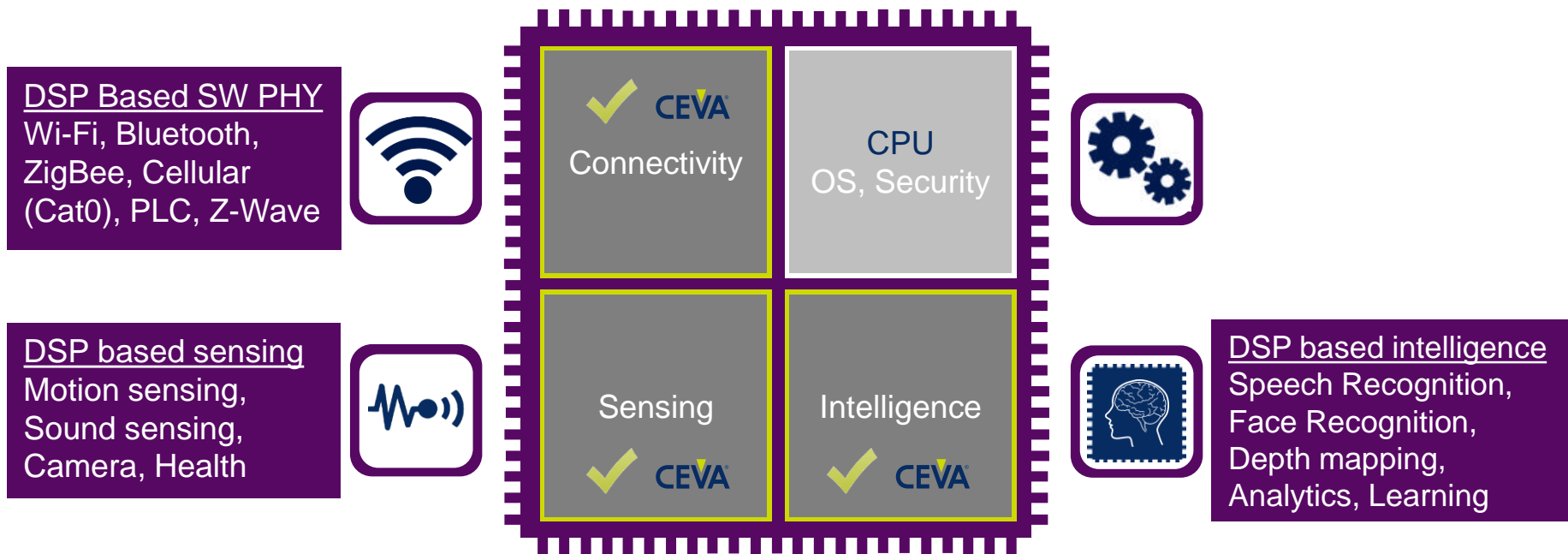
Domain	Processing	Smart Analysis	Actions
Speech	Speech recognition	Voice command Speaker verification	Turn on/off lights, window shades, appliances ... Allow access to devices per user profiles
Sound	Sound sensing	Is music playing ? Which music ? Alert noises ? (e.g. breaking glass)	Change light-bulb color per music type Call security company; notify owner
Vision	Face recognition	Who is in the house ? Resident or guest ?	Set mood (color, music) per person or group Send message to owner about guests presence
Motion	Motion detection	People moving in home ? Device being moved ?	Learn habits of tenants Alert about anomalies
Connectivity	SW PHY	Is Wi-Fi available ?	Yes – use in-home Wi-Fi No – use LTE (preferred for security events)

But where should the **smartness** be – local, cloud ?

