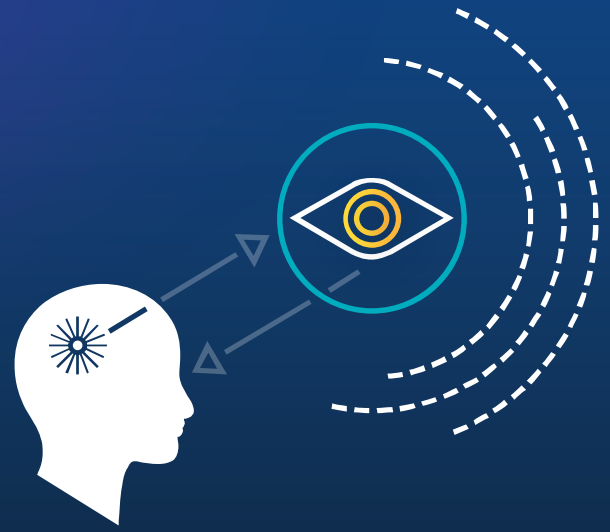
Qualcomm Technologies, Inc.
August 2015

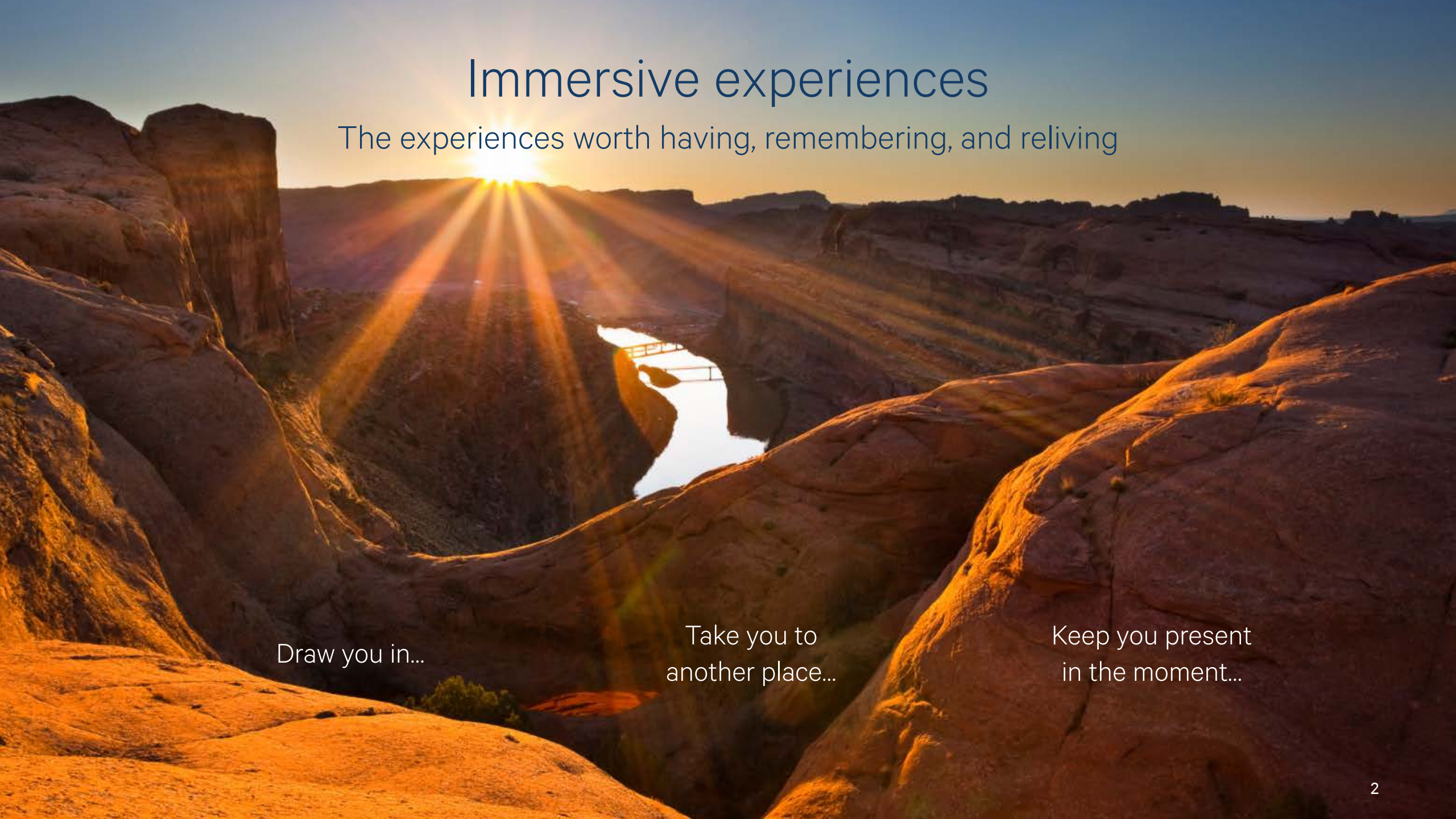
Driving the new era of immersive experiences

QUALCOMM®

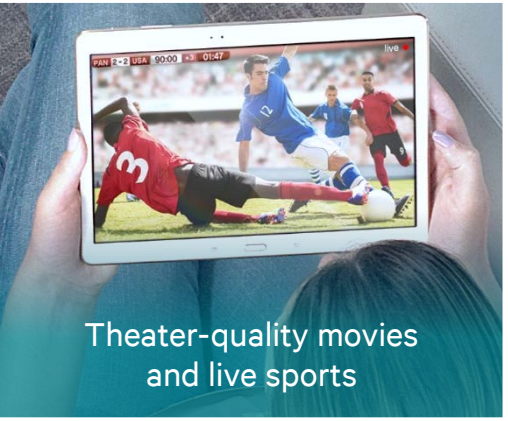


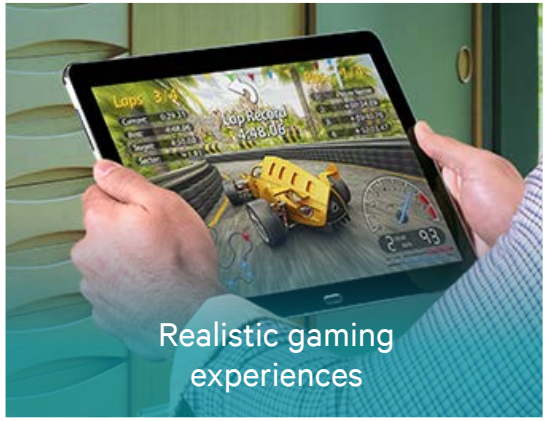
Immersive experiences

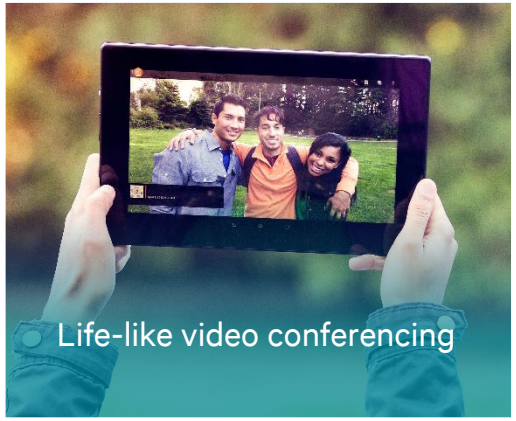
The experiences worth having, remembering, and reliving

