

AIsonic™ Audio Edge Processors Samsung Update

November 2019

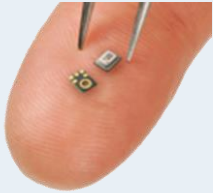


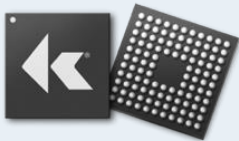
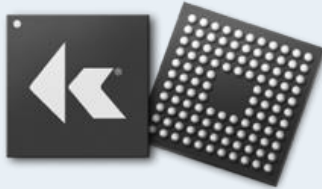
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- Knowles Intelligent Audio Strategy
- Product Portfolio Overview and Roadmap
- Use Case Discussion and Demos
- Summary and Next Steps

Product Portfolio Overview & Roadmap

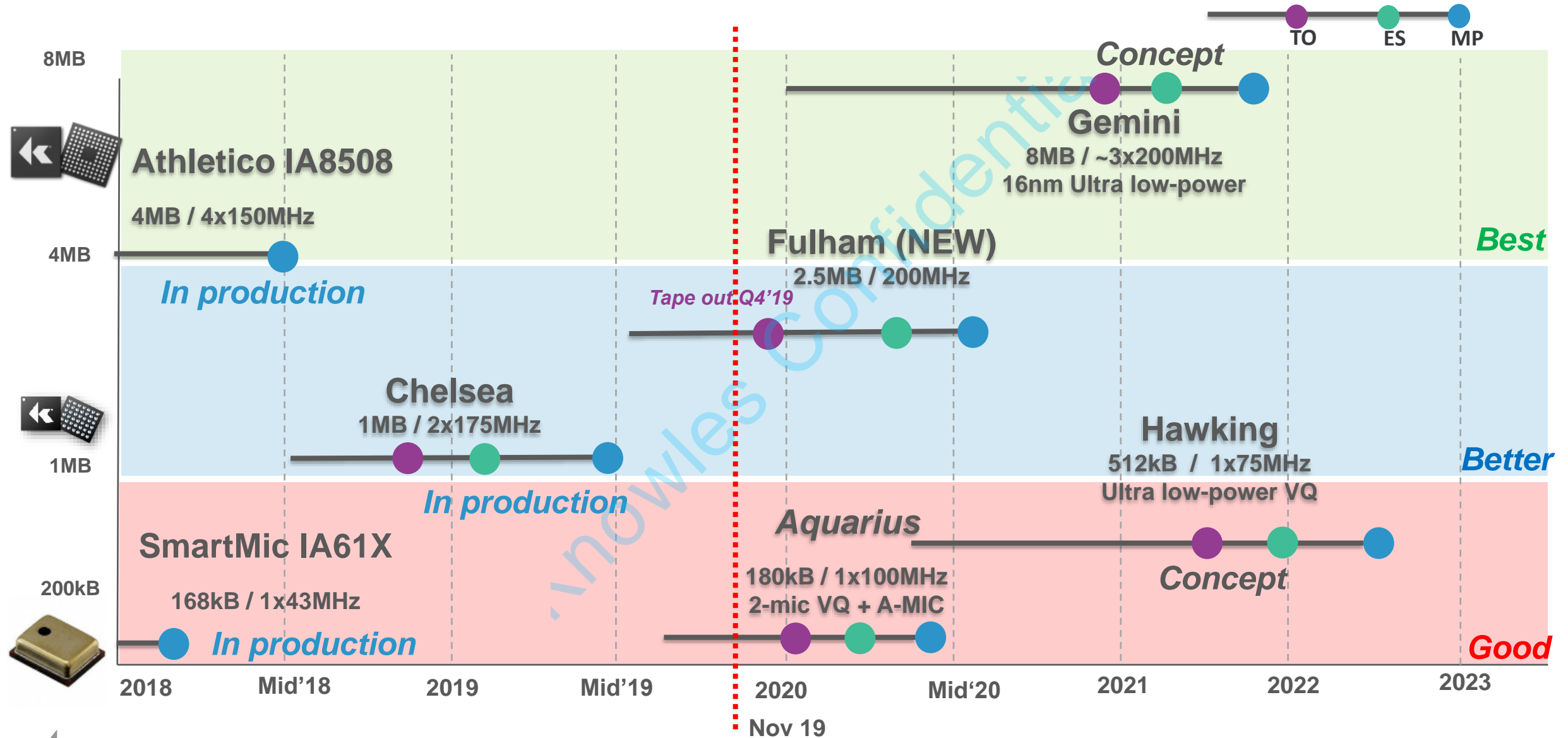
AlSonic Edge Processor Overview

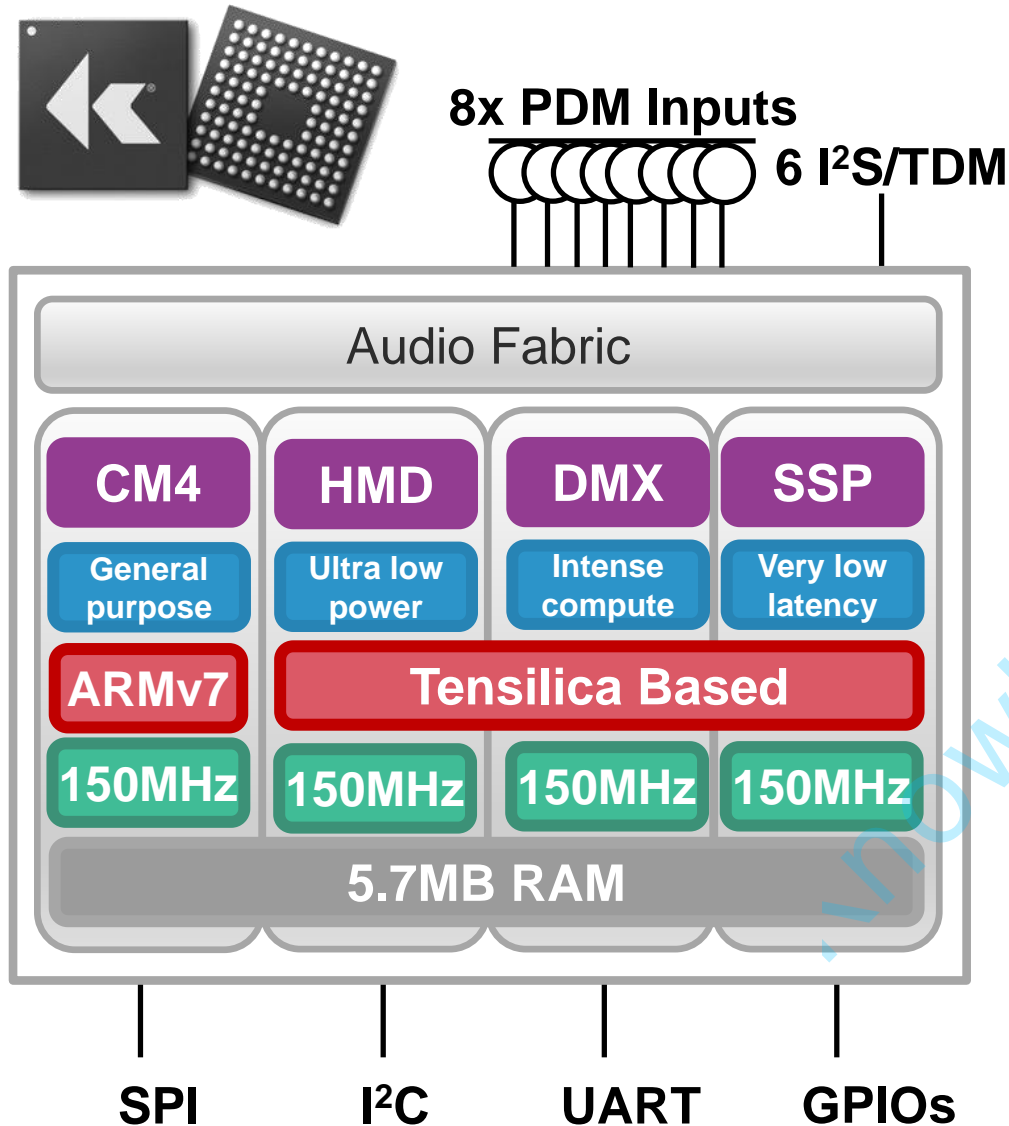
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Product	Shapiro (IA610)	Aquarius (new) (IA810)	Chelsea (IA8201)	Fulham (new) (IA82xx)	Athletico (IA8508)
					