Smart IoT Platform – DSP Enabled



▶ CEVA IoT solutions for Connectivity + Sensing + Intelligence



Challenges in IoT Connectivity

Multiple and constantly evolving communication standards
 The IoT is composed of an almost endless list of comms standards

	ANT+	Bluetooth	LTE	DECT ULE	NFC	PLC	Wi-Fi	ZigBee	Z-Wave	Others
Wearables	•	•	•		•		•			•
Smart Devices	•	•	•		•		•			•
Smart Homes		•	•	•	•	•	•	•	•	•
Cars		•	•				•			•
Smart Cities						•	•	•	•	•
Industrial Internet					•		•			•

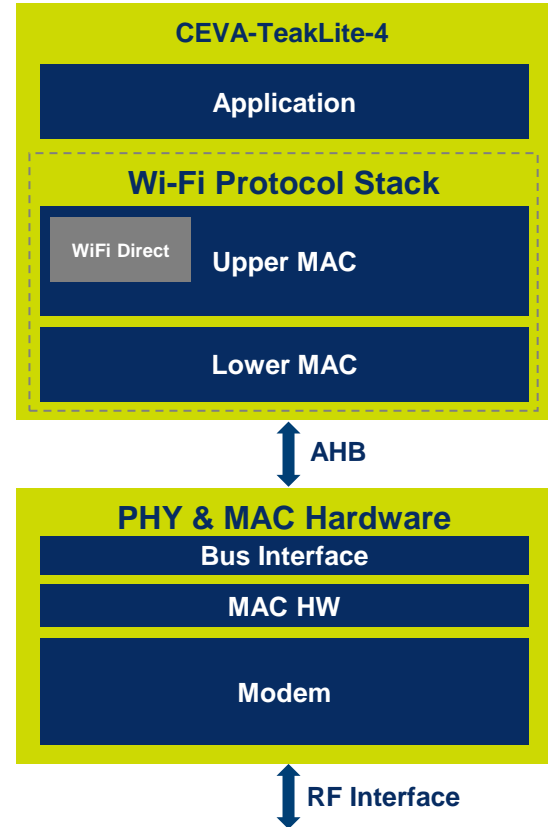


CEVA's DSP based SW PHY allows multi-standard connectivity platform

CEVA-WiFi Platform



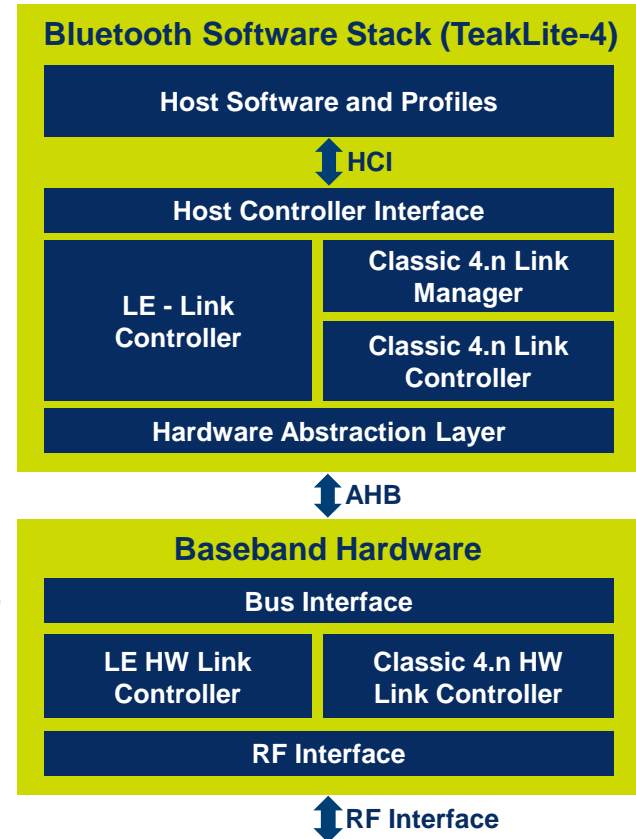
- ▶ Based on **CEVA-TeakLite-4** DSP + PHY and MAC hardware
 - ▶ Enables most power efficient design
 - ▶ Scalable for other connectivity standards
 - ▶ TeakLite-4 available for additional functionality such as audio, voice, sensing
- ▶ Down to **500K gates**
 - ▶ Complete solution: DSP, PHY, MAC, HW, SW
- ▶ Less than **30mW** for 1Mbps 802.11n 1X1 in 55nm