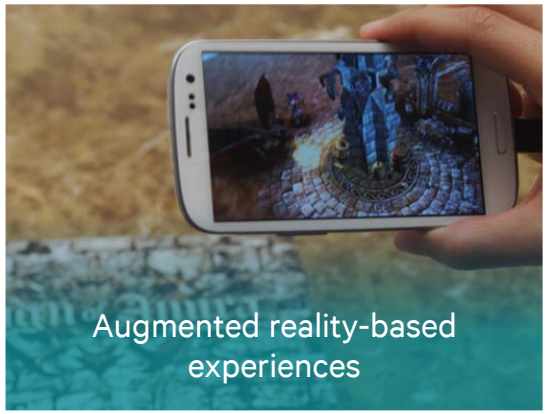


Immersion enhances everyday experiences







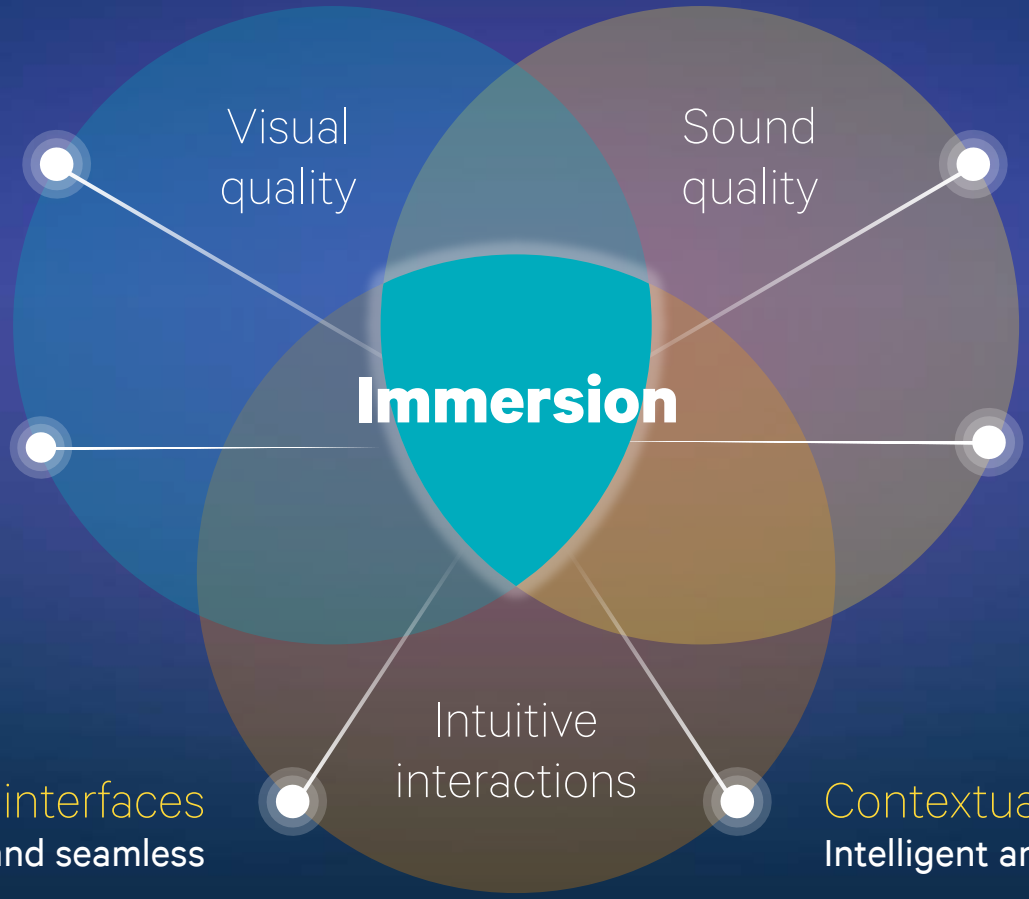


Experiences become more realistic, engaging, and satisfying

Spanning devices at home, work, and throughout life

Driving the new era of immersive experiences

Focusing on broader dimensions



Pixel quantity
Resolution and frame rate

Pixel quality
Color accuracy, contrast, and brightness

Natural user interfaces
Responsive, accurate, and seamless

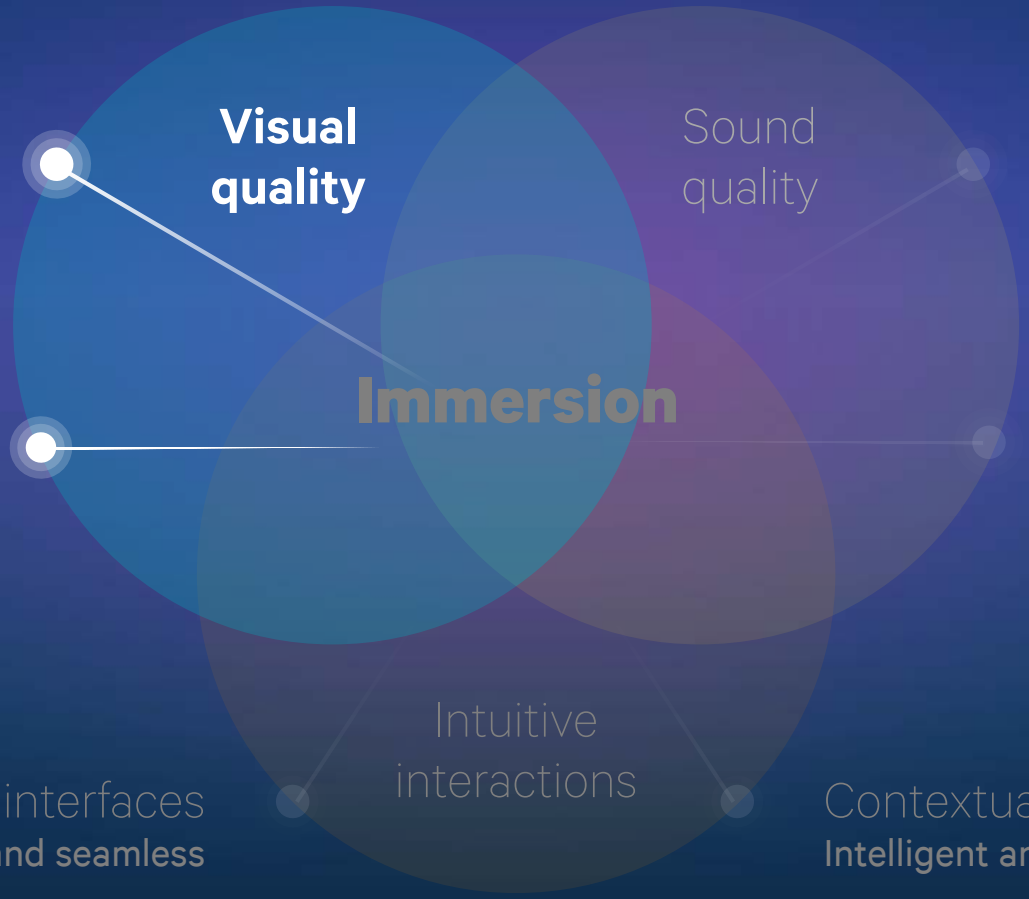
High resolution audio
Sampling rate and precision

