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Making always-on vision a reality

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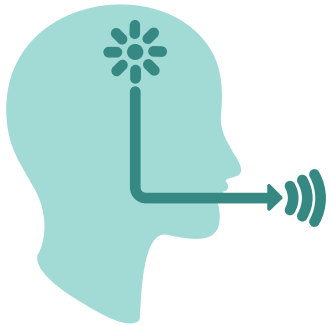
Outline

1. Problem statement
   - Challenges to develop always-on vision
2. Qualcomm Technologies innovation
   - How we are pioneering the always-on solution
3. Use cases and market opportunity
   - Supports many use cases across numerous verticals
   - Demos

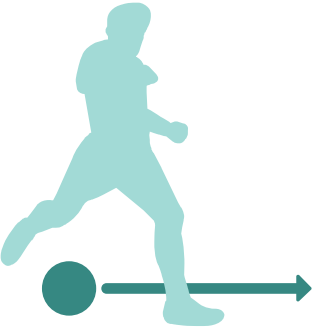
The always-on UI and contextual awareness trend

Delivering significant value across the whole ecosystem (> 1B units/year[1])

Always-on touch



Always-on voice

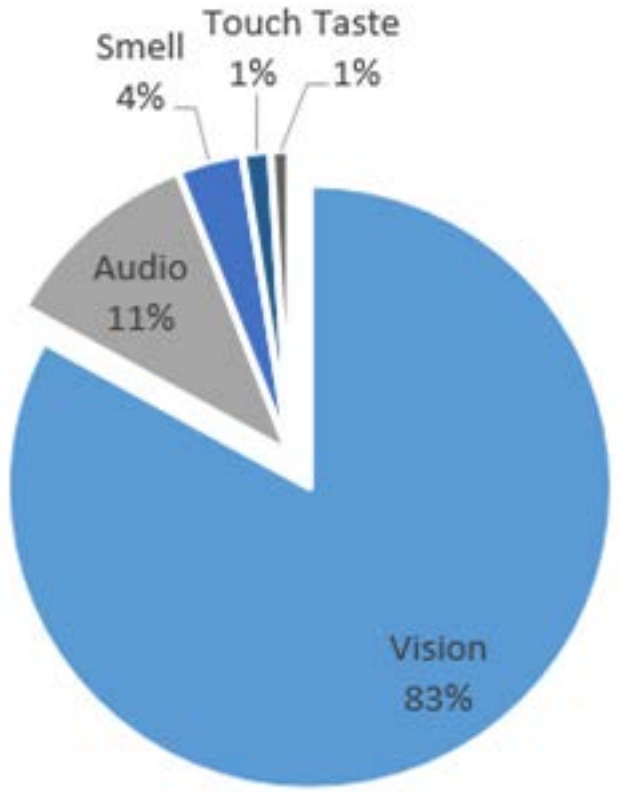


Always-on motion

1: Source: IDC Mar. ‘17

Human perception is dominated by vision

- 83% of our external world perception is through vision
- Yet, always-on vision technologies have been extremely challenging



Source: Hatwell, Y. (1994). Traitéde psychologie expérimentale. Paris, P.U.F.)