CEVA-Bluetooth Platform



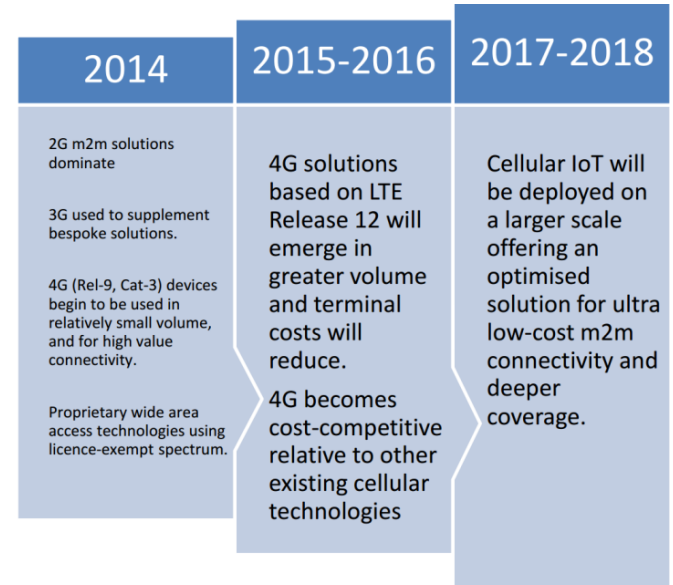
- ▶ CEVA-Bluetooth
 - ▶ Classic Bluetooth (2.1+EDR, 3.0)
 - ▶ Low Energy Bluetooth (4.0/4.1/4.2) Single/Dual Mode
 - ▶ CEVA-Bluetooth BB HW integrated with TL4
 - ▶ CEVA-Bluetooth Controller SW stack running on TL4
 - ▶ Customizable RF interface for 3rd party Radio
- ▶ Single Mode
 - ▶ Reduced HW/SW footprint for low power & cost
- ▶ Dual Mode
 - ▶ Addition of low energy protocol HW/SW to Classic BT
- ▶ Bluetooth 5.0 is just around the corner
 - ▶ Audio over BLE, IPv6 over BLE, extended range and much more



LTE MTC (Machine Type Communication)



- ▶ LTE-CAT0 is the first 3GPP category that solves MTC requirements
 - ▶ Robust and reliability in building coverage
 - ▶ Better cell-edge performance
 - ▶ Support many users
 - ▶ Specify LTE device with cost comparable to EGPRS - motivate migration of MTC traffic from 2G to LTE
 - ▶ Enhance LTE coverage by up to 15dB
 - ▶ **Increase battery life – allow 10 years of operation with 2xAA batteries**