Sound integrity
3D surround sound and clarity

Contextual interactions
Intelligent and personalized

Driving the new era of immersive experiences

Focusing on broader dimensions



Pixel quantity
Resolution and frame rate

Pixel quality
Color accuracy, contrast, and brightness

High resolution audio
Sampling rate and precision

Sound integrity
3D surround sound and clarity

Natural user interfaces
Responsive, accurate, and seamless

Contextual interactions
Intelligent and personalized

Visual quality is much more than resolution and frame rate

Color accuracy, contrast, and brightness are also critical elements

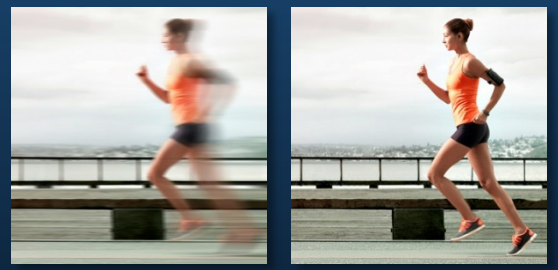
Pixel quantity

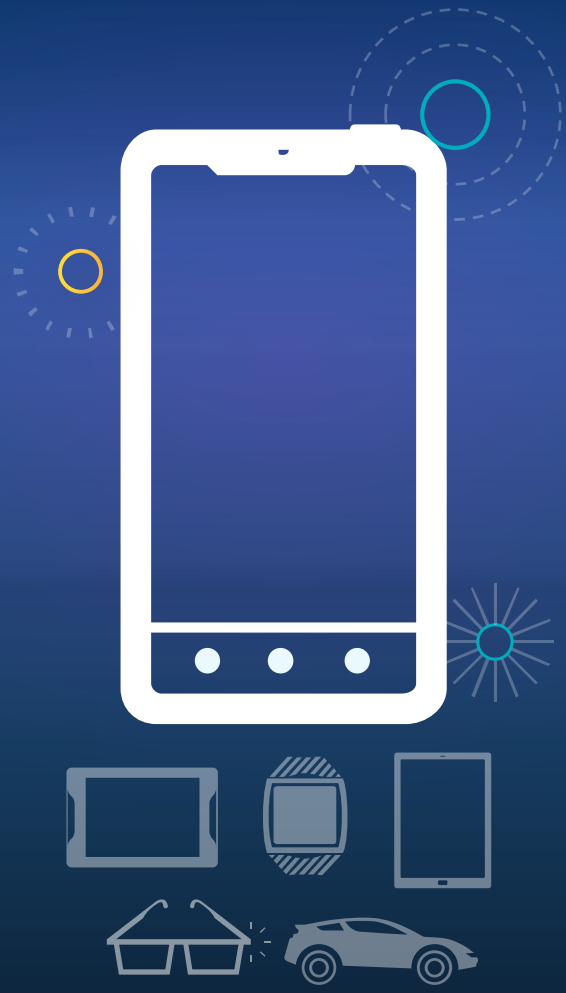
Resolution

Increased definition and sharpness

Frame rate

Reduced blurring and latency

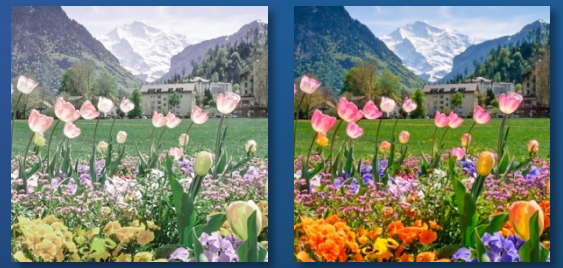




Pixel quality

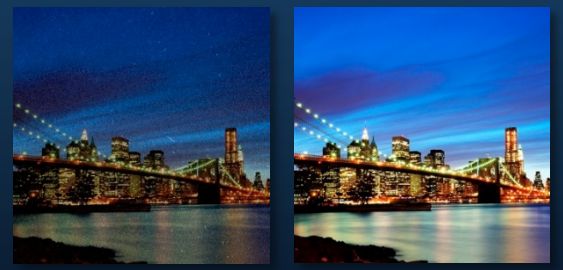
Color accuracy

More realistic colors through an expanded color gamut, depth, and temperature



Contrast and brightness

Increased detail through a larger dynamic range and lighting enhancements



Taking an end-to-end approach to improve visual quality

The journey of light from the mobile camera to a correct pixel on the display is challenging

Lens and sensor

Mobile size constraints create challenges:

- Poor light gathering
- Increased noise

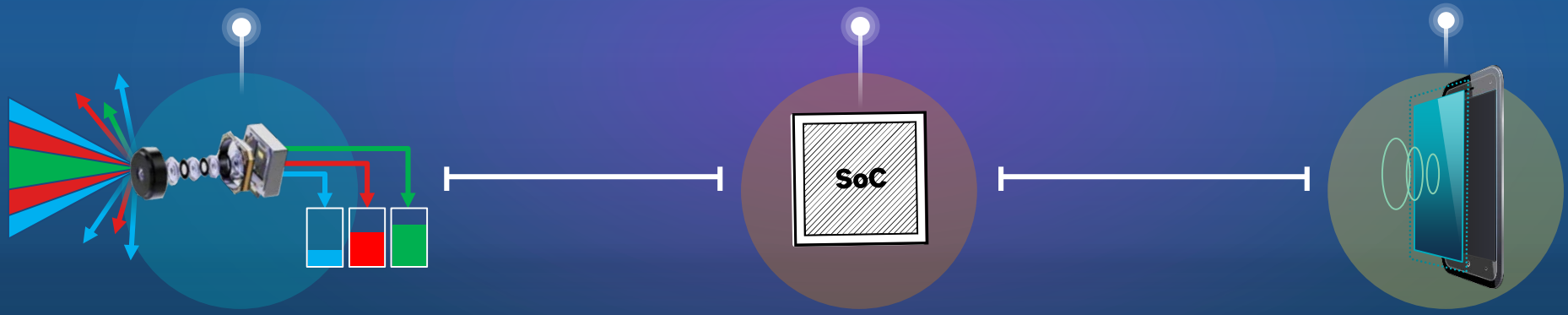
SoC

Addresses camera and display challenges while enhancing images

Display

Physical limitations of LCDs and LEDs:

- Partial color gamut
- Limited contrast and brightness



End-to-end solutions

Color management, artifact removal, optimized click-to-shoot time

Component tuning | Image processing | System optimization

A heterogeneous computing approach is needed

Specialized engines to meet visual processing requirements at low power and thermals

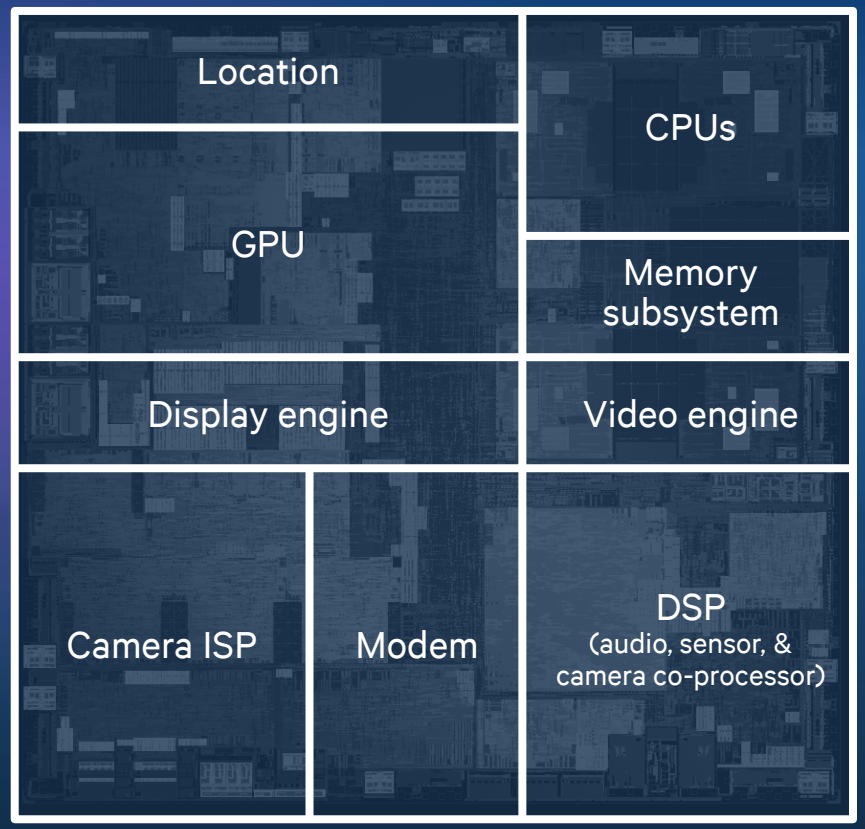
Camera image capture
Lens correction, noise removal, and 3A

Image processing
Color correction, tone mapping, and computational photography

Video compression
Video encode and decode

High-end gaming
Rendering, tessellation, and geometry shading

Display image
Compositing, gamut mapping, and calibration to displays



Cognitive technologies are making visuals more immersive

Using computer vision and machine learning to capture and playback better pixels

Capture

Playback

Scene understanding

- Recognize the objects, people, and the overall scene

Automatic configuration

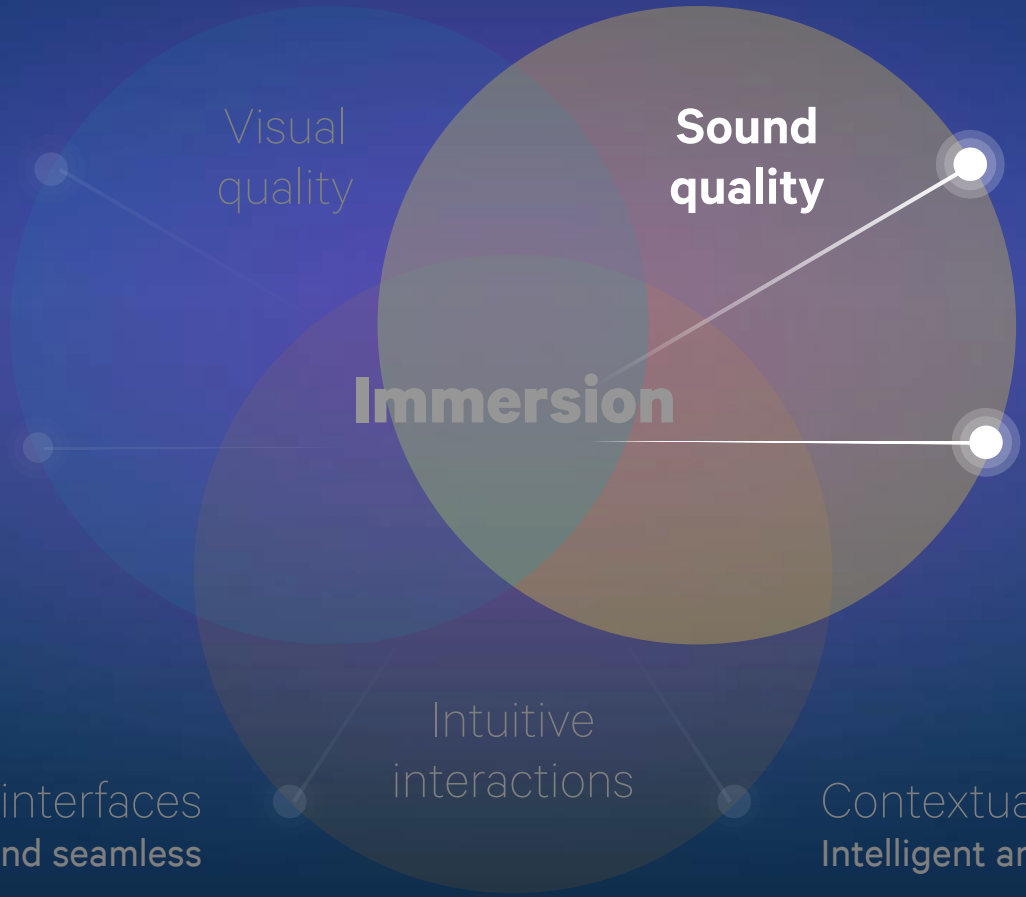
- Adjust camera settings
- Track, zoom, and focus on objects of interest

Relive your moments

- Pixels adjust to user preferences and environment for best viewing experience

Driving the new era of immersive experiences

Focusing on broader dimensions



Pixel quantity
Resolution and frame rate

Pixel quality
Color accuracy, contrast, and brightness

Natural user interfaces
Responsive, accurate, and seamless

High resolution audio
Sampling rate and precision

Sound integrity
3D surround sound and clarity

Contextual interactions
Intelligent and personalized

Enriching sound by focusing on broader dimensions

Providing truly immersive audio experiences optimized for how humans hear

High resolution audio

Sampling rate

Increased sampling rates to match human hearing

Precision

Increased bits-per-sample for increased audio fidelity

Sound integrity

3D surround sound

Accurate 3D capture and playback of audio

Clear audio

Zoom and focus on the important sound while filtering out the noise

Using multiple dimensions to capture vivid 3D sound

Understand environment

Automatically adjust settings based on environment detection and voice identification