Description	<ul style="list-style-type: none"> • Low power voice-wake • DSP+mic = smallest package • Lowest cost solution 	<ul style="list-style-type: none"> • Small, cost-effective discrete DSP for VoiceUI • Supports analog mics • Industry leading 2-mic voice wake performance 	<ul style="list-style-type: none"> • High performance • Multi-mic voice-wake • Expanded for advanced conf call, ambient noise sense, context awareness 	<ul style="list-style-type: none"> • Expanded memory for best voice + new features • Dual core for low power, high compute • Expanded AI/ Context 	<ul style="list-style-type: none"> • Highest performance • Quad core • Natural Language Processing
Size/Package	9 pin SPH (microphone) 3.50 mm x 2.65 mm	25 pin LGA 2.0mm x 2.1mm	42 pin LGA 2.6 mm x 3.0 mm	90 pin LGA ~3.65mm x 3.65mm	100 pin eWLB 5 mm x 5 mm
Memory	248kB (168kB User Avail)	248kB (180kB User Avail)	1.4MB (1MB User Avail)	3MB (2.5MB User Avail)	5.7MB (4MB User Avail)
Speed	43 MHz 1-Core	100MHz 1-Core	175 MHz 2-Cores	200 MHz 2-Cores	150 MHz 4-Cores
Mics supported	1mic (integrated)	2 AMICs or 2 DMICs	Up to 4 mics	Up to 8 mics	Up to 8 mics
IO	2PDM, 1TDM 1 I2C, 1 UART, 1 SPI 6 GPIOs w/interrupts	2 Analog, 2 PDM, 1TDM 1 I2C, 1 UART, 1 SPI, 6 GPIO	4 PDM, 3TDM 2x I2C, 2x SPI, 2x UART, 24 GPIOs w/interrupts	8 PDM, 4TDM 2x I2C, 3x SPI, 2 x UART, 32 GPIOs w/interrupts	8 PDM, 6TDM 5x I2C, 3x SPI, 2x UART Up to 32 GPIOs

IA Mobile Product Roadmap

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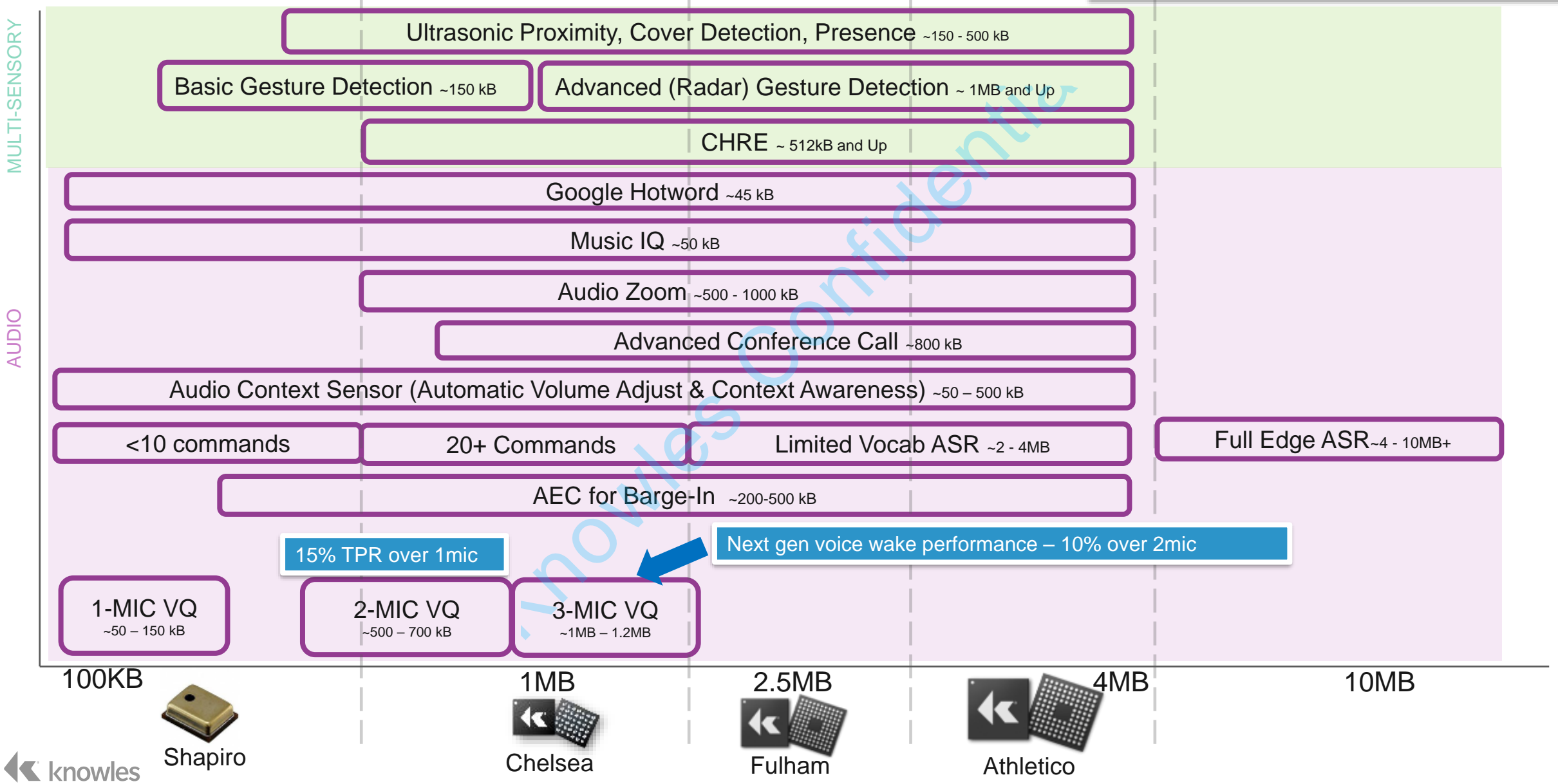
Maximum Memory, Audio & Edge Processing for Mobile