Machine vision today

Conventional approaches are very power hungry

Image sensor

10’s mWs

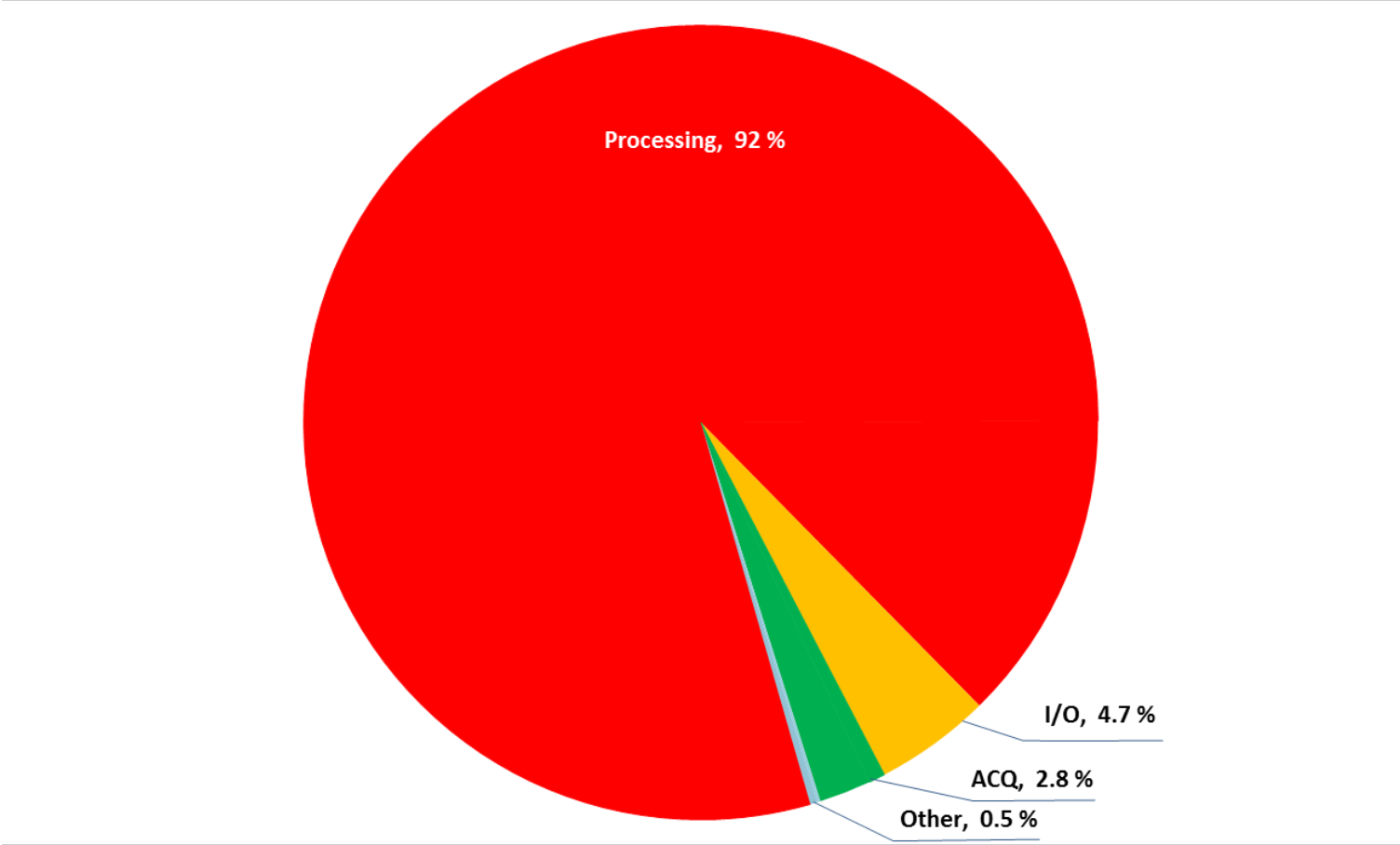
Processor and algorithms

100’s mW

(use case and processor specific)