Isolate sounds of interest

Zoom, focus, and track the sounds of interest while separating out other sounds

Capture realistic sound

Capture high-resolution, 3D surround sound through object-based or scene-based audio

Object-based sound capture

Scene-based sound capture

Immersive audio playback for realistic 3D surround sound

Speaker virtualization for
3D surround sound

Facial recognition and
head tracking for dynamic
sweet spot

Optimizing sound quality across the system

The journey of audio from the microphone to the speaker is challenging

Mic

Size, cost, and placement constraints result in:

- Limited number of mics
- Increased noise

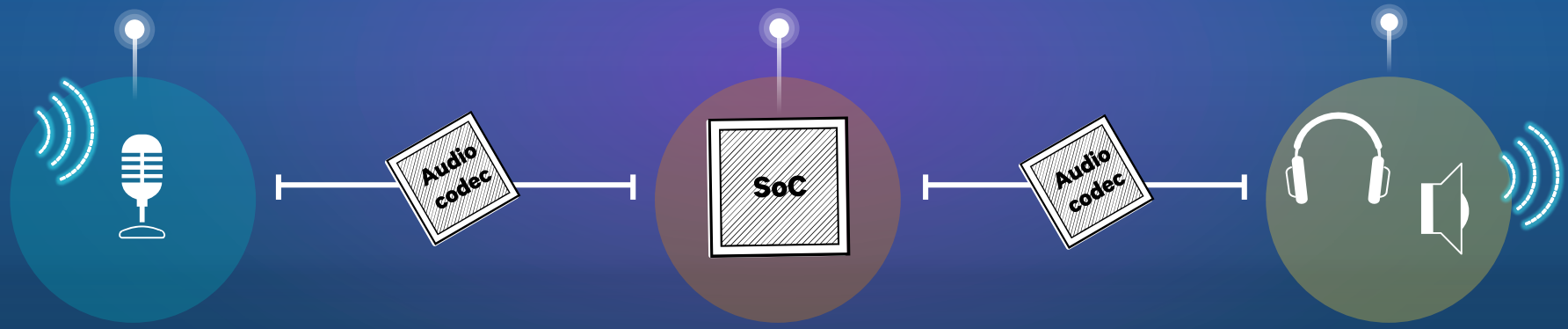
SoC

Addresses mic and speaker challenges while enhancing audio

Speaker

Size and cost constraints result in:

- Limited number of speakers
- Reduced quality and fidelity



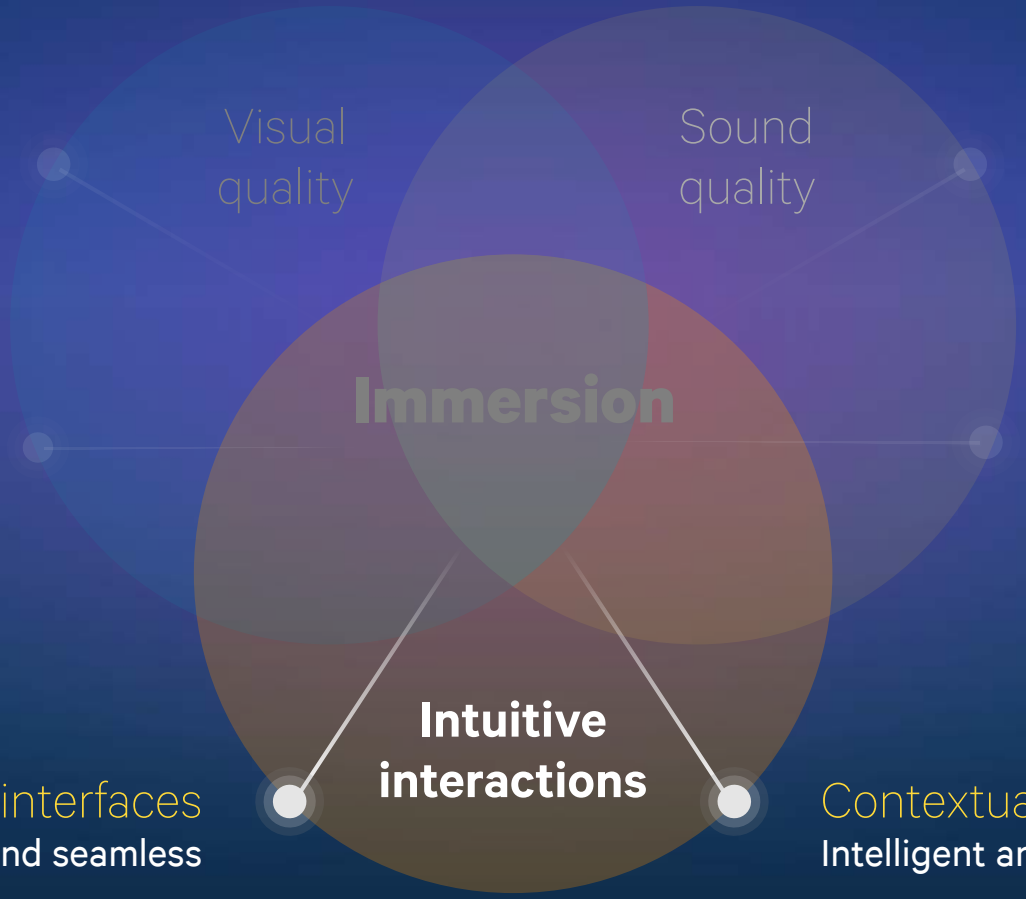
End-to-end solutions

High-res audio, noise suppression, and 3D surround sound

Component tuning | Audio processing | System optimization

Driving the new era of immersive experiences

Focusing on broader dimensions



Pixel quantity
Resolution and frame rate

High resolution audio
Sampling rate and precision

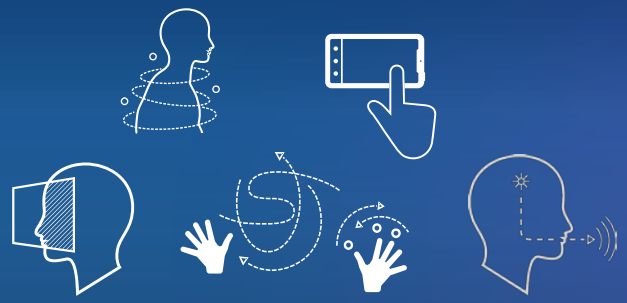
Pixel quality
Color accuracy, contrast, and brightness