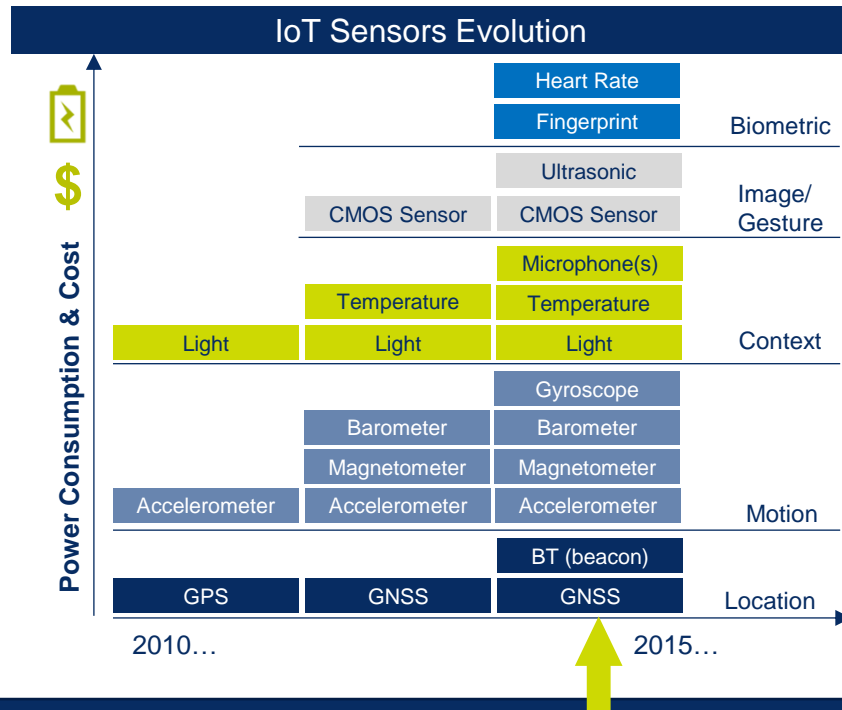
Always-On Multiple Sensing

Sensing in IoT is based on various and growing list of sensors



Low cost, low power sensors are common

- ▶ However, low cost/power generally means *noisier* sensors
- ▶ So where do DSPs fit in sensing?
 - ▶ Need a lot of signal-cleaning (filtering, smoothing, calibrating, etc') in order to extract meaningful data
 - ▶ Intelligent context awareness
 - ▶ DSP requirements further increase with introduction of mics and biometric sensors



Power consumption is key criteria: need <2mA for the complete always-on use case

N-Axis Sensor Fusion Using CEVA-TL410



- ▶ Combined processing of sensory data from disparate sources: accelerometer, gyroscope and magnetometer etc.
- ▶ Contextual awareness, for example:
 - ▶ Person standing, walking, running
- ▶ Gesture control, for example:
 - ▶ Single/double tap, air signature, shake, tilt, pick up
- ▶ Indoor navigation, for example:
 - ▶ Pedometer, heading and pedestrian dead reckoning (lat/lon)
- ▶ Requires ultra low-power DSP to accurately deduce motion and environments data, eliminate false readings and leave sufficient headroom

CEVA-TL410 DSP performance: 0.5-5 MIPS

Running the Same Code on CPU Takes Over 100X More Power



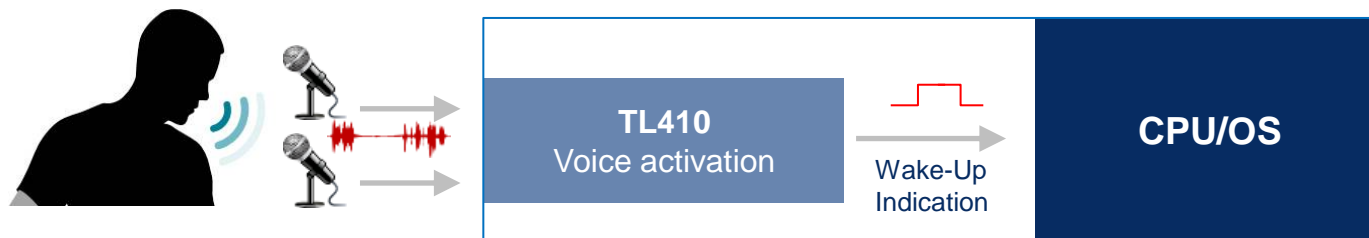
Always-On Voice Activation

- ▶ CEVA-TL410 enables $< 20\mu\text{W}$ DSP power consumption at 28nm for always-on voice trigger and command



Keyword, e.g. "OK Watch"