Algorithms running in the processor consume majority of the power

Example: Gesture algorithm partitioning



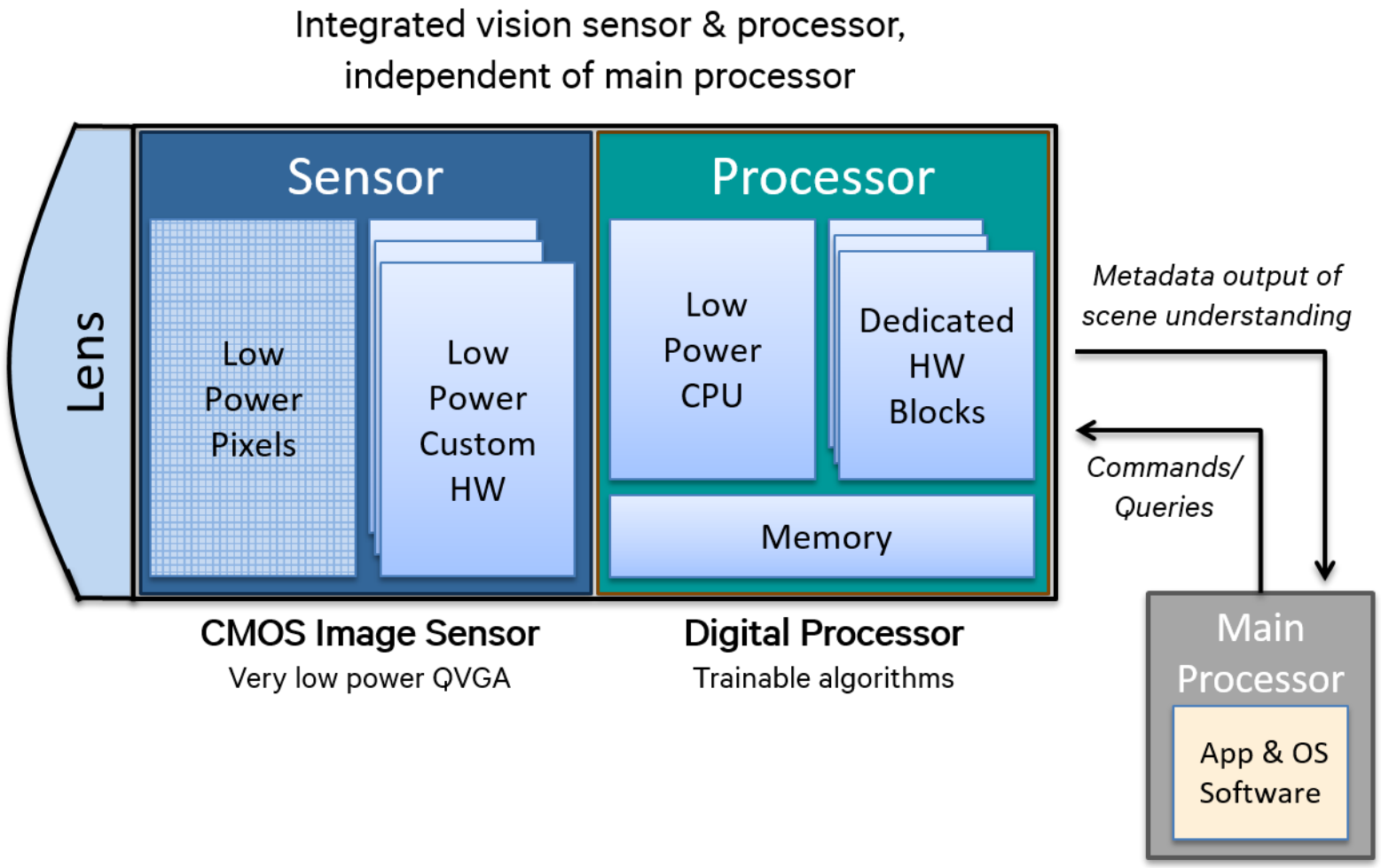
Source: Qualcomm Technologies, Inc.

Our always-on vision research and innovation

Solving the key challenges

- Highly integrated & holistically optimized system
- Ultra-low power designs
- Advanced technology nodes

- Always-on vision defined and targeted as < 1 mA, **active and end-to-end** (image sensor and digital processor)



Sensor considerations and optimizations

- Low-resolution sensing, inspired by nature
- Data sparsity
- Event-driven architecture
- Ultra-low power designs

High resolution cameras are not required for always-on vision

There's plenty of room for low resolution cameras — A “sweet” spot at < 1M pixels

- Information density is the information per pixel and is more important than just sensor resolution
- The information density required depends on many factors, such as use case, distance, lens, illumination, etc.
- Low-resolution cameras can complement high-resolution cameras

Low-resolution vision: Lessons from nature

Starfish

- ~ 120 “pixels” x 5
- Use case: scene detection (e.g. reef)