Sound integrity
3D surround sound and clarity

Natural user interfaces
Responsive, accurate, and seamless

Contextual interactions
Intelligent and personalized

Intuitive interactions immerse us in the moment



Natural user interfaces

- Seamless
- Responsive
- Accurate

Providing the appropriate interfaces based on the user, device, and application

Contextual interactions

- Intelligent
- Personalized

Providing the right level of immersion based on context

Natural user interfaces for intuitive interactions

Motion & gesture recognition
Use computer vision, motion sensors, or touch

Voice recognition
Use natural language processing

Face recognition
Use computer vision to recognize facial expressions

Personalized interfaces
Learn and know user preferences based on machine learning

Eye tracking
Use computer vision to measure point of gaze

Bringing life to objects
Efficient user interfaces for IoE

Providing the right level of immersion based on context

Trusting your device to take appropriate actions

Contextual awareness

- Scene recognition
- Sensor fusion
- Proximal discovery
- Learned preferences

Intelligent notifications

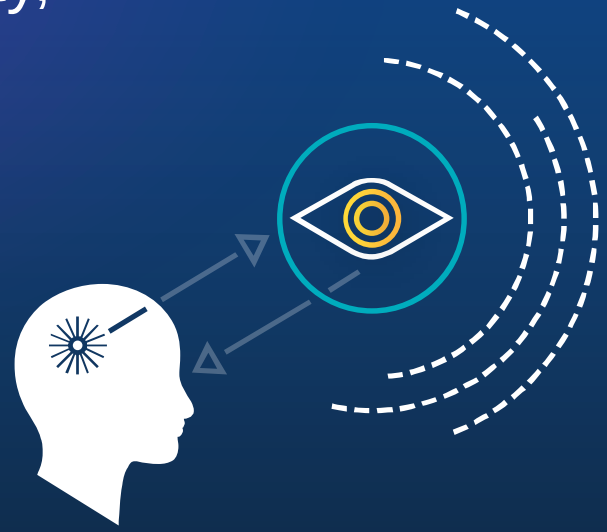
- The right information at the right time
- Appropriately interrupted immersion

Personalized experiences

- Reduced friction
- Customized for the user

Making virtual reality truly immersive

Through increased visual quality, enhanced sound quality, and more intuitive interactions



Virtual reality is the ultimate level of immersion

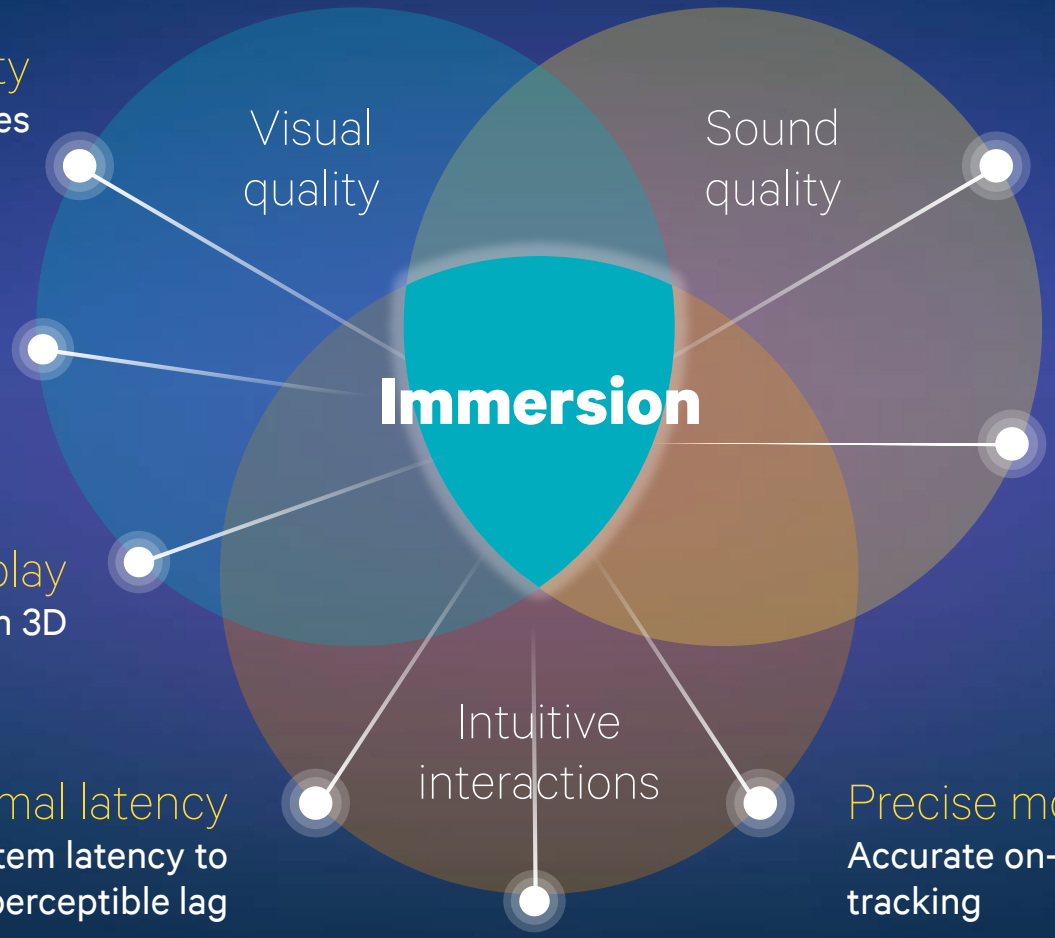
Stimulating our senses with realistic feedback

Visuals so vibrant that they are indistinguishable from the real world

Sound so accurate that it is true to life

Interactions so intuitive that you forget there is even an interface

Immersive virtual reality has extreme requirements



Extreme pixel quantity and quality
Screen is very close to the eyes

Broad field of view
Humans have a 180 degree field of view

Stereoscopic display
Humans see in 3D

High resolution audio
Up to human hearing capabilities

3D surround sound
Realistic 3D positional audio that is accurate to the real world

Minimal latency
Minimized system latency to remove perceptible lag

Precise motion tracking
Accurate on-device motion tracking

Natural user interfaces
Seamlessly interact with VR using natural movements, free from wires

