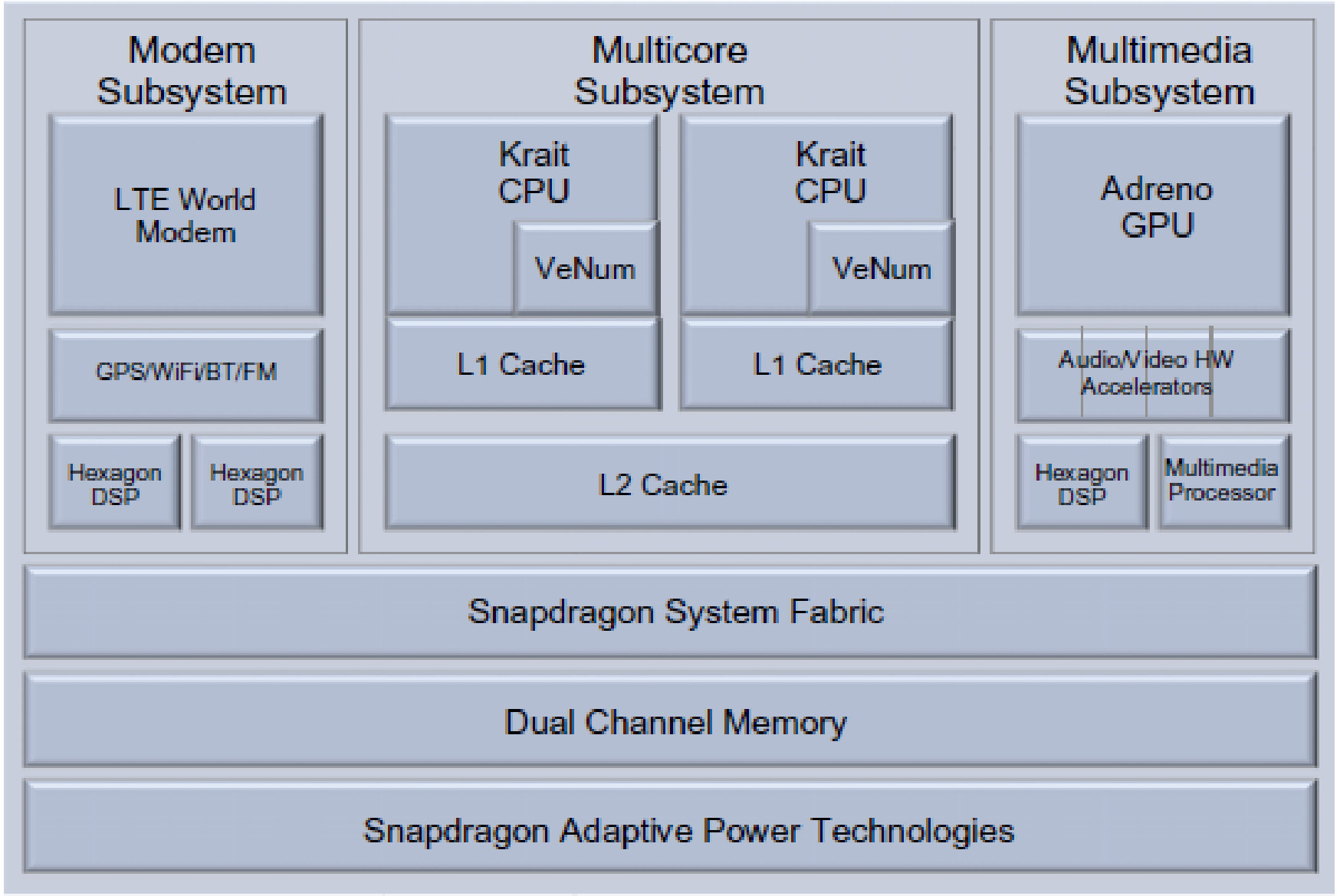
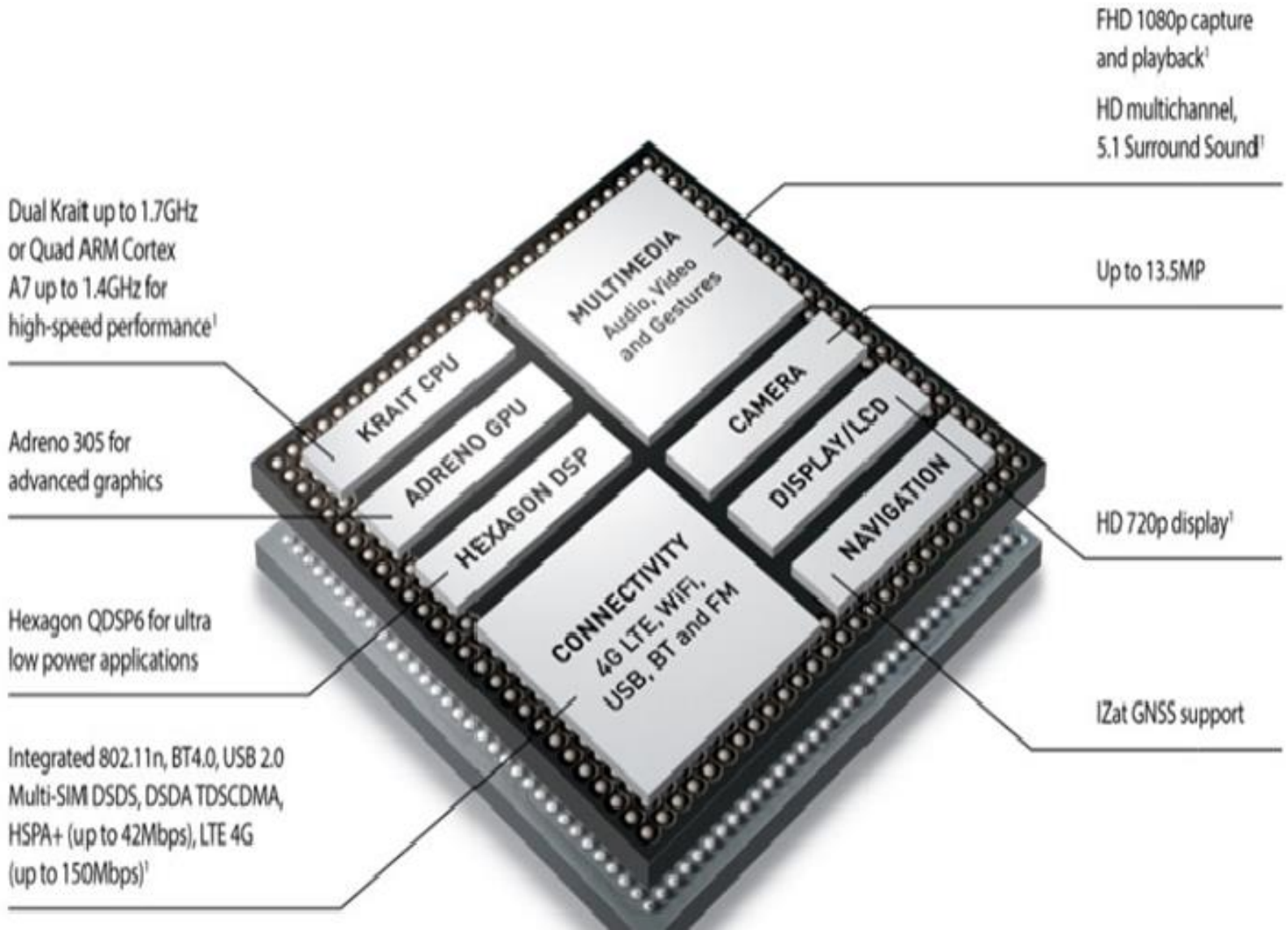
Prof SRN Reddy, IGDTUW

Figure 1: MSM8960 Block Diagram



Snapdragan SoC






	Snapdragon S4 Play	Snapdragon S4 Plus	Snapdragon S4 Pro	Snapdragon S4 Prime
CPU	Up to 1.2 GHz Dual ARM Cortex A5	Up to 1.7 GHz Dual Krait CPU	Up to 1.7 GHz Dual or Quad Krait CPU	Up to 1.7 GHz Quad Krait CPU
GPU	Adreno 203 GPU	Up to Adreno 305 GPU	Adreno 320 GPU	Adreno 320 GPU
Video	FWVGA	Up to 1080p HD video	1080p HD video	1080p HD video
Modem	3G/4G World/multimode LTE	3G/4G World/multimode LTE	3G/4G World/multimode LTE	3G/4G World/multimode LTE
Camera	8 MP	Up to 20MP, Stereoscopic 3D Kit	Up to 20MP, Stereoscopic 3D Kit	Up to 20MP, Stereoscopic 3D Kit
GPS	gpsOne Gen 7	gpsOne Gen8A	gpsOne Gen8A	gpsOne Gen8A
USB	High Speed USB 2.0	USB 2.0 High Speed OTG (480Mbps)	USB 2.0 High Speed OTG (480Mbps)	USB 2.0 High Speed OTG (480Mbps)
Bluetooth	Discrete solution BT 3.x	Integrated digital core BT4.0 †	Integrated digital core BT4.0 †	Integrated digital core BT4.0 †
WiFi	Discrete solution 802.11n (2.4GHz)	Integrated digital core 802.11n (2.4/5GHz)†	Integrated digital core 802.11n (2.4/5GHz)†	Integrated digital core 802.11n (2.4/5GHz)†
Process Technology*	45nm	28nm	28nm	28nm