Bee

- ~ 5000 “pixels”
- Use cases: navigation and object recognition

Face detection use case: Resolution and bit depth

Our algorithms work well at low resolution and bit depth

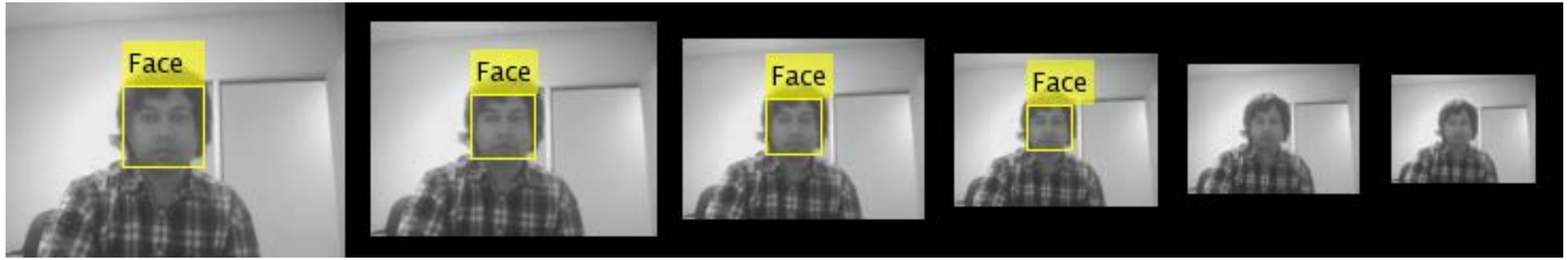
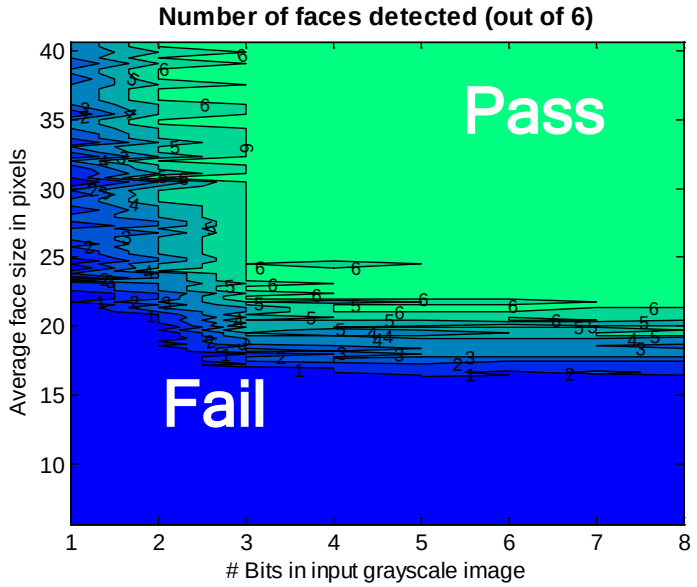


Image	120 x 160	101 x 135	85 x 114	72 x 96	61 x 81	51 x 68
Face	39 x 39	31 x 31	27 x 27	22 x 22	Not found	Not found



Data sparsity for data compression

Temporal sensing approach as an example

Image

Temporal contrast

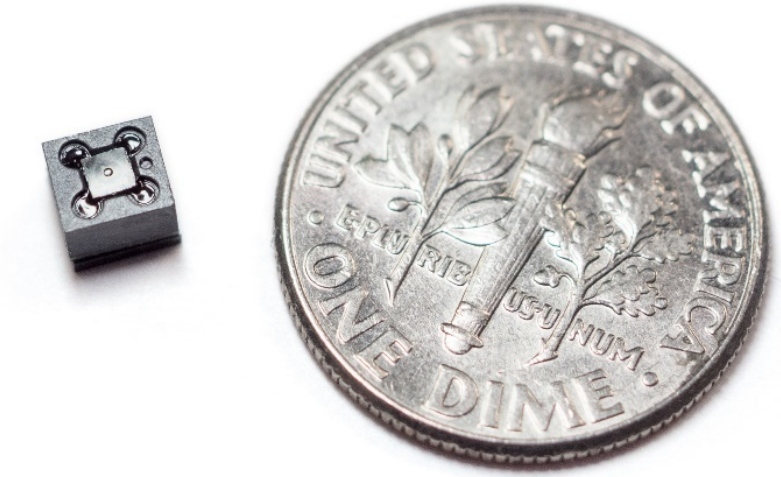
Metadata: { redDot, 86, 69}

Image data sparsity → Metadata output

Our prototype always-on computer vision module (CVM)