An end-to-end approach is required for virtual reality

Optimizing for motion to display latency

Motion detection

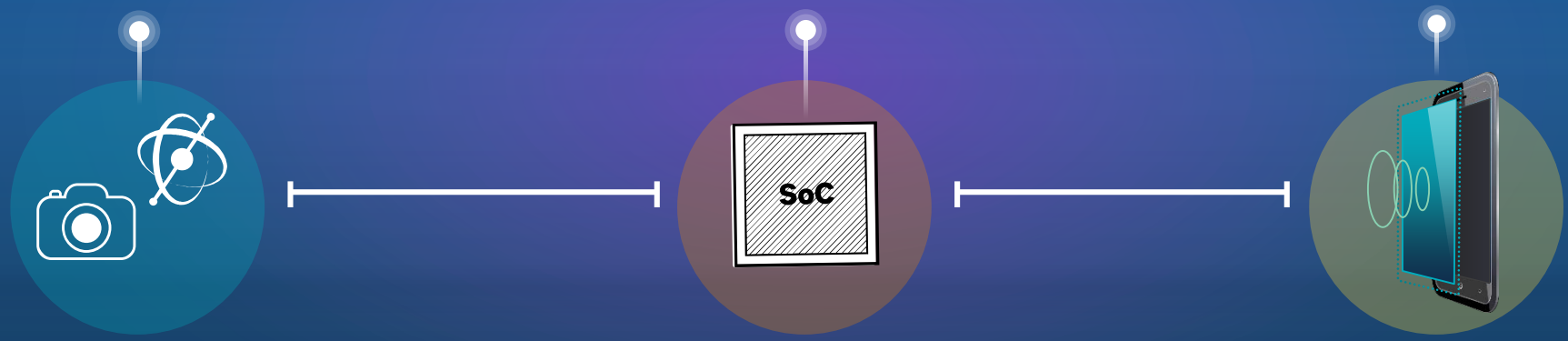
Gyro, accelerometer, camera, or other sensors detect movement

Visual processing

Calculate movement and create appropriate image through multi-stage visual processing

Screen update

Immediately update display with image to minimize latency



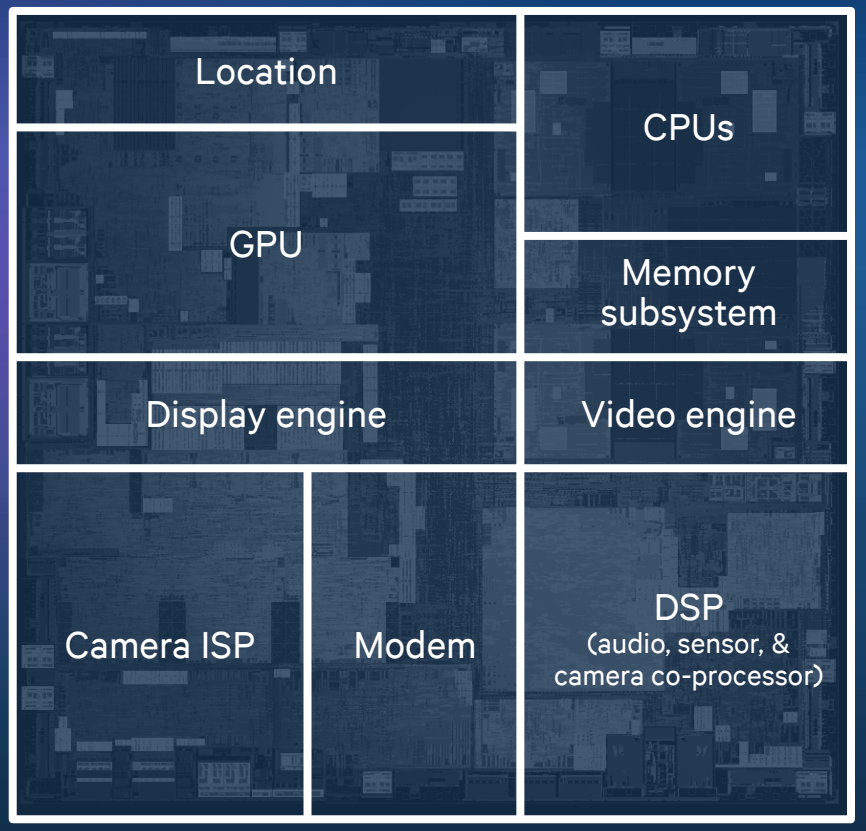
End-to-end approach

A heterogeneous computing approach is needed for VR

Specialized engines to meet processing requirements at low power and thermals

Virtual reality

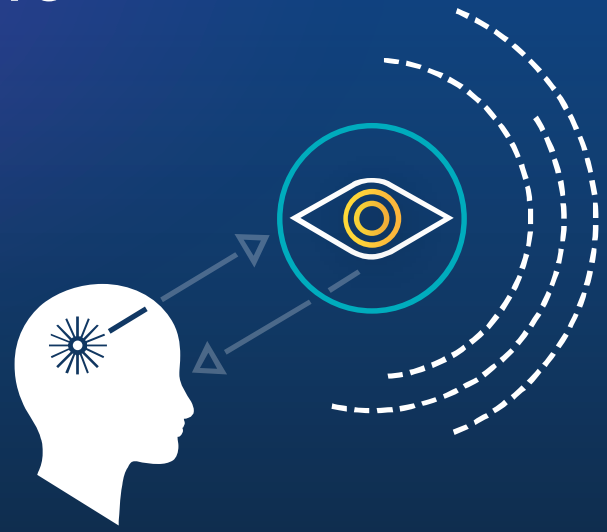
Computer vision, image processing, sensor processing, graphics, video processing, location, and cloud interaction



Entire SoC is used!

Qualcomm Technologies, Inc. (QTI) is uniquely positioned

To deliver efficient, comprehensive solutions for immersive experiences



QTI is uniquely positioned to deliver superior immersive experiences

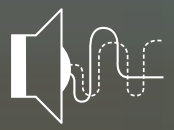
Providing efficient, comprehensive solutions

Immersive experiences

Visual quality

- Consistent, accurate color
- In-focus images
- Low-light video & photography

Sound quality



- 3D surround sound
- Noise removal
- Dynamic sweet spot

Intuitive interactions

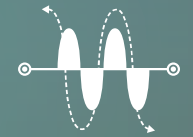
- Seamless, responsive, smooth user interfaces
- Intelligent, contextual interactions

Within device constraints

Development time / Sleek form factor / Power and thermal efficiency / Cost

Commercialization

Via Snapdragon™ solutions



- Efficient heterogeneous computing architecture
- Custom designed processing engines
- Comprehensive solutions across tiers

Via ecosystem enablement

- Snapdragon development platforms
- App developer tools
- Ecosystem collaboration