- **Audio Processing Platform with Four Cores**
 - 3 Tensilica, audio-centric DSP cores – low power, low latency, high compute
 - 1 floating-point ARM Cortex M4 – Bluetooth connectivity stack, sensor control
- **Memory and Compute 10x the Competition**
 - 5.7MB RAM to support rich use cases
 - Up to 5700 MOPS optimized for machine learning
- **On board Audio algorithms provided**
 - Library of algorithm blocks including beamforming and scene analysis
 - Open framework for running concurrent plugin
- **Open DSP for 3rd Party Algorithms**
 - Optimized Knowles instruction set with ARM and HiFi3 compatibility
 - Configuration and control tools allow complete prototyping, design, and debug

Use Case Roadmap

New use-cases on AI Sonic Audio Edge Processors

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Audio Zoom Discussion

Audio Zoom Feature Background and High Level Proposal

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User wants to capture AV and be able to zoom into a source, amplify target audio and suppress unwanted background noise

Knowles Proposal – Focus on 3 Aspects

1. Narrow Focus Angle to Better Isolate Sources

- Current zoom angle performance too wide
- **KN Goal** - narrow the focus angle to $\pm 15^\circ$ to better capture target

2. Increase Suppression and Enhance Audio

- Current suppression level is minimal and introduces distortion into target audio
- **KN Goal** - increase suppression level to $\sim 6\text{dB}$ and ensure high fidelity capture

3. Long Term – More & Better Mics for Best Performance

- **More MICs** – Going from 3 to 4 mics will noticeably improve suppression level
- **Higher SNR MICs** (e.g. Everest) - improved performance of the microphones enhances suppression ability of beam former



Audio Zoom Testing Setup Details

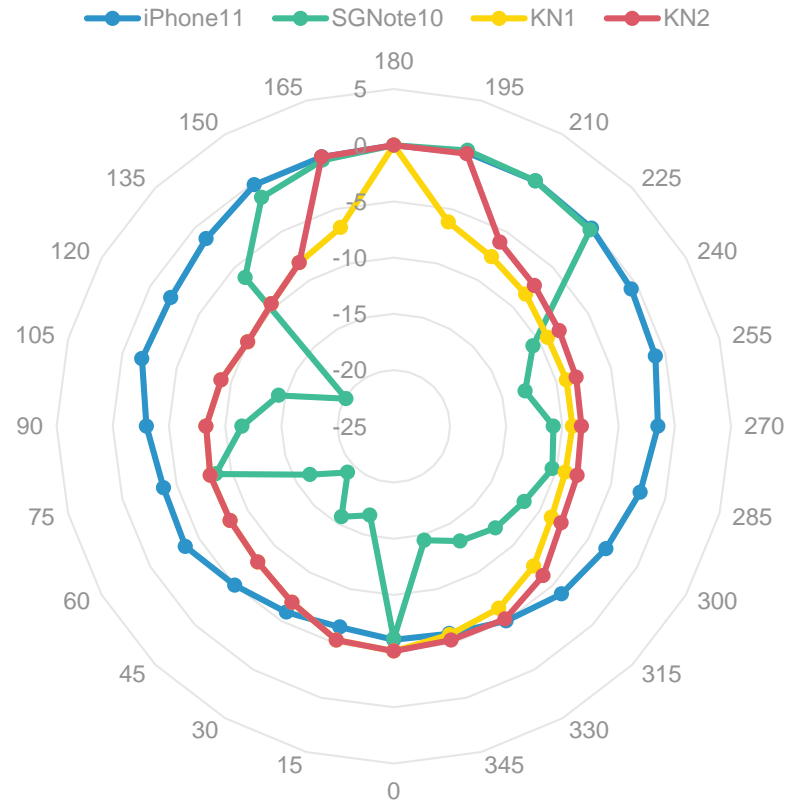
- Samsung Peacock ID is used in this experiment. The 3 mics used are D, C, A. D mic is actually on back of the ID facing a target.
- ID is calibrated using anechoic pink noise recordings.
- For generating polar plots, speech and pink noise recordings collected in an anechoic chamber in increments of 15 degrees are used.
- Target direction is set to 180 degrees and target direction width is set to 30 degrees. Beamformer is a fixed-bearing beamformer (fixed look direction + adaptive noise cancellation).
- Noise suppressor operates to remove pink noise even inside the beamwidth of interest.



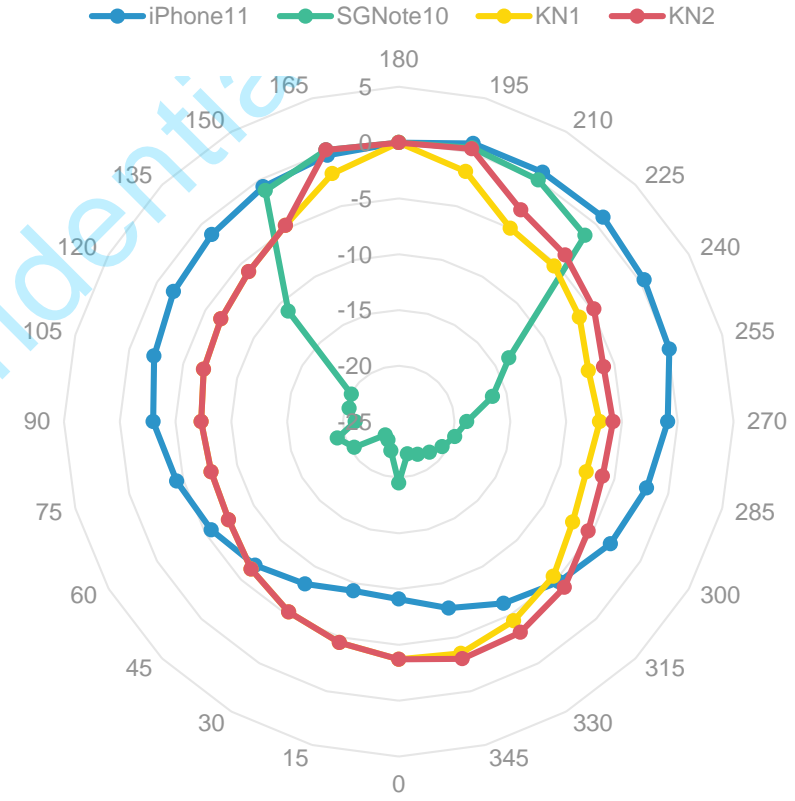
Audio Zoom Details - Initial Internal Results

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Normalized Polar Plot w.r.t. 180 deg: PINK NOISE



Normalized Polar Plot w.r.t. 180 deg: SPEECH



- Comparison analysis (polar plots) of speech and pink noise completed between 2 Knowles options, Note 10, and iphone 11
- Knowles provides sharpest beam angle of attenuation of all solutions: $\pm 15^\circ$ (Note 10 is $\pm 30^\circ$ & iphone 11 is more gradual)
- Knowles current attenuation level is $\sim 6-7\text{dB}$, other solutions showing much less attenuation in the target angle range

Knowles Benefits

❖ **Best Performance and Efficiency**

❖ **AP independent deployment
Exynos / Qualcomm**

❖ **Additional Features**

Action Plan	Purpose	Timeline (From Project Start)
Samsung & KN agreement	Identify and mutually commit to the project	Day 0
KN provides data collection requirements to Samsung	Enables optimal performance	3 days
KN to provide streams with various tunings	Each tuning will represent tradeoff between suppression level and effect on audio fidelity – Samsung to choose ideal tuning	3 weeks
Full demonstrations on target hardware platform	To be co-defined between Samsung and KN	6 weeks

Athletico Mobile Use Cases

Example Use Case Details of Athletico in Mobile Phone

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#	Use-cases	Athletico Functionality	AP
1	Always ON : OK Google detection	<ul style="list-style-type: none"> OK Google- first stage detection OK Google detection during Media Record mode Echo canceller for Barge-in 	Additional Stages on SDM855 after Athletico front end, low power processing.
2	Always ON : Ambient Music detection (Athletico runs this 100%)	<ul style="list-style-type: none"> Local detection for Song/Artist Ambient Music detection even during Media Record Echo canceller during music playback 	Other Stages on SDM855
3	“Motion Sense” Detection Face Unlock (Athletico runs this 100%)	<ul style="list-style-type: none"> Radar Sensor detects the face near the phone for fastest Face Unlock in industry. Privacy to have all this on phone only. Flicker Sensor data passthrough, enabling the Face Unlock camera/ToF measurements on the system. 	AP runs Face Unlock, but Radar Sensor on Athletico.
4	“Motion Sense” Presence: Alarm Clock, Power screen on/off, and more (Athletico runs this 100%)	<ul style="list-style-type: none"> Radar Sensor detects user is near the device. I.e hand reach towards phone, or walking away from the phone, can turn on/off the screen. All processed on Athletico. 	AP decides what to do with Athletico Radar Sensor information of scenario. Alarm goes softer as your hand nears the phone. Walking away from phone turns off screen.
5	“Motion Sense” Gesture: Music Track Swipe forward (Athletico runs this 100%)	<ul style="list-style-type: none"> Radar Sensor Running on Athletico detects swipes to skip songs, shut off alarm, interact w/ games. Smart enough to reject coffee mug passing over top of phone(similar to swipe) vs hand swipe motion 	AP will combine Gesture with Apps, gaming,
6	Battery Saver	<ul style="list-style-type: none"> Athletico provides power data from its use cases upwards to the system to optimize. 	SDM855 takes power data across system for optimization