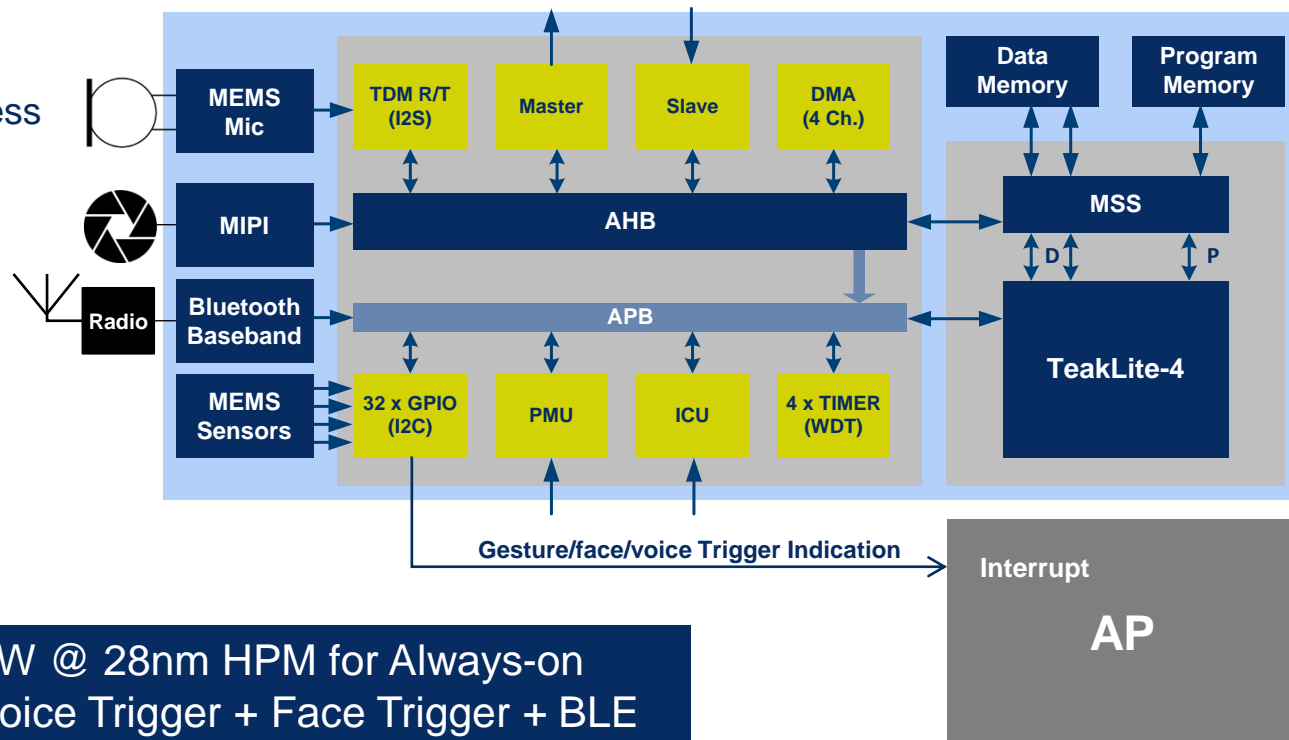
Speech Recognition SW
- Voice Trigger
- Voice Command
- Speaker verification



DSP-Based Sensing

Multiple Sensing Technologies Using a Single DSP

- ▶ Sensor fusion
 - ▶ Contextual awareness
 - ▶ Motion gestures
 - ▶ Indoor navigation
- ▶ Voice trigger
- ▶ Ultrasonic gestures
- ▶ Face trigger
- ▶ BLE



Less than 150uW @ 28nm HPM for Always-on
Sensor Fusion + Voice Trigger + Face Trigger + BLE

IoT Layers – Local Intelligence vs. Cloud



▶ DSP powered local intelligence enables:

- ▶ Camera/microphone/other sensors raw data does not need to be sent to the cloud, only processed meta-data is being sent → **Increased privacy**
- ▶ Reduced data bandwidth, transfer overhead and processing latency to/from cloud → **lower on-device power + lower cost of cloud service**
- ▶ Efficient processing for scene analysis (sound/vision) with lower power than GP CPU/GPU → **Lower power consumption, longer battery life**
- ▶ Increased security by using multiple connectivity standards → **Using SW PHY allows switching from Wi-Fi to LTE for tamper-proof security actions**



Local intelligence is key for **smart** IoT devices !