Key features

- Ultra-low power, < 1 mA (end-to-end, w/ sensor included)
- Small size
- Low cost
- Privacy (output is metadata)
- Configurable for different use cases
- QVGA sensor
- Near-IR compatible



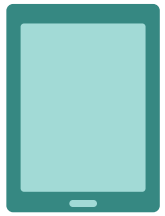
Vision will enhance many use cases across numerous verticals

Smartphone

- Face-based auto-wake and auto-sleep
- Always-on trigger for other use cases
- Always-on trigger for iris authentication (removes multiple steps and user initiation)

Smart watch

- Face-based auto-wake and auto-sleep
- Always-on gestures

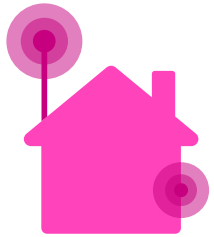


Tablets

- Simple gaze tracking for advertising attribution
- Improved landscape/portrait screen orientation

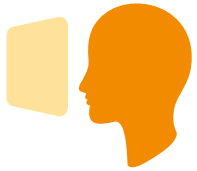
Virtual reality

- Low power gaze tracking (foveated rendering)
- Low power visual odometry for 6 DoF



‘Intelligent’ occupancy trigger

- Distinguish humans from other objects
- Add data layer to trigger: How many? Where?
- Trigger on particular events or objects



‘Intelligent’ interactivity trigger

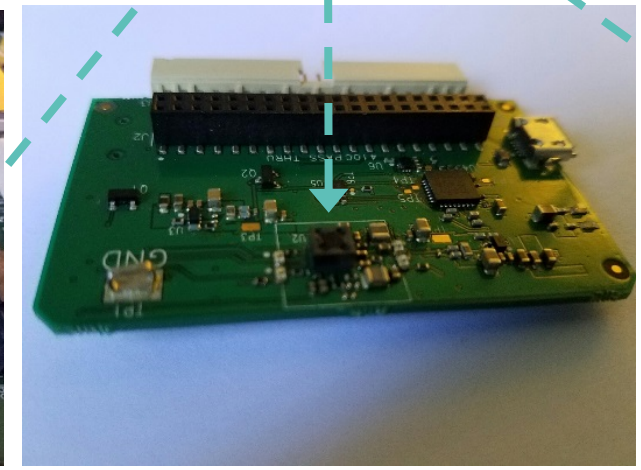
- Face detection as a trigger for interactivity
- Smart appliance can react when a user approaches to engage it

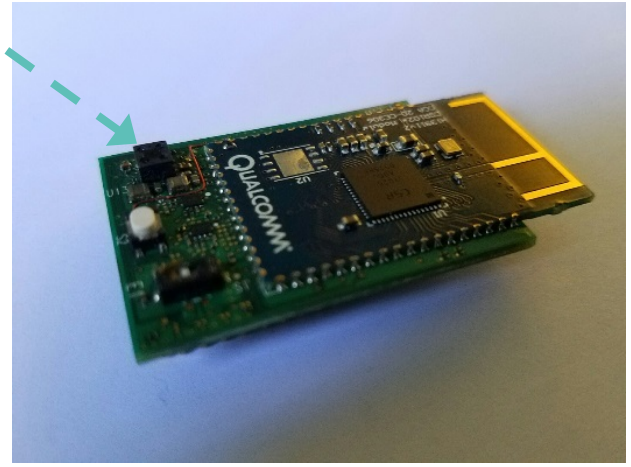
Standalone intelligent data sensor

- Heat maps of how a space is occupied
- Privacy advantages – data only, no images captured