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#	Use-cases	Athletico Functionality	AP
7	Camera App - Flicker sensor detect	Flicker Sensor is connected to Athletico, pass-through data to SoC	SDM855 processes Flicker data
8	Network Voice Call	Athletico passes Audio use cases with low latency- for all carriers.	Noise Suppression resides on SDM855
9	VOIP Call – Google Duo, Hangouts, Skype, etc.	Athletico passes VOIP Audio specs	Noise Suppression resides on SDM855
10	Media Recording – Sound Recorder, Media Recording(Camera)	Athletico used for passing Audio OK google support during Media Record	Other Stages on SDM855
11	Context Awareness - Car mode.	Athletico buffers Audio and passes to SLPI for CHRE to detect its in Car Mode. This allows for Google Assistant to provide quick message replies to incoming calls “I’m driving- call you later”.	Other Stages on SDM855, SLPI
12	Context Awareness - Car Crash Detection	Athletico buffers Audio and passes to SLPI for CHRE to detect its in a crash.	Other Stages on SDM855, SLPI
13	Live Transcription YouTube, Record	Athletico used for passing Audio	Other Stages on SDM855
14	Next Gen Google Assistant – no need to say OK Google	Athletico used for passing Audio, and Radar Sensor running on Athletico enables use cases without the hotword phrase. Ex. when it knows it’s the user (Face ID), or in a string of commands.	Other Stages on SDM855

■ Technology Overview

- Radar for motion is built from a new sensor/antenna/IC module that enables new types of touchless interactions
- Radar technology is unique compared to other technologies in its ability to track sub-millimeter motion at high speed and accuracy

■ Radar Benefits over Other Gesture Mechanisms

- **Precision** – Coarse Mode (20mm), Fine Mode (Sub 1mm)
- **Distance** – More than 5 meters
- **Field of View** - 180° field of view for spatial awareness everywhere
- **Power** – Can reach as low as 0.5mW and for many use cases between 1mW – 10mW

■ Existing Gesture Applications

- Seamless Face Unlock – Wakes phone on approach
- Media Navigation – Using swipes to speed-up and change media
- Snooze Alarms/Ring Tones – Snooze with hand wave

Radar Module Image

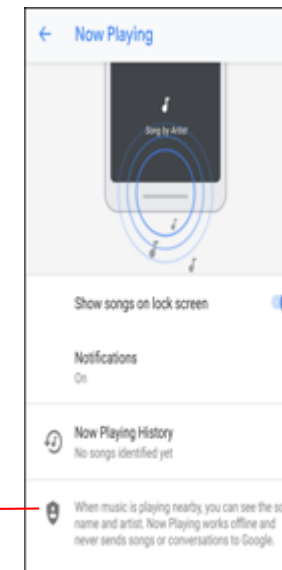
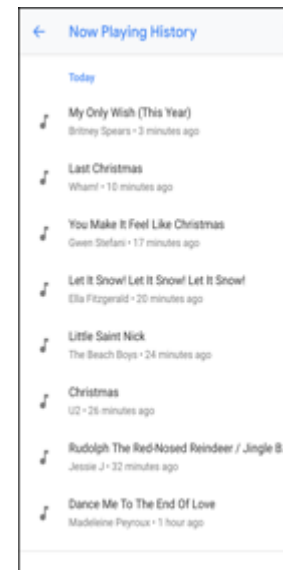
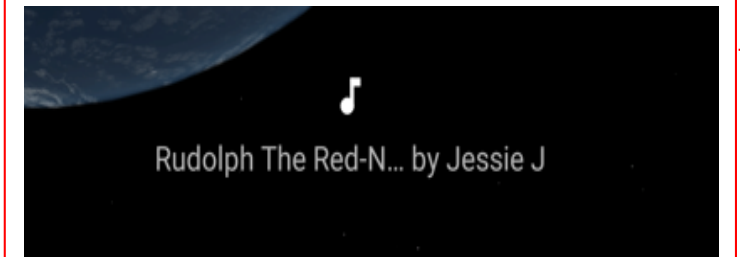
Image of Radar Sensor die and Antennas – 6mm x 5mm

Gesture Application Video

- Identifies music in background, automatically
 - “Background”=listens to tunes; does not use cloud, private
 - “Automatically”=does not require user to start an app
- Advantages compared to traditional apps
 - Runs all the time; no app, and no button press needed
 - Allows ‘look-back’ to see a history what you heard earlier
- Why run on KN AEP’s?
 - Lowest power
 - Can run all the time
- Why Music IQ
 - Convenient, works anywhere, no app
 - Add to play list
 - Monetize music searches



When music is playing nearby, you can see the song name and artist. Now Playing works offline and never sends songs or conversations to Google.

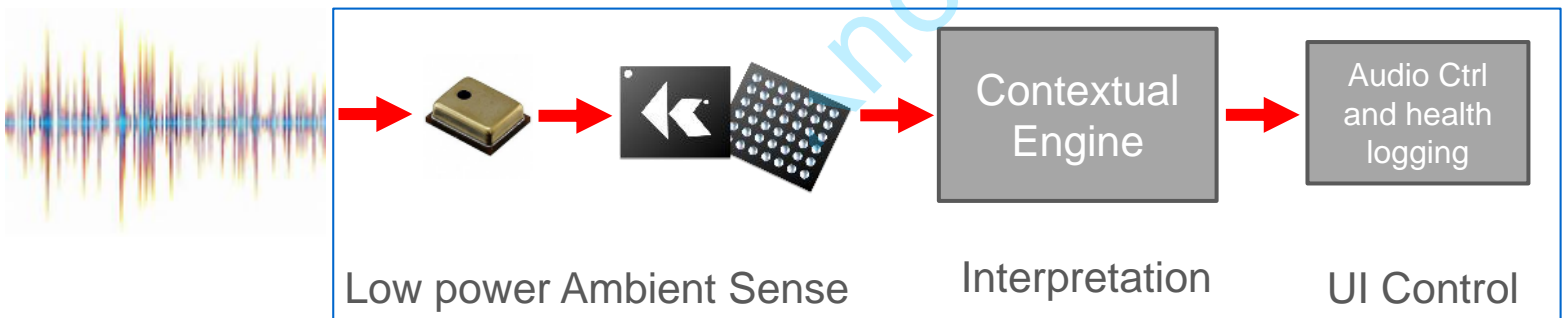
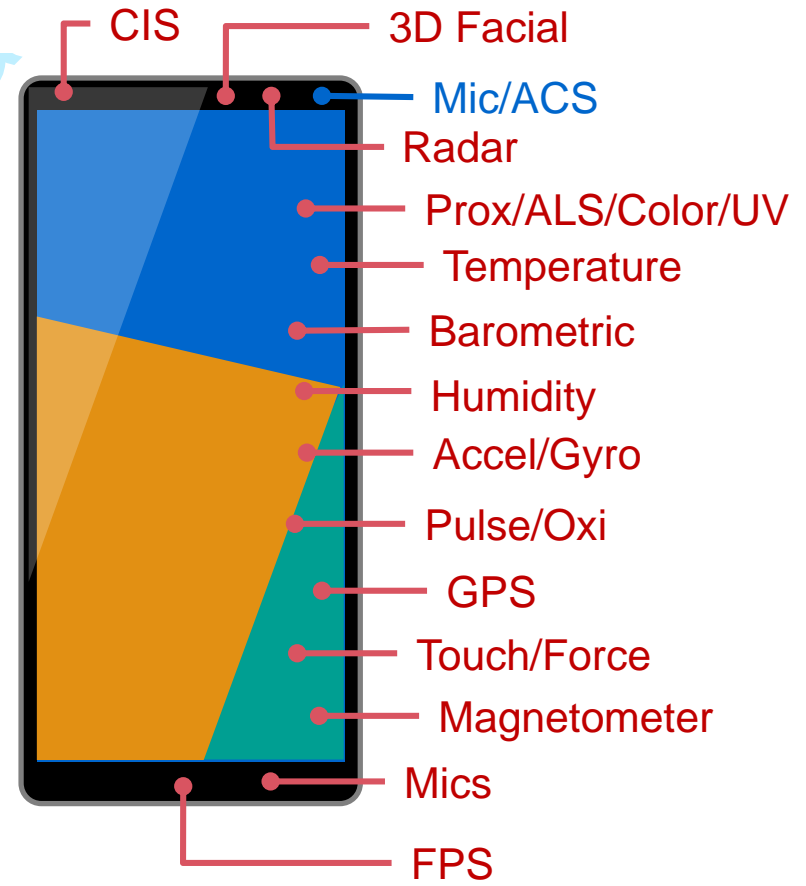


Other IA Mobile Use Cases

Acoustic Context Sensor (ACS)

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- A new virtual sensor for acoustic sensing
 - Adds another dimension to context sensing
 - Improves user experience through multiple applications
- Target Applications
 - Environment detection (e.g. in-car detect & indoor/outdoor detect)
 - Intelligent system volume adjustment
 - Source Identification (e.g. music detection, speech detection)
- Why run on KN AEP's?
 - Accurate monitoring only possible on an always on device
 - Minimal power in addition to already running VQ
 - Plan to add reference input for robustness



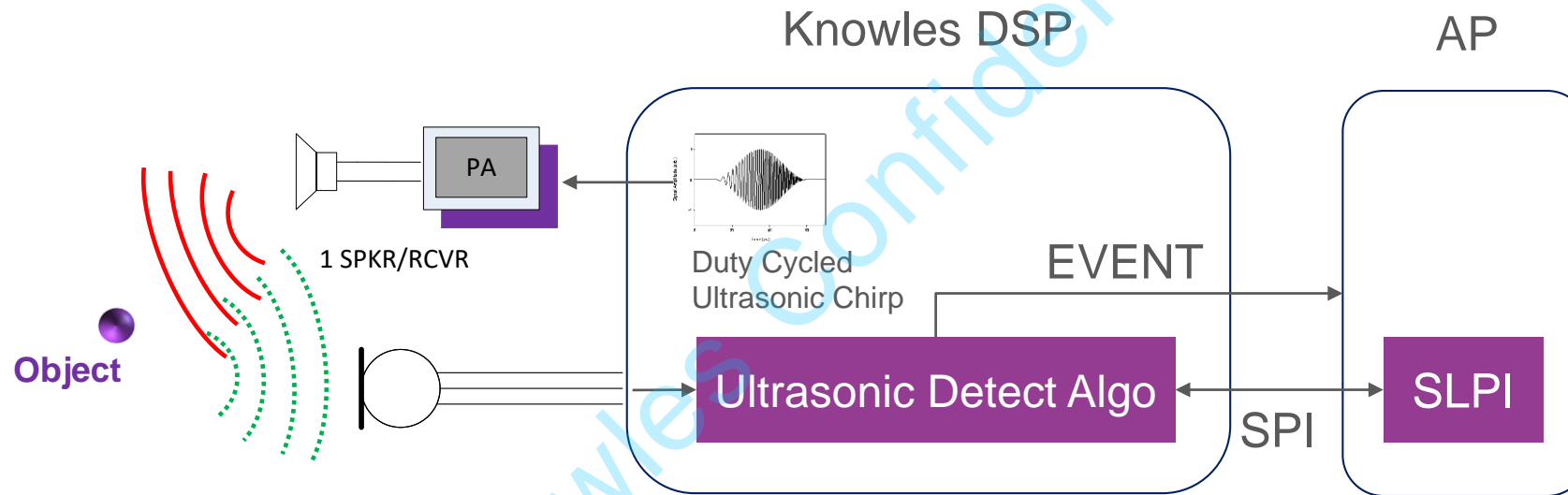
- Running on Chelsea/IA8201
 - Does not add power to existing VQ
 - Always running in background
- Intelligently monitors distracting noise
 - Noise level measurements are in line graph
 - Notification/volume changes in “Media volume”
- Video explanation
 - Babble playing in background (not affected)
 - Claps (not affected unless long duration)
 - Lecture (not detected as noise)
 - Train (detected as background noise)

New BNE Video

Why Low Power Ultrasonic?

Pocket detection and always-on presence and gesture require low power ultrasonic operation

How Knowles Architecture Achieves Low Power



- KN DSP drives the transmit path (receiver) - this prevents need for AP audio path being ON
- KN DSP duty cycles the PA and ultrasonic chirp signal to minimize power
- AP is kept almost entirely asleep – if sensor inputs are needed for use case accuracy, SLPI on AP provides when required in a low power fashion
- KN DSP can provide significantly lower power operation for ultrasonic detection algorithm (5x-20x) compared to running on AP

- Knowles offers the most power-efficient Audio & ML edge processors accompanied with compelling features that enhance end-user experience
- Athletico in millions of units mass production with Tier-1 mobile phone enabling compelling use cases with very low power compared to AP implementation
- Knowles processors are the first to enable the radar technology in the mobile phone industry with the highest performance gesture capability on the market
- Discuss potential to work closely with Samsung to enable new use cases and drive toward adoption on production phone platforms

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Thank You!