DSP-Based Audio Analytics



Valuable Sound Classification & Analysis

- ▶ Mobile, Wearable, Smart Home and Robot applications
 - ▶ Voice recognition and speaker identification
 - ▶ Speaker separation through beamforming
 - ▶ Environment sensing (e.g. cinema, train)
 - ▶ Emotion detection
- ▶ Security applications can alert upon:
 - ▶ Glass breakage
 - ▶ Baby crying
 - ▶ Keyword (virtual red button)
 - ▶ Aggression



CEVA-TL421 as an Audio Analyzer

- ▶ Extensive computational power enables a standalone (cloudless) audio analysis
 - ▶ 4th generation native 32-bit quad-MAC DSP
 - ▶ Up to 1.5 GHz @ 28nm HPM
- ▶ Efficient processing of large amounts of data
 - ▶ Handcrafted data cache and DMA
 - ▶ 128-bit data bandwidth
 - ▶ Dual load/store units
- ▶ Enables intensive noise reduction required for accurate analysis
- ▶ Lowest-power on its category



Advanced contextual awareness includes intelligent sound analysis and requires a powerful programmable audio/voice processor

Computer Vision & Video Analytics

- ▶ Markets: Mobile, Wearable, Smart Home, Smart Cities, Security & Surveillance
- ▶ Moving more video analytics to the camera end (reduce cloud/server processing)
- ▶ Example Applications
 - ▶ Human & object recognition
 - ▶ Face recognition, gesture recognition
 - ▶ Tracking based on feature and pattern matching
 - ▶ Emotion detection
 - ▶ Image and video enhancement for complex outdoor conditions



CEVA-XM: Computer Vision Engine

- ▶ Dedicated computer vision engine for complex analytics applications
- ▶ 4th generation computer vision DSP
- ▶ Up to 1.2GHz @ 28nm HPM
- ▶ Combines fixed and floating-point math
- ▶ Up to 4096-bit vector processing per cycle
- ▶ Efficient processing of large amounts of data
- ▶ Innovative DMA mechanism capable of transpose, crop and checkered data on the fly
- ▶ 512-bit bandwidth
- ▶ Fully equipped with SW framework, library and tools for easy SW porting and optimization

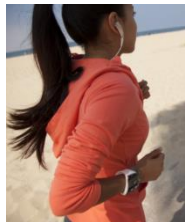
Growing need for sophisticated digital analysis on Camera
calls for dedicated CV programmable processors

CEVA-TL4 Outperforms Common MCU/CPU



▶ Power sensitive use-cases:

1. Smartwatch used for sport activity (standalone, w/o phone), running: *Sensor fusion, Voice activation, Music playback, and Sound sensing (for safety alerts, e.g. car horn)*



→ using a DSP consumes 1/2* of the power of a small MCU!

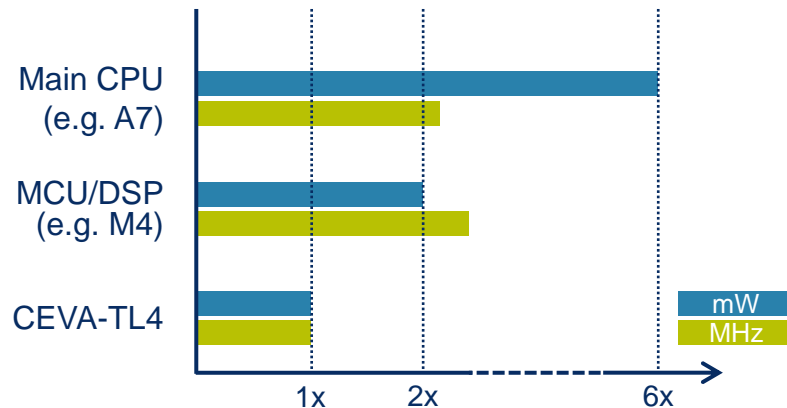
2. Portable WiFi internet radio receiver, running: *WiFi, HD audio decode, Post-processing, Voice activation*



→ using a DSP for WiFi and audio offloading consumes 1/6* of the power of the main CPU!