Using an efficient heterogeneous computing solution

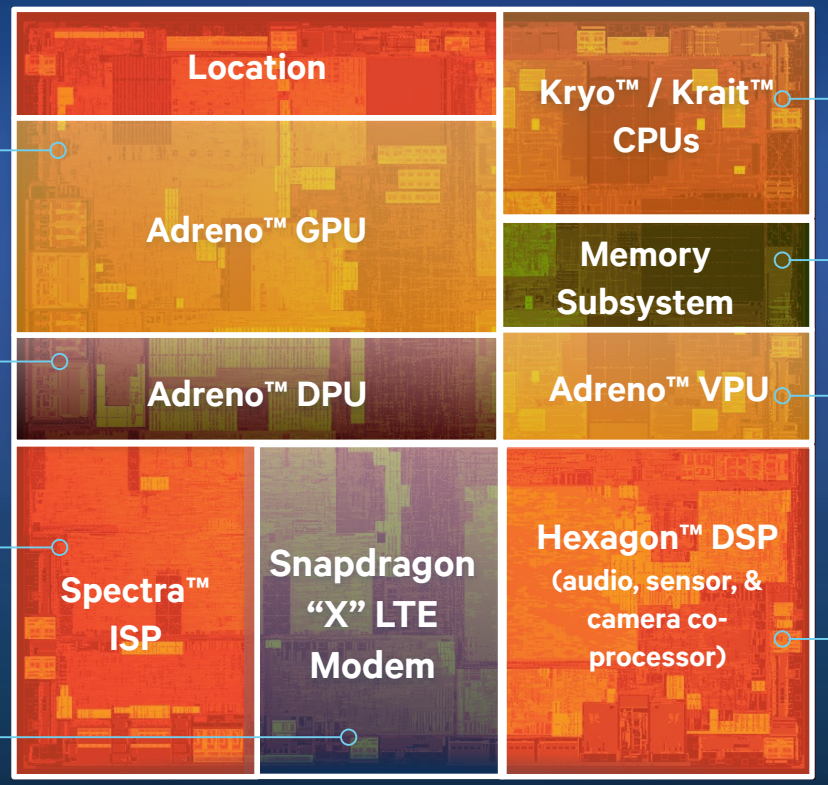
Specialized engines to meet processing requirements at low power and thermals

- Superior performance per mW
- GPU compute for image processing
- Graphics rendering with HW tessellation

- TruPalette™ color enhancement
- ecoPix™ power savings
- Composition

- 14-bit twin ISP
- Ultra-fast laser & phase detect autofocus
- Triple noise reduction: Bayer, wavelet, and temporal
- Dual camera support for depth, sensor fusion, and ultra low light

- High bandwidth at low power and latency
- Multiple radio technologies and bands



* Not to scale

- Efficient custom CPU architecture
- Image and audio processing

- Universal bandwidth compression
- Memory management for heterogeneous computing

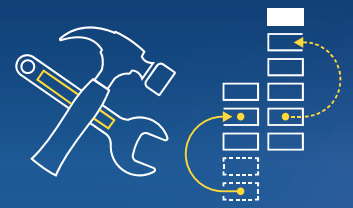
- Efficient, high quality 4K encode/decode
- Industry leading Wi-Fi Display

- Custom instructions for image, audio, and sensor processing
- High-quality voice with Fluence™ Pro
- 3D immersive audio
- Ultra-low power sensor processing and fusion

Snapdragon processors

Offering superior development and optimization tools

Enabling content creation and tuned devices



Content creation tools

Specialized solutions for development
- Adreno SDK
- Vuforia™ SDK
- Hexagon SDK

Debugger for solving
- Snapdragon Debugger

Profiler for optimization
- Snapdragon Profiler

Third-party middleware support
- Unity & Epic Unreal Engine

Device optimization tools

Calibration and tuning
- Chromatix™ color optimization tool
- Qualcomm Display Color Management
- Qualcomm Audio Calibration Tool

Analysis and debugging
- Qualcomm Commercial Analysis Toolkit
- Qualcomm eXtensible Diagnostic Monitor

Other ecosystem enablement

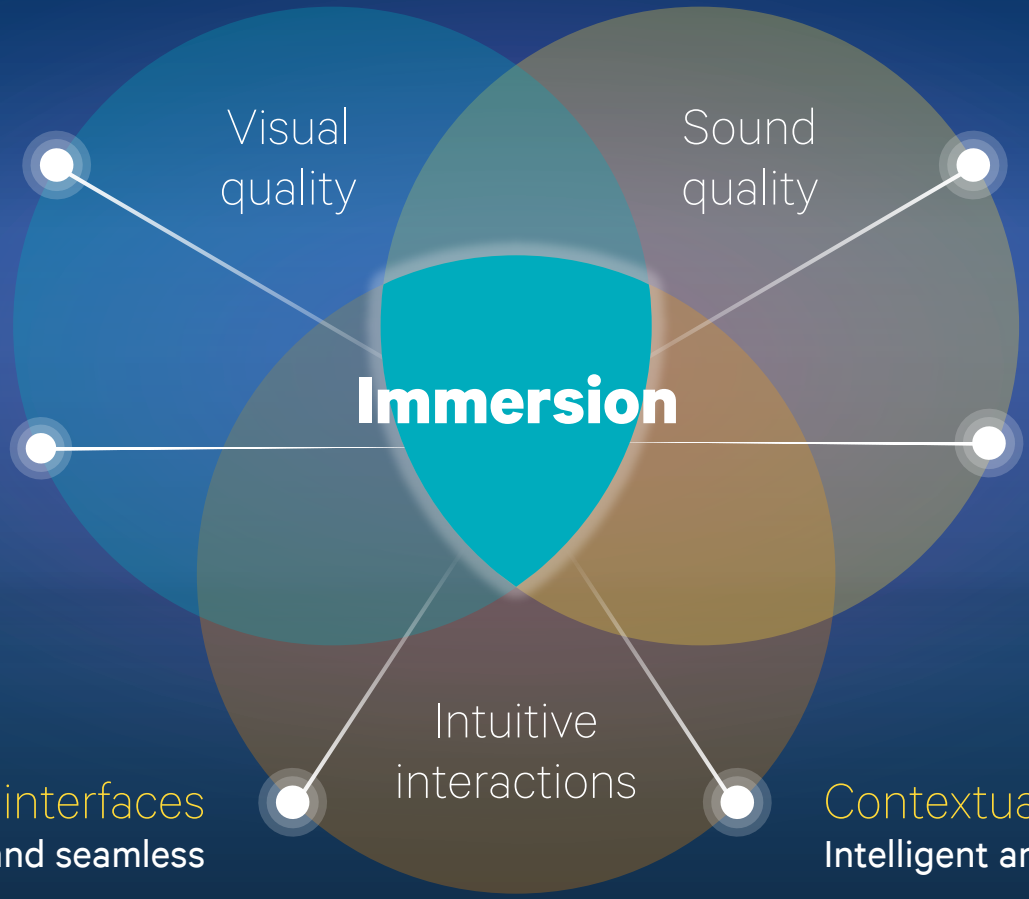
Development devices
- Mobile Development Platform
- DragonBoard™

Customer support
- Customer engineers

Vuforia and Chromatix are products of QTI. DraonBoard is distributed by Intrinsyc.

Driving the new era of immersive experiences

Focusing on broader dimensions



Pixel quantity
Resolution and frame rate

Pixel quality
Color accuracy, contrast, and brightness

Natural user interfaces
Responsive, accurate, and seamless

High resolution audio
Sampling rate and precision

Sound integrity
3D surround sound and clarity

Contextual interactions
Intelligent and personalized

End-to-end solutions

Heterogeneous computing

Cognitive technologies

Thank you

Follow us on:

For more information on Qualcomm, visit us at:
www.qualcomm.com & www.qualcomm.com/blog