	Snapdragon 800	Snapdragon 600	Snapdragon 400	Snapdragon 200
CPU	Up to 2.3 GHz Quad Krait 400 CPU	Up to 1.9 GHz Quad Krait 300 CPU	Up to 1.7 GHz Dual Krait 300 CPU	Up to 1.4 GHz Quad Cortex A5 CPU
GPU	Adreno 330 GPU	Adreno 320 GPU	Adreno 305 GPU	Adreno 203 GPU
DSP	Hexagon, QDSP6V5A, 600MHz	Hexagon, QDSP6V4, 500MHz	Hexagon, QDSP6V4, 500MHz	QDSP5, 384MHz
Video	4k x 2k UHD video capture/playback	1080p HD video	1080p HD video	720p HD Video (30/15 fps)
Modem	3G/4G World/multimode LTE on select processors	No modem	3G/4G World/multimode LTE on select processors	3G CDMA/UMTS/GSM on select processors
Camera	Up to 55MP, Stereoscopic 3D, Dual ISP	Up to 21MP, Stereoscopic 3D	Up to 13.5MP, Stereoscopic 3D on select processors	Up to 8MP
GPS	IZat Gen8B	IZat Gen8A	IZat Gen8A	IZat Gen7A
USB	USB 3.0/2.0	USB 2.0	USB 2.0	USB 2.0
Bluetooth	BT4.0 Integrated digital core	BT4.0 Integrated digital core	BT4.0 Integrated digital core	BT4.0 Integrated digital core
WiFi	802.11n/ac (2.4/5GHz) Integrated digital core	802.11n/ac (2.4/5GHz) Integrated digital core	802.11n/ac (2.4/5GHz) Integrated digital core	802.11n/ac (2.4/5GHz) Integrated digital core
Process	28nm HPm	28nm LP	28nm LP	45nm LP

Development Boards Comparison

	APQ8060A	APQ8064	APQ8074
Processor	APQ8060A dual core Krait (1.5 GHz)	APQ8064 quad core Krait (1.7 GHz)	APQ8074 quad core Krait (2.3 GHz)
Memory	1GB LPDDR2 16GB eMMC	2GB DDR3 4GB NAND flash	2GB LPDDR3 16GB eMMC
PMIC	PM8921	PM8920	PM8941 + PM8841
LCD	4.0" WVGA touch screen	4.0" QXGA touch screen	4.3" qHD touch screen
Display	HDMI (1080p@60fps)	HDMI (1080p)	HDMI (1080p@60fps)
Graphics	Adreno 225	Adreno 320	Adreno 330
Keyboard	Reset, Power, Vol/zoom (+/-), Camera Buttons	Reset, Power, Vol/zoom (+/-), Camera Buttons	Power, Vol/zoom (+/-) Buttons
Camera	8MP MIPI-CSI2 [Gen1 HW] 5MP MIPI-CSI2 [Gen2 HW] Supports up to 20MP	5MP MIPI-CSI2 Supports up to 20MP	5MP MIPI-CSI2 Supports up to 32MP
Sensors	3-axis accelerometer 3-axis gyro Barometer and temperature 3-axis compass 24 pin Header for custom sensor board	3-axis accelerometer 3-axis gyro Pressure 3-axis compass Proximity 24 pin Header for custom sensor board	3-axis accelerometer 3-axis gyro Barometer and temperature 3-axis compass 24 pin Header for custom sensor board
Radio	BT/Wi-Fi/FM WCN3660 [Gen1 HW] BT/Wi-Fi QCA6234 [Gen2 HW]	BT/Wi-Fi QCA6234	BT/Wi-Fi QCA6234
GPS	WGR7640	WGR7640	WGR7640

	BT/Wi-Fi QCA6234 [Gen2 HW]		
GPS	WGR7640	WGR7640	WGR7640
Connectors	RS-232 USB OTG micro AB 2xUSB 2.0 Ethernet 5.1 Audio Output 3.5mm Headphone port Micro SD card MIPI-CSI (camera) MIPI-DSI (display) GPIOs/Education header (16 Pin) 2xSATA JTAG header Test points Audio expansion header NFC header IR header USIM – SIM card micro HDMI ATX power connector	RS-232 USB-OTG USB 2.0 Gigabit Ethernet 5.1 Audio Output ANC/3.5mm Headphone port Micro SD card MIPI-CSI (camera) MIPI-DSI (display) GPIOs (16 Pin) 2xSATA JTAG header Test points Mini PCIe/mSATA PCIe TSIF/I2S header SPI NFC Header UIM interface	Q7 SoM interface RS-232 USB OTG micro AB 2xUSB 3.0 2xUSB 2.0 2xUSB 2.0 (header) Gigabit Ethernet 3-port audio jack ANC/3.5mm Headphone port Micro SD card MIPI-CSI (camera) MIPI-DSI (display) GPIOs/Education header (16 Pin) 2xSATA JTAG header Test points Audio expansion header NFC Header HDMI Display port 3xfront panel headers (6 pin) ATX power connector
Battery	2200 mAH	2200 mAH	Smart battery interface (6 pin)

[Translate]

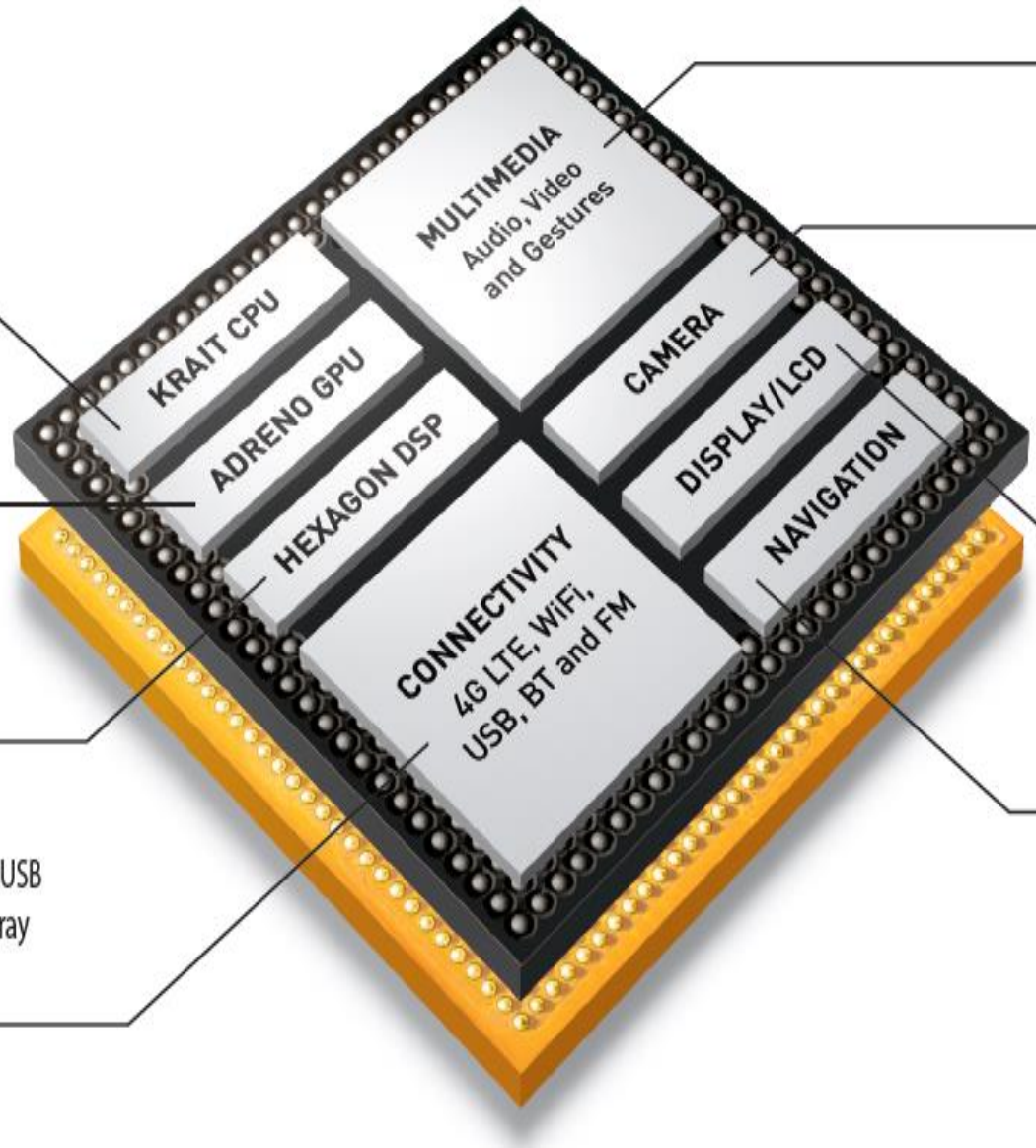
600 PROCESSOR

Krait 300 CPU provides improved, sustained performance in a mobile power profile

Speed enhanced Adreno 320 GPU

Hexagon QDSP6 for ultra low power applications

Integrated LTE[3], 802.11n/ac, USB 2.0 and BT 4.0 offer broad array of high-speed connectivity



1080p HD Capture and Playback

DTS-HD and Dolby Digital Plus audio

Up to 21MP

Support for up 2048x1536 + 1080p external display

IZat GNSS

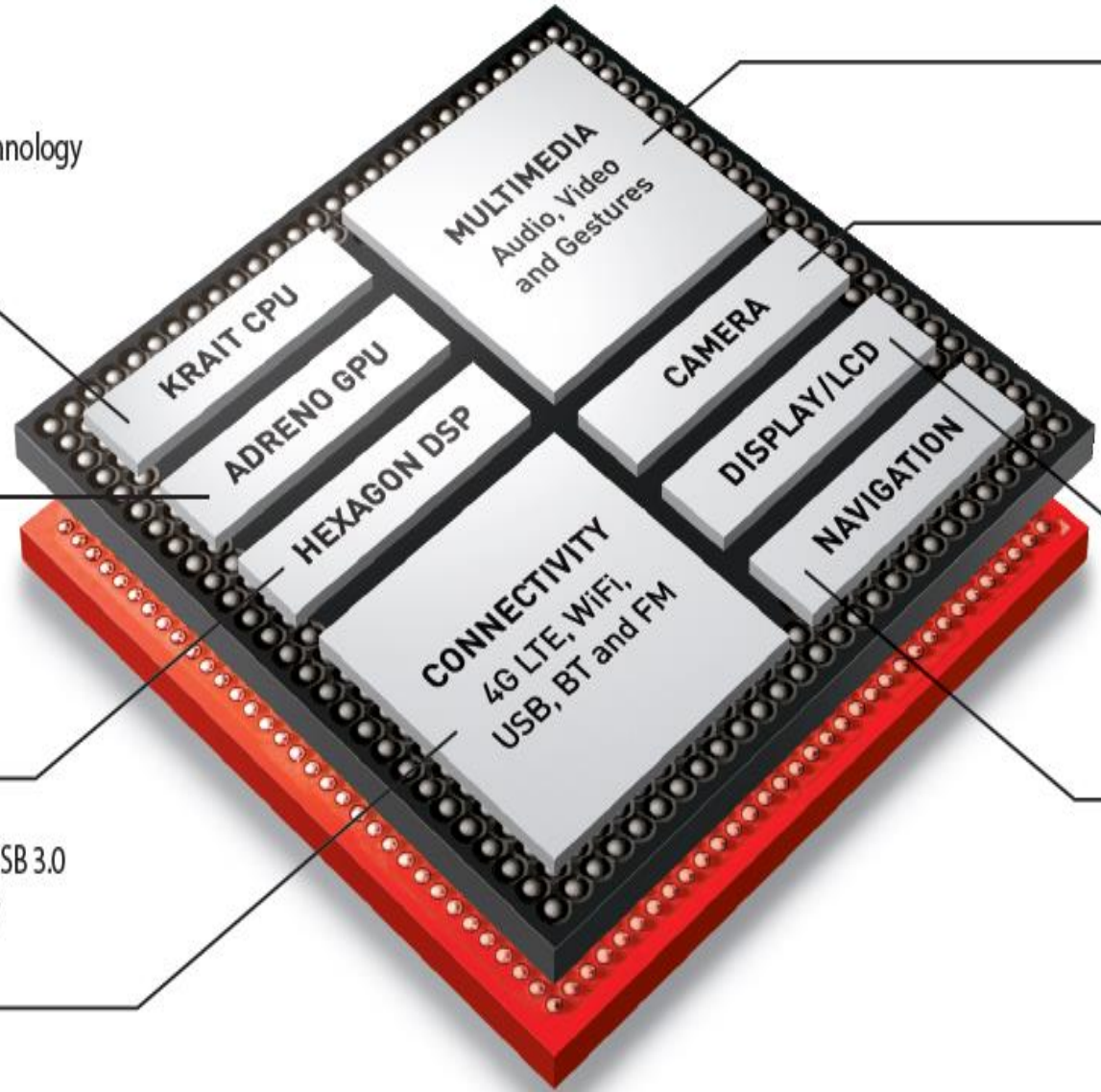
800 PROCESSOR

Krait 400 CPU
features 28HPm process technology
superior
2GHz+ performance

Adreno 330 for
advanced graphics

Hexagon QDSP6
for ultra low power
applications and custom
programmability

Integrated LTE[3], 802.11ac[3], USB 3.0
and BT 4.0 offers broad array
of high speed connectivity



Ultra HD Capture
and Playback

DTS-HD and Dolby
Digital Plus audio

Expanded Gestures

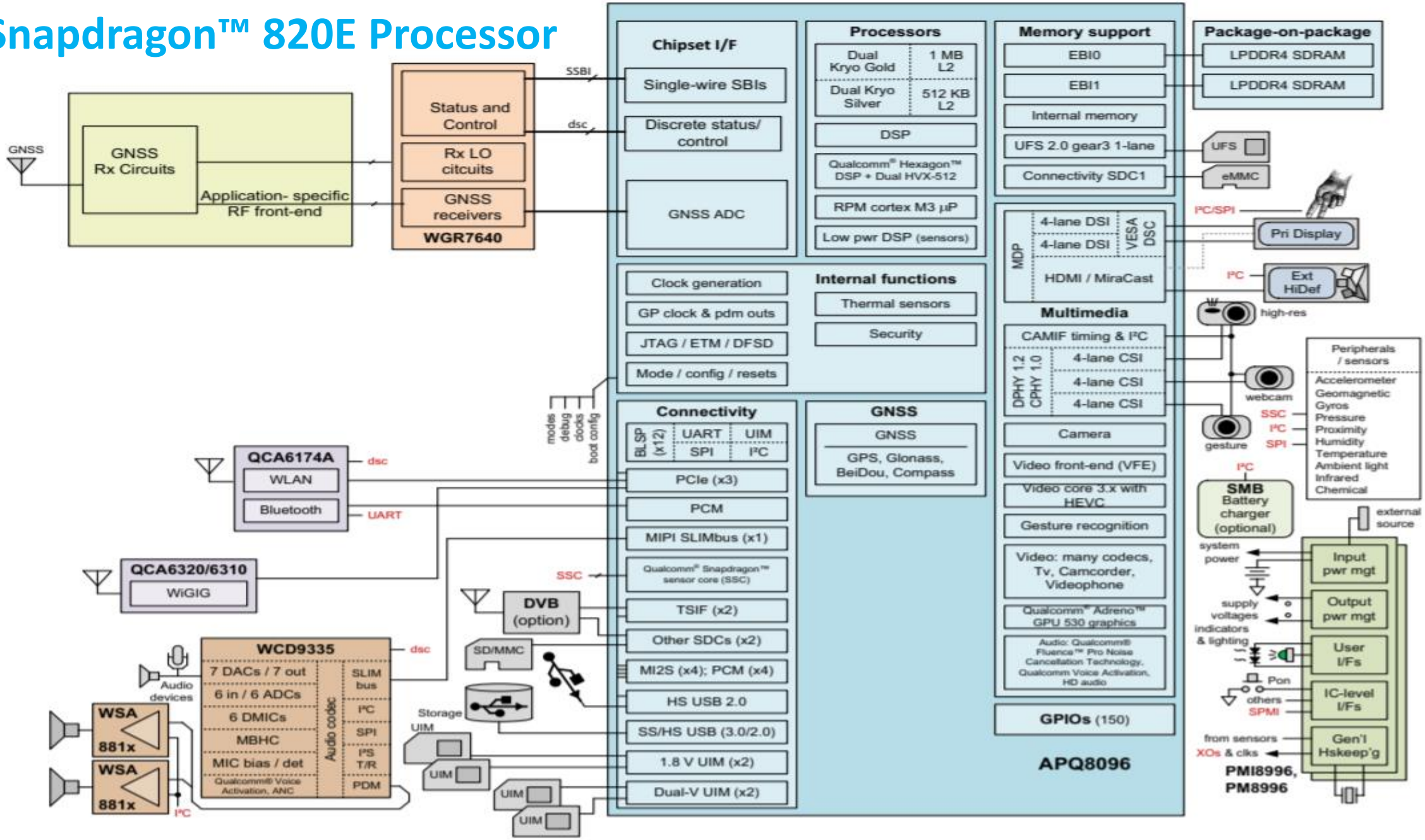
55MP with dual ISP

Support for up
to 2560x2048 display

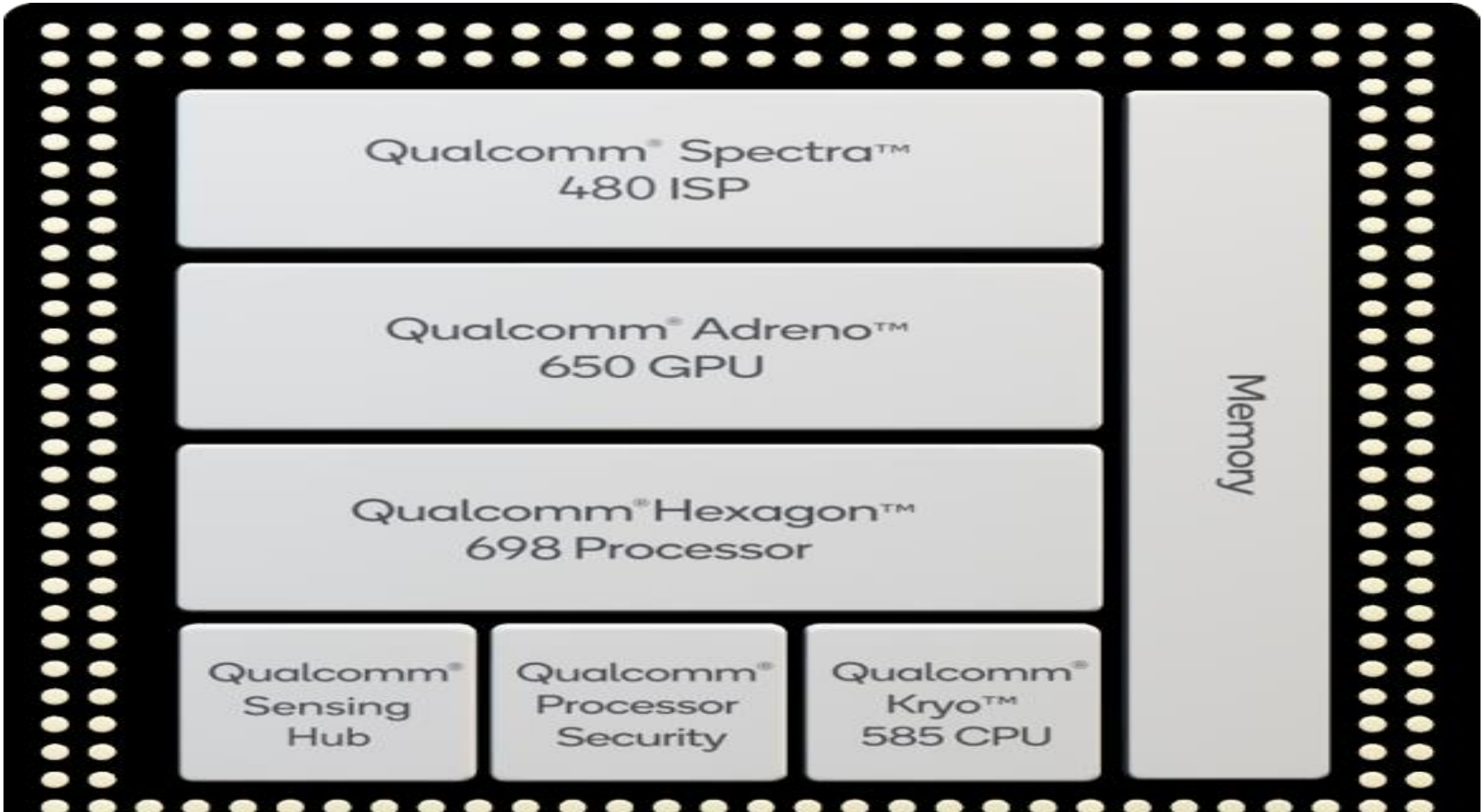
Miracast 1080p
HD support

IZat GNSS with
support for three
GPS constellations

Snapdragon™ 820E Processor



SoC 865


Qualcomm® Spectra™
480 ISP
Qualcomm® Adreno™
650 GPU
Qualcomm® Hexagon™
698 Processor
Qualcomm®
Sensing
Hub
Qualcomm®
Processor
Security
Qualcomm®
Kryo™
585 CPU
Memory

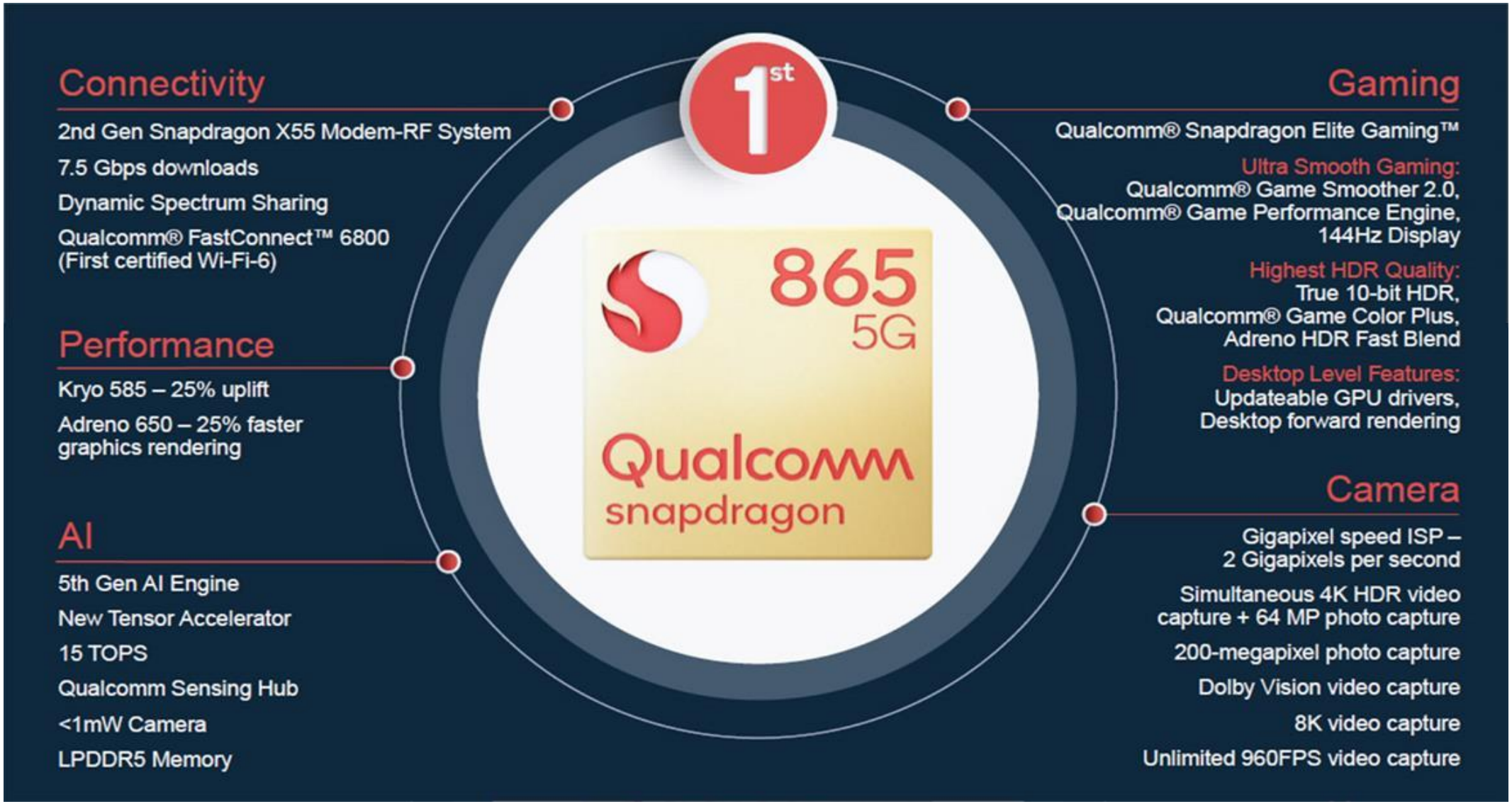
Artificial Intelligence

- Adreno 650 GPU
- Kryo 585 CPU
- Hexagon 698 DSP Processor : 15 trillion operations per second
  - Hexagon Tensor Accelerator
  - Hexagon Vector eXtensions
  - Hexagon Scalar Accelerator
- Qualcomm Sensing Hub:-Integrated directly into the AI engine
  - Ultra low power hub for audio, voice and sensors
  - Supports AI algorithms at low power
  - Support for fusing contextual data streams including sensors, audio and voice
  - Supports multiple voice assistants
  - Multi-mic far-field detection and echo cancellation
- It Provides intuitive mobile experiences in photography, gaming and voice interactions such as real-time AI translation

5G Modem-RF System

- Snapdragon X55 5G Modem-RF System
- Dynamic Spectrum Sharing
- Qualcomm® 5G PowerSave
- Qualcomm® Smart Transmit™
- Global 5G multi-SIM
- Downlink: Up to 7.5 Gbps
- Uplink: Up to 3 Gbps
- Multimode support: 5G NR, LTE including CBRS, WCDMA, HSPA, TD-SCDMA, CDMA 1x, EV-DO, GSM/EDGE Wi-Fi & Bluetooth

Features [2]


Connectivity
2nd Gen Snapdragon X55 Modem-RF System
7.5 Gbps downloads
Dynamic Spectrum Sharing
Qualcomm® FastConnect™ 6800
(First certified Wi-Fi-6)
Performance
Kryo 585 – 25% uplift
Adreno 650 – 25% faster
graphics rendering
AI
5th Gen AI Engine
New Tensor Accelerator
15 TOPS
Qualcomm Sensing Hub
<1mW Camera
LPDDR5 Memory
1st
865
5G
Qualcomm
snapdragon
Gaming
Qualcomm® Snapdragon Elite Gaming™
Ultra Smooth Gaming:
Qualcomm® Game Smoother 2.0,
Qualcomm® Game Performance Engine,
144Hz Display
Highest HDR Quality:
True 10-bit HDR,
Qualcomm® Game Color Plus,
Adreno HDR Fast Blend
Desktop Level Features:
Updateable GPU drivers,
Desktop forward rendering
Camera
Gigapixel speed ISP –
2 Gigapixels per second
Simultaneous 4K HDR video
capture + 64 MP photo capture
200-megapixel photo capture
Dolby Vision video capture
8K video capture
Unlimited 960FPS video capture

Kryo 585 CPU

- **Qualcomm Kryo** is a series of custom or semi-custom ARM-based CPUs included in the Snapdragon line of SoCs.
- These CPUs implement the ARMv8-A 64-bit instruction set, and serve as the successor to the previous 32-bit Krait CPUs.
- Kryo = Qualcomm custom
  - Kryo 2 = ARM Cortex-A73
  - Kryo 3 = ARM Cortex-A75
  - Kryo 4 = ARM Cortex-A76
  - Kryo 5 = ARM Cortex-A77

Cortex-A77

- It is designed for premium tier applications with very low-power consumption for applications like smartphones , laptops etc.
- H/W Implementation of AES
- Additional ALU, 160 instructions size Instruction Queue
- Designed in 7nm
- Low Power, high performance
- Support for xR and advanced ML in H/W

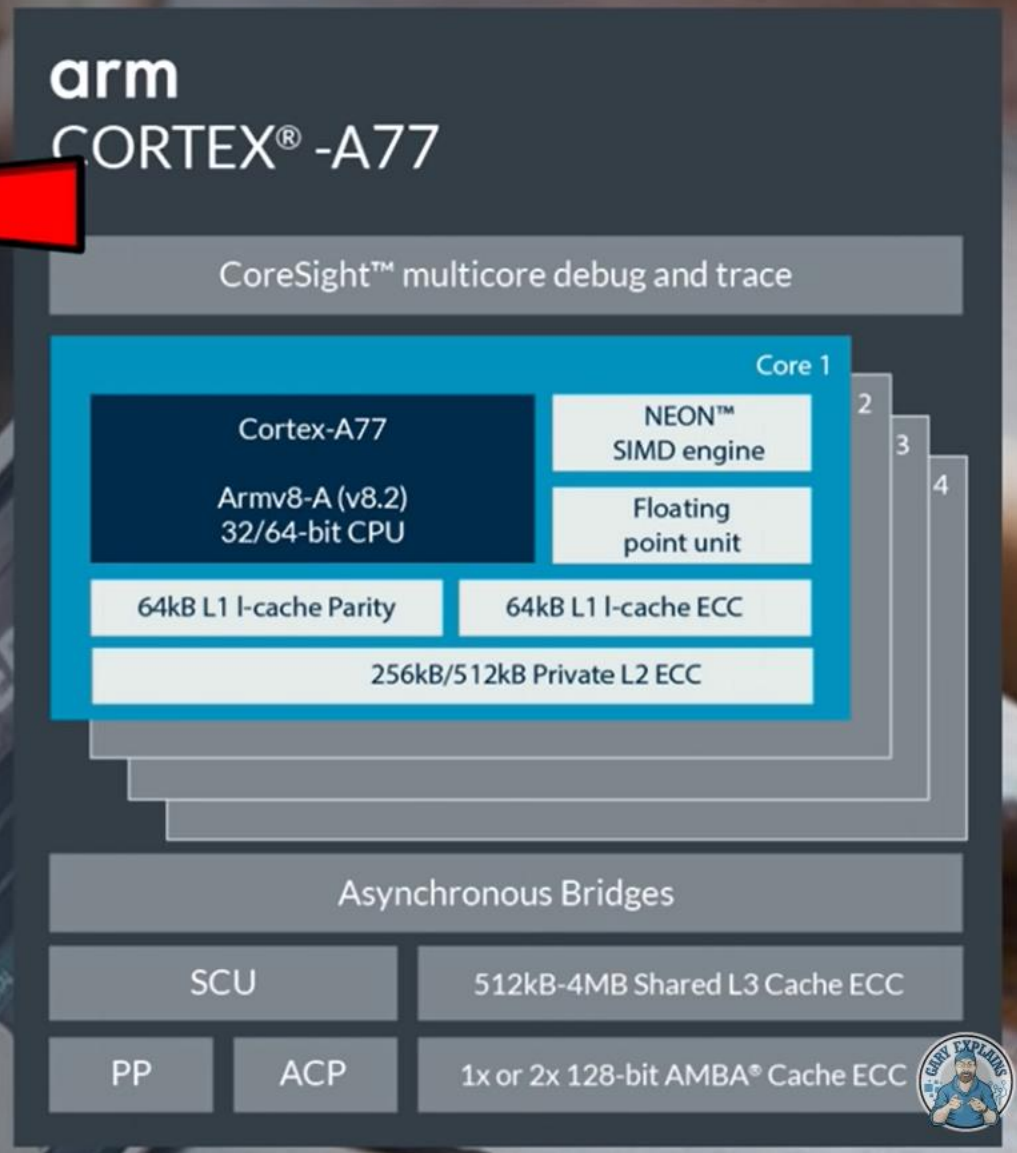
Core Name	Introduction	Microarchitecture	SoCs	SoC's
Kryo 240	Kryo 240 Silver	January 2020	Cortex-A53	Snapdragon 460
	Kryo 240 Gold		Cortex-A73	
Kryo 250	Kryo 250 Silver	June 2018	Cortex-A53	Snapdragon 632
	Kryo 250 Gold		Cortex-A73	
Kryo 260	Kryo 260 Silver	May 2017 April 2019 January 2020	Cortex-A53	Snapdragon 660 Snapdragon 665 Snapdragon 662
	Kryo 260 Gold		Cortex-A73	
Kryo 280	Kryo 280 Silver	November 2016	Cortex-A53	Snapdragon 835
	Kryo 280 Gold		Cortex-A73	
Kryo 360	Kryo 360 Silver	May 2018	Cortex-A55	Snapdragon 710
	Kryo 360 Gold		Cortex-A75	
Kryo 385	Kryo 385 Silver	December 2017	Cortex-A55	Snapdragon 845
	Kryo 385 Gold		Cortex-A75	
Kryo 460	Kryo 460 Silver	October 2018	Cortex-A55	Snapdragon 675
	Kryo 460 Gold		Cortex-A76	
Kryo 465	Kryo 465 Silver	January 2020	Cortex-A55	Snapdragon 720G
	Kryo 465 Gold		Cortex-A76	
Kryo 470	Kryo 470 Silver	April 2019	Cortex-A55	Snapdragon 730/730G
	Kryo 470 Gold		Cortex-A76	
Kryo 485	Kryo 485 Silver	December 2018	Cortex-A55	Snapdragon 855
	Kryo 485 Gold		Cortex-A76	
Kryo 495	Kryo 495 Silver	December 2018	Cortex-A55	Snapdragon 8cx
	Kryo 495 Gold		Cortex-A76	
Kryo 595	Kryo 595 Silver	December 2019	Cortex-A55	Snapdragon 865

Introducing Arm Cortex-A77: Redefined mobile performance

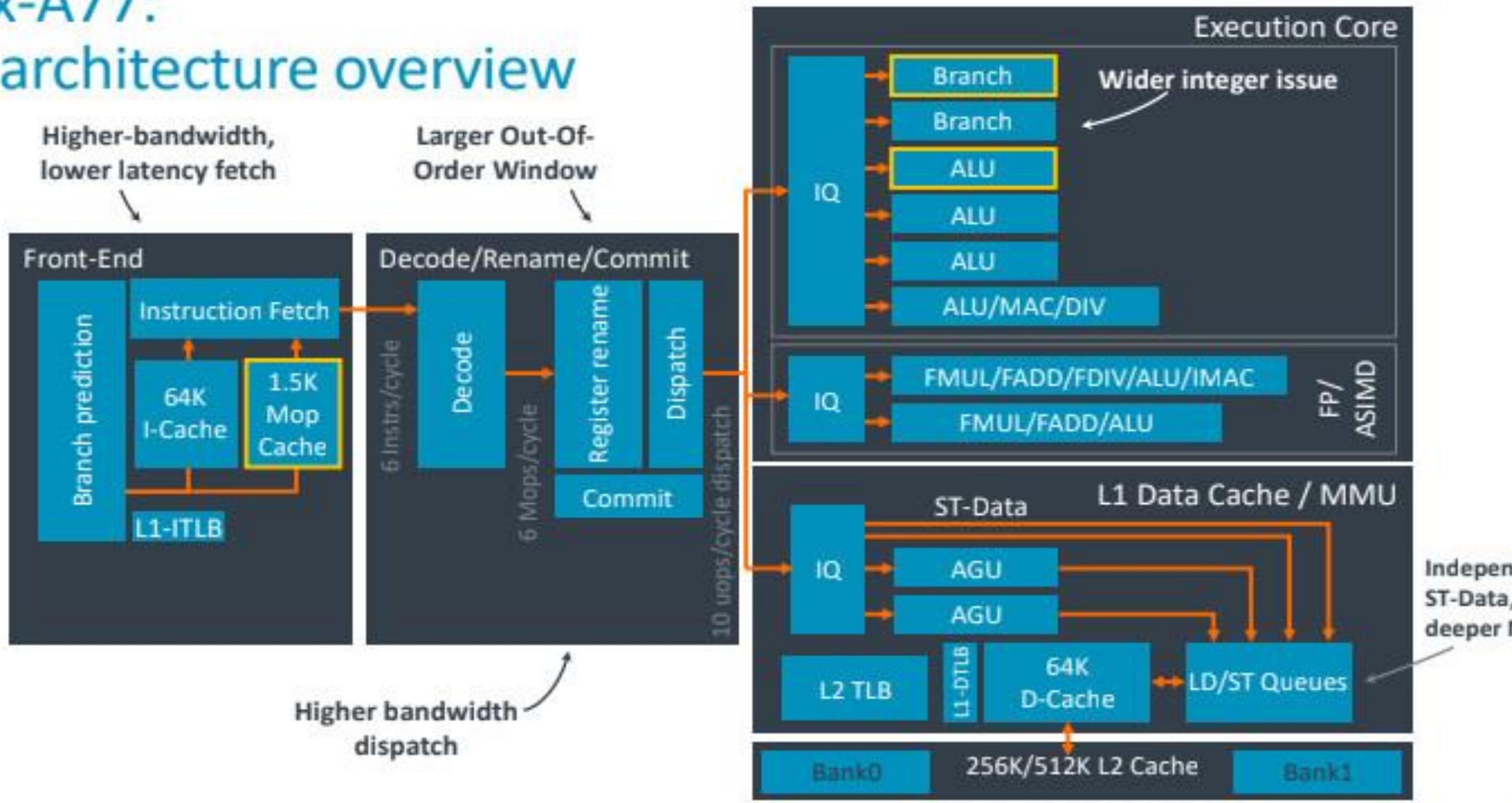
- Cortex-A77 represents Arm's continued push for more performance at best-in-class efficiency
  - Development built on the efficient Cortex-A76 design template
- Cortex-A77 is the 2nd generation design bringing substantial performance upgrade over Cortex-A76
  - 20+ percent more IPC performance
- Cortex-A77 is built for next-generation smartphones and laptops
  - Ideal to support upcoming use cases like xR and advanced ML

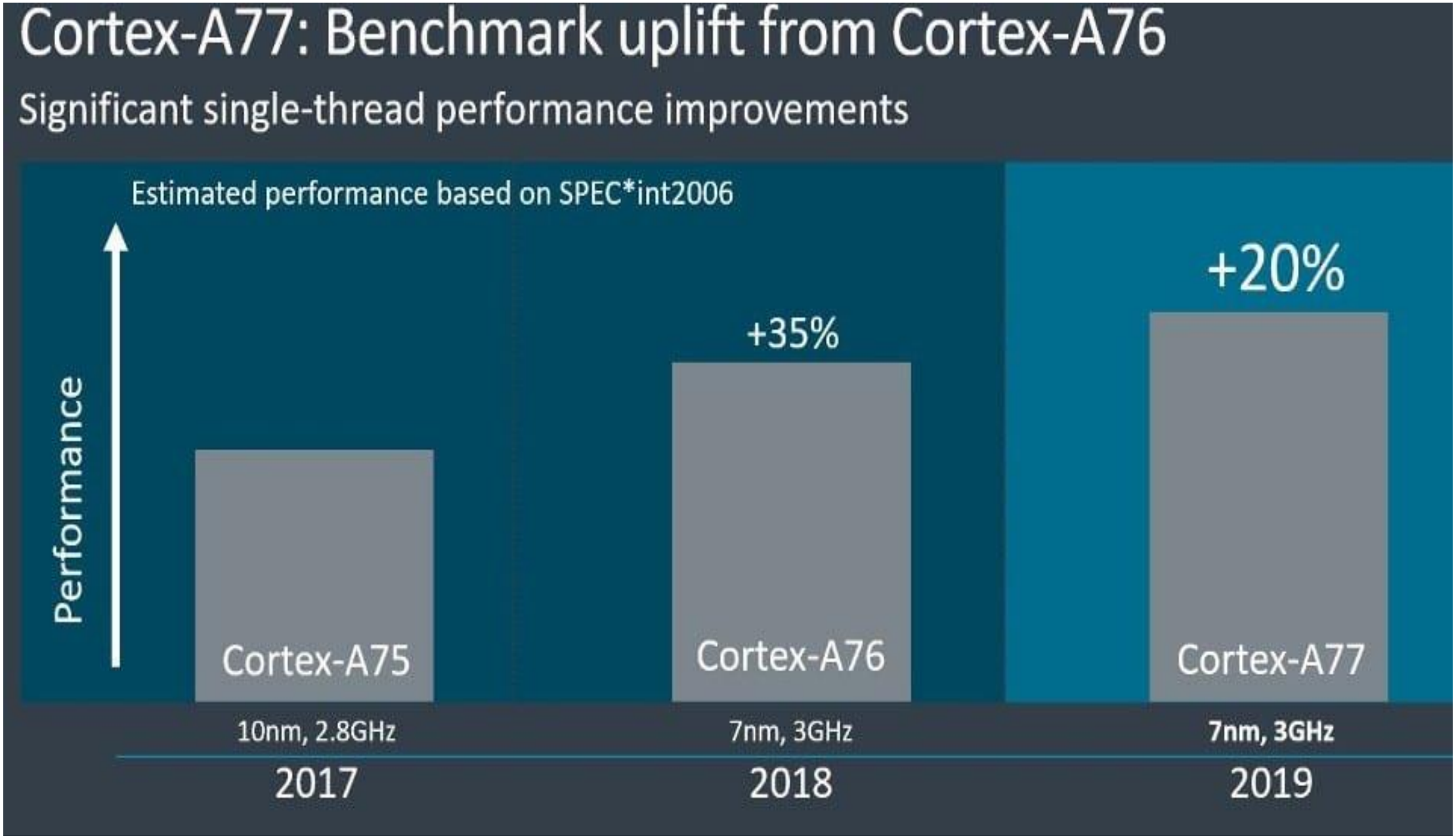
Cortex-A77: Redefined mobile device performance

- Built with upgrades in mind
  - Key architecture and interfaces aligned with Cortex-A76
  - Support for DynamIQ Shared Unit (DSU)
- Key features:
  - Armv8.2 architecture, AArch32 and AArch64 support
  - 64KB L1 I/D caches
  - 256KB and 512KB private L2 caches
  - Up to 4MB shared L3 cache
- big.LITTLE capable using Cortex-A55



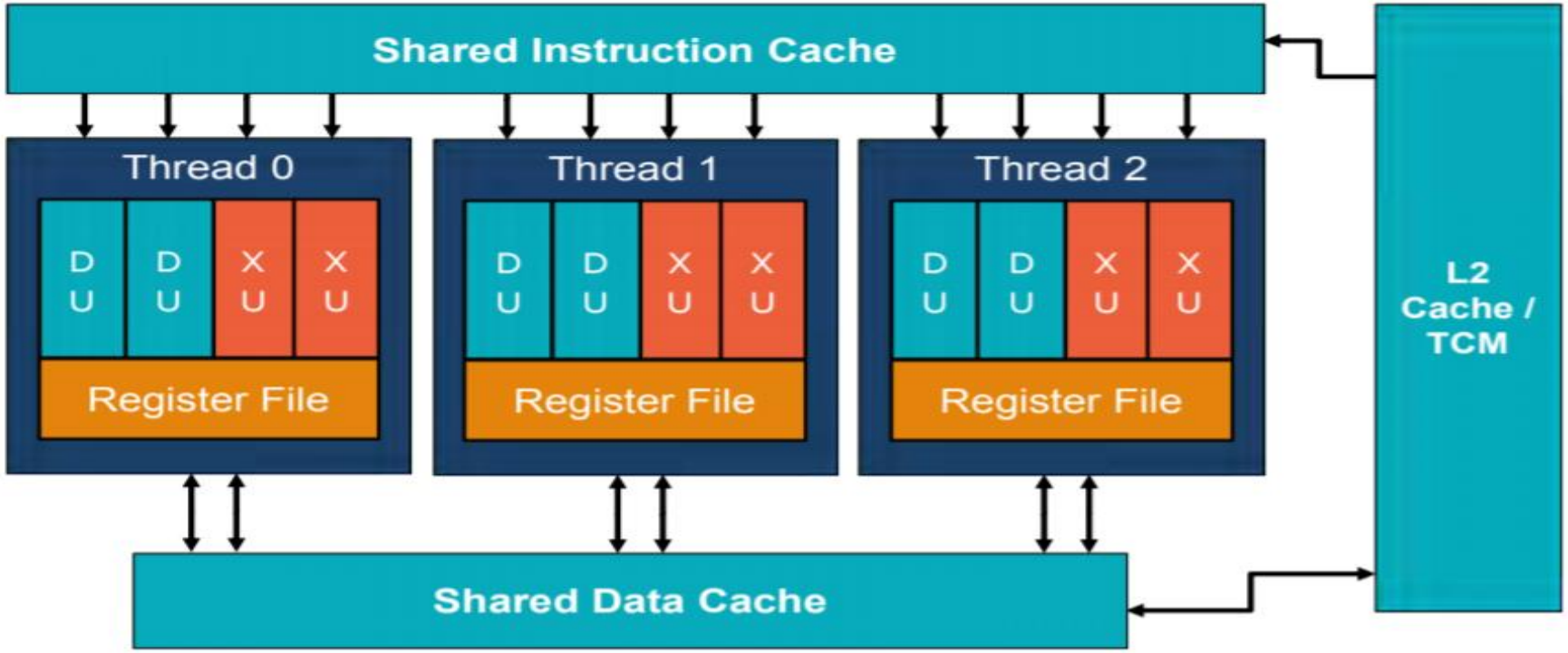
Cortex-A77: Microarchitecture overview



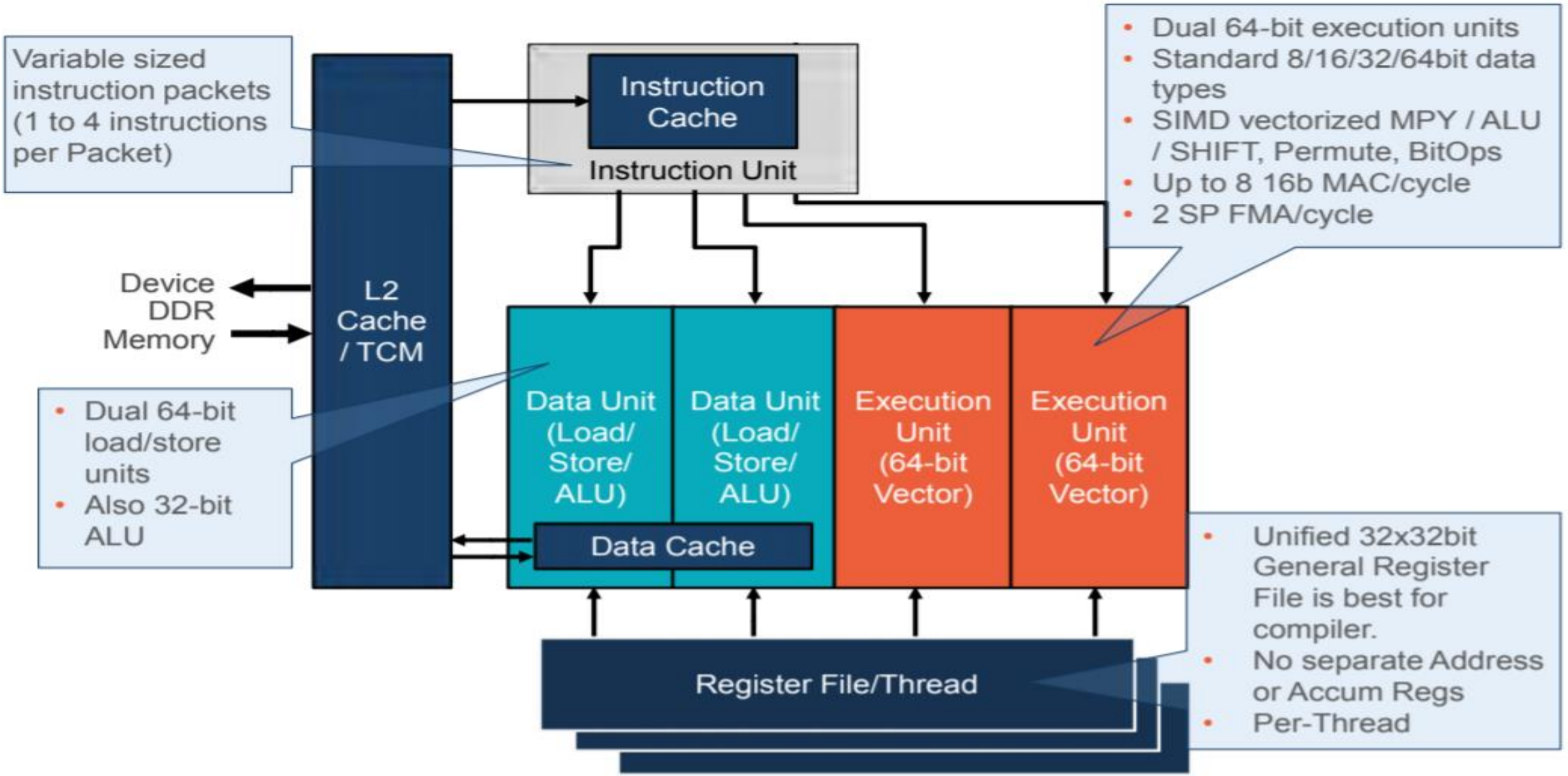

Cortex-A77: Benchmark uplift from Cortex-A76
Significant single-thread performance improvements
Estimated performance based on SPEC*int2006
Performance
+35%
+20%
Cortex-A75
Cortex-A76
Cortex-A77
10nm, 2.8GHz
7nm, 3GHz
7nm, 3GHz
2017
2018
2019

Hexagonal DSP

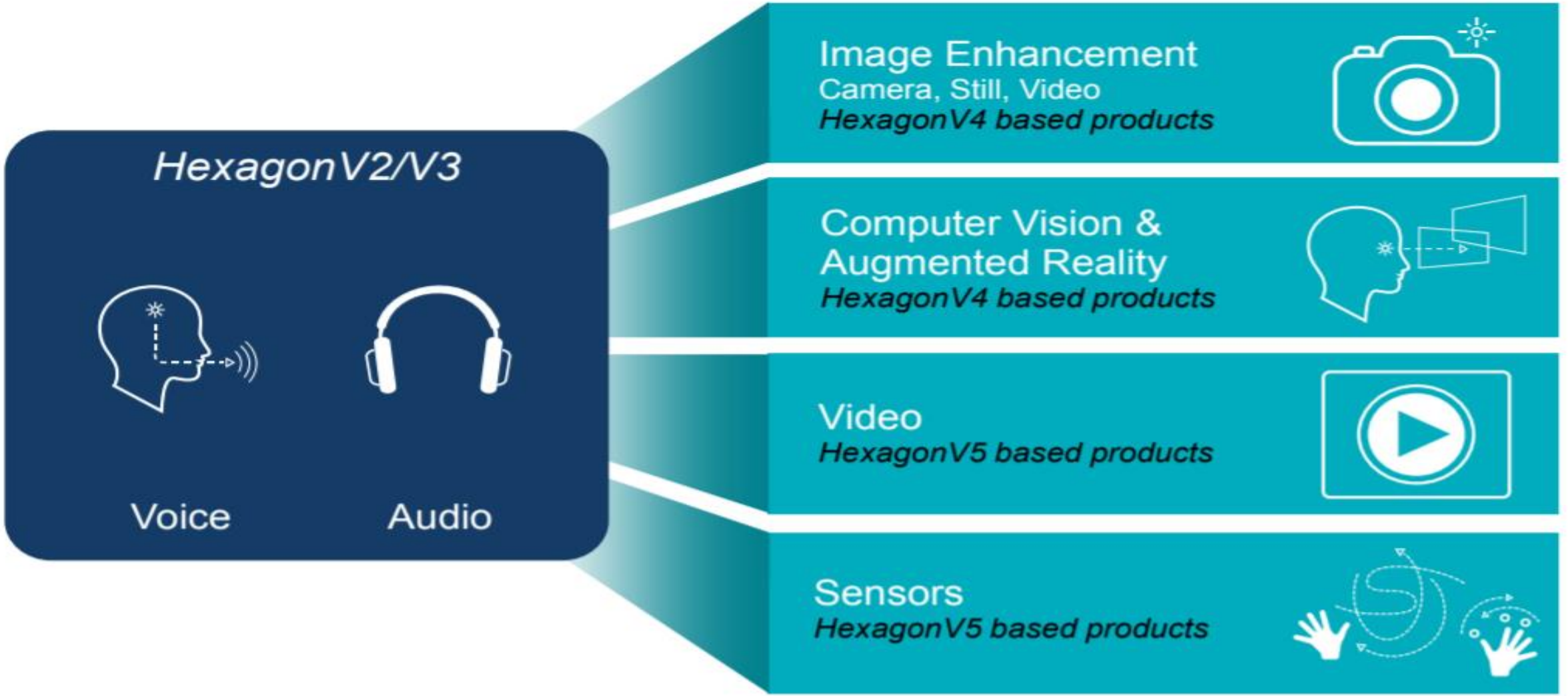
- Hexagon V5 includes three hardware threads
- Architected to look like a multi-core with communication through shared memory



VLIW: Area & power efficient multi-issue



Expansion of Hexagon DSP use cases beyond audio

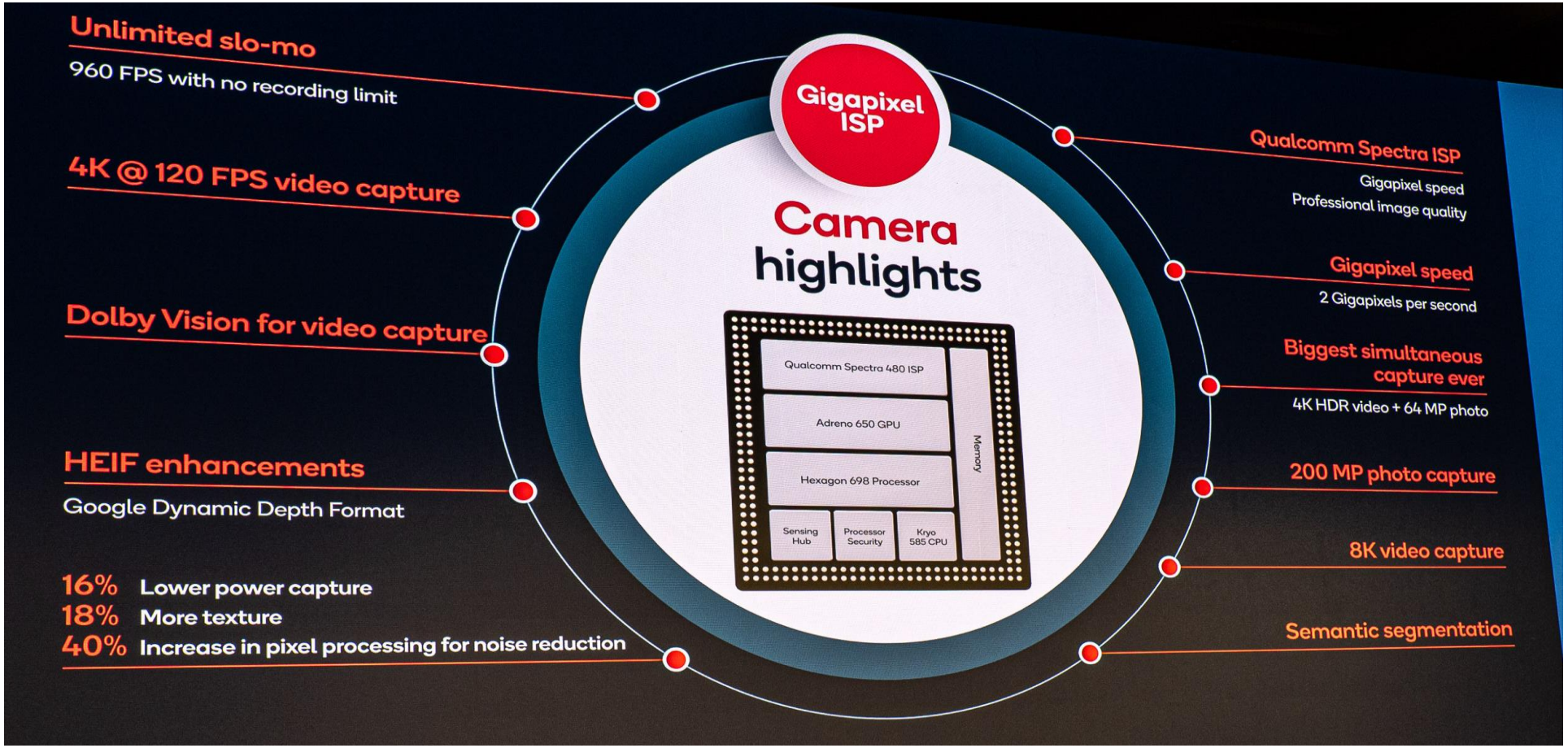


Hexagon DSP is evolving for use beyond voice and audio to computer vision, video and imaging features

Adreno 650 GPU

- **Adreno** is a series of graphics processing unit (GPU) semiconductor intellectual property cores developed by Qualcomm and used in a variety of their SoCs
- HDR gaming (10-bit color depth, Rec. 2020 color gamut)
- Physically Based Rendering
- API Support: OpenGL® ES 3.2, OpenCL™ 2.0 FP, Vulkan 1.1
- Hardware-accelerated H.265 and VP9 decoder
- HDR Playback Codec support for HDR10+, HDR10, HLG and Dolby Vision

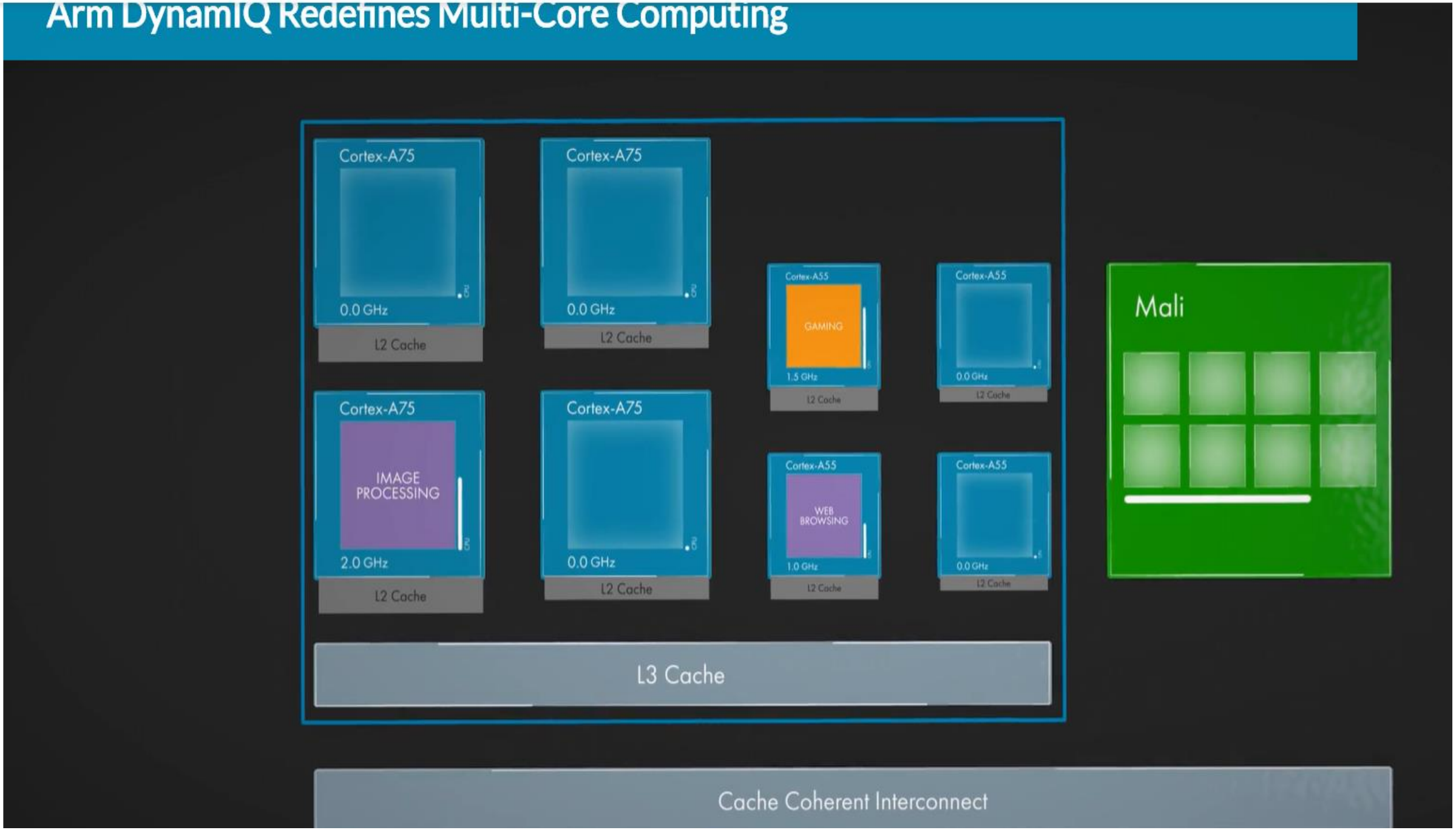
480 Image Signal Processor

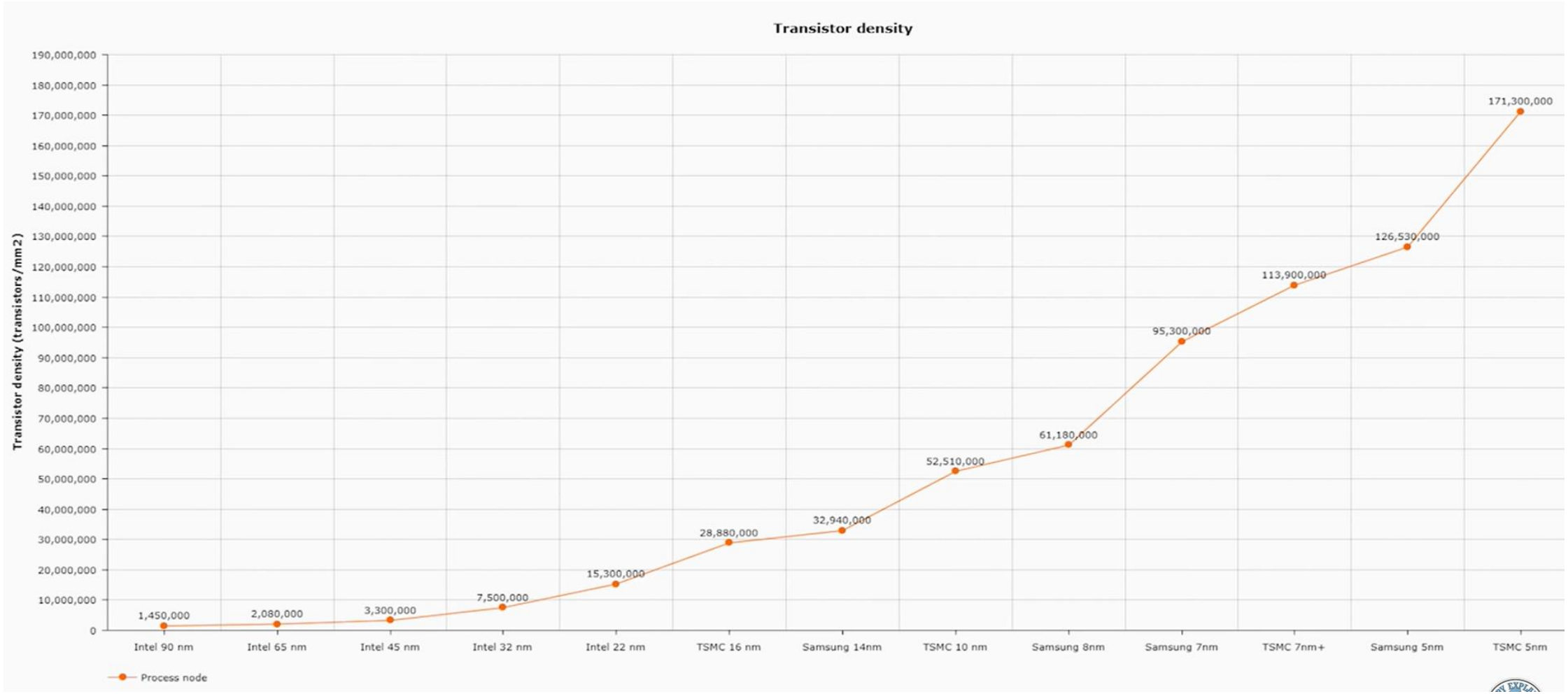


ARM’s DynamIQ Technology

- It is the new foundation for smarter, faster, and more powerful user experiences for the next generation of intelligent devices.
- It redefines multi-core computing by combining the big and LITTLE CPUs into a single, fully-integrated cluster
- Adds many new and enhanced benefits in power and performance
- DynamIQ is a new single cluster design with a mix of up to 8 different processors that unleashes configuration options never achieved before.
- This flexibility, combined with performance scalability, enables virtually unlimited design spectrum for a wide range of purpose-built solutions
- CPU can scale at different frequencies for customized solutions

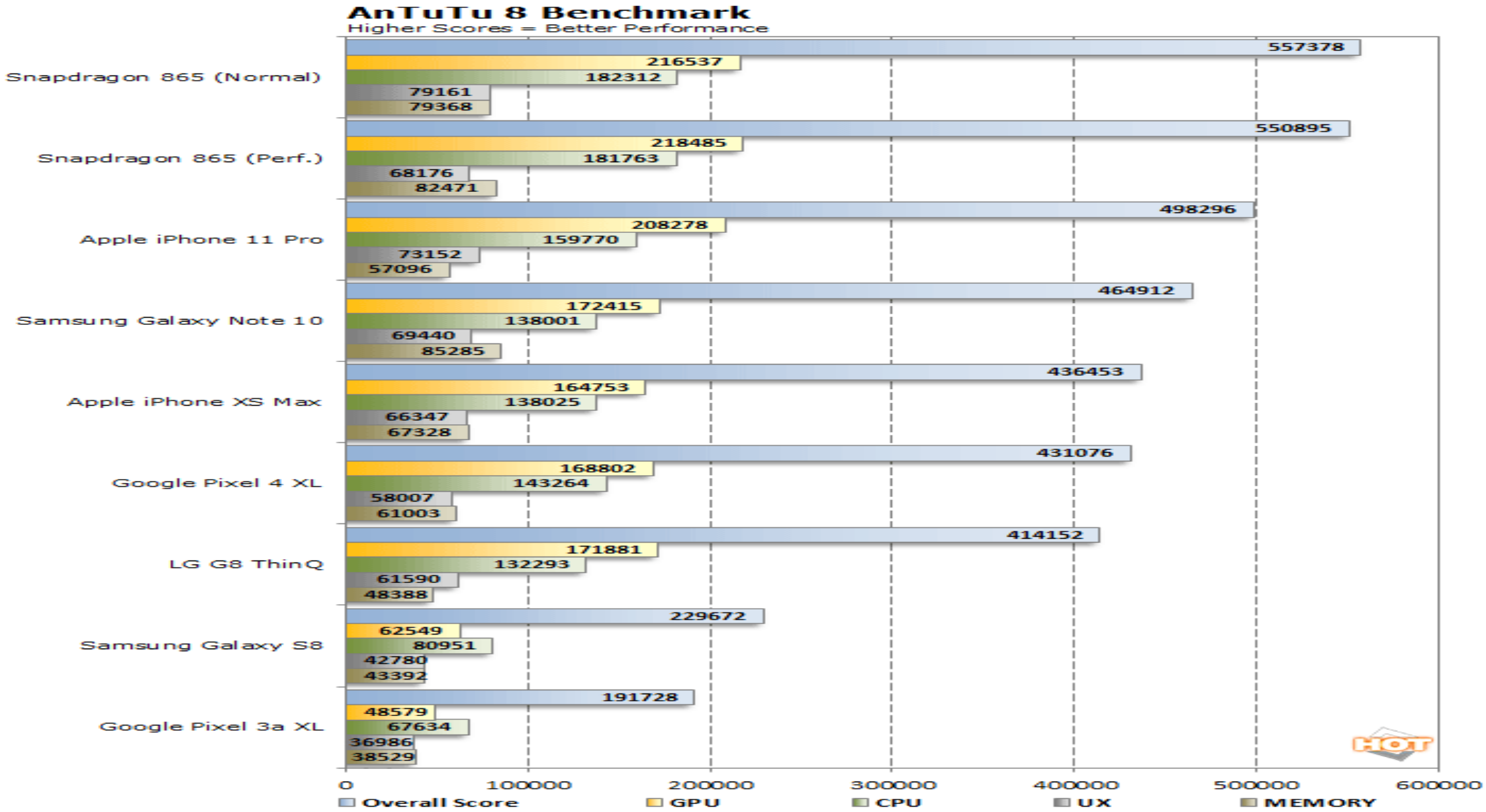
Arm DynamIQ Redefines Multi-Core Computing




Transistor density
Transistor density (transistors/mm2)
190,000,000
180,000,000
170,000,000
160,000,000
150,000,000
140,000,000
130,000,000
120,000,000
110,000,000
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1,450,000
2,080,000
3,300,000
7,500,000
15,300,000
28,880,000
32,940,000
52,510,000
61,180,000
95,300,000
113,900,000
126,530,000
171,300,000
Intel 90 nm
Intel 65 nm
Intel 45 nm
Intel 32 nm
Intel 22 nm
TSMC 16 nm
Samsung 14nm
TSMC 10 nm
Samsung 8nm
Samsung 7nm
TSMC 7nm+
Samsung 5nm
TSMC 