Prototype development platforms and SDK

Always-on
CVM module



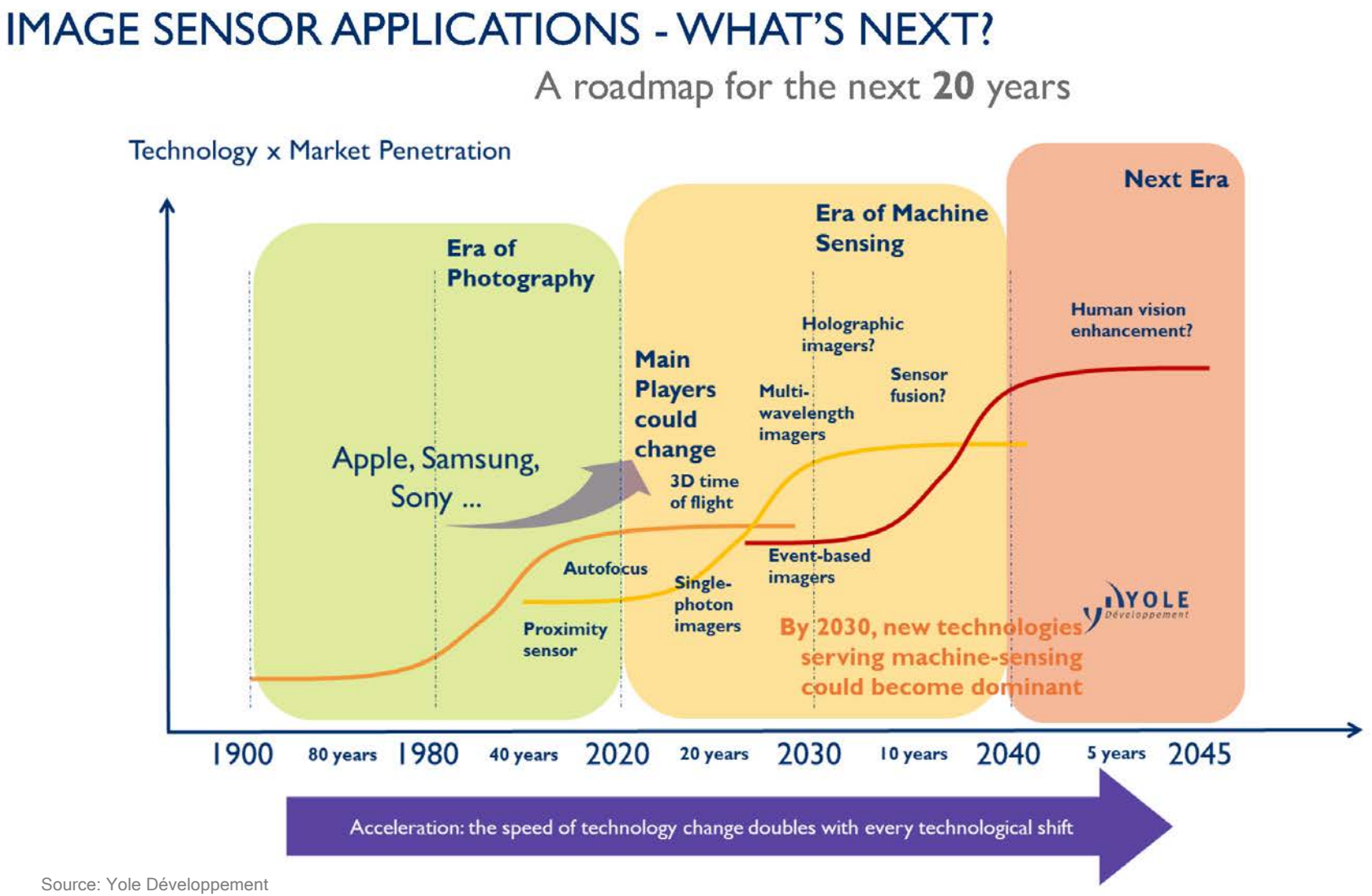


Qualcomm® Snapdragon™ 820
Development Platform (phone/tablet)

Snapdragon 410C
Development Platform
(IoT)

Connectivity Platform
(data “tag”)

The grand “vision”: Ubiquitous vision for sensing



- Qualcomm Technologies is helping to drive this industry transformation
- Be part of the growing ecosystem

Source: Yole Développement

Resources

- https://www.qualcomm.com/invention/research/projects/computer-vision/always-on
- https://www.qualcomm.com/news/onq/2017/02/28/always-computer-vision-sensing-science-fiction-science-reality
- https://www.qualcomm.com/invention/cognitive-technologies

- Contact us at CVM@qti.qualcomm.com for developing new use cases and hardware evaluation for your products

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