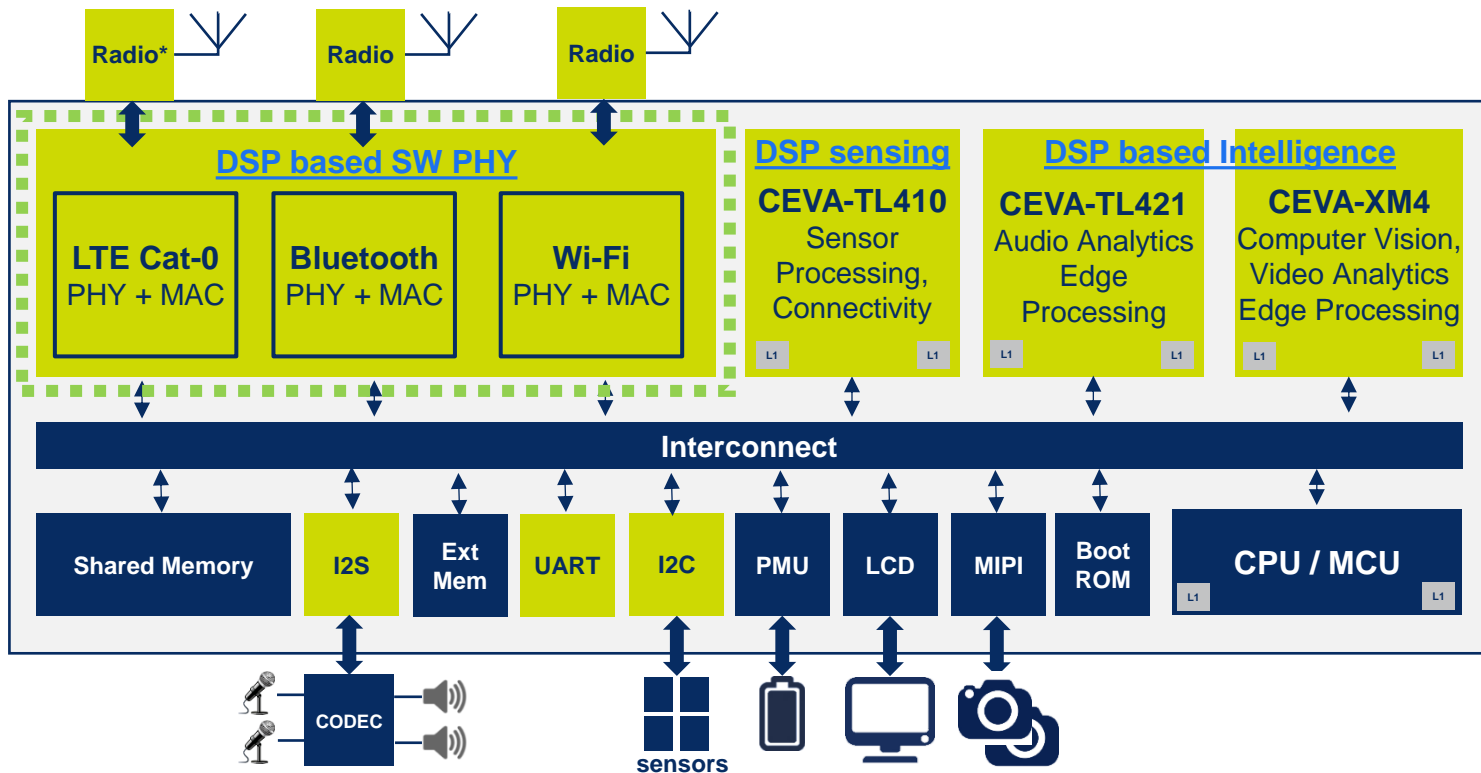
* Core only (DSP, CPU, MCU)

▶ DSP typical power saving:



MP3 decode **Power** and **MIPS** consumption compared to optimized CEVA DSP [Core only, 40nmLP]

CEVA IoT Platform Enablers



We enable smart IoT devices, come build with us !



THANK YOU

*ChipEx*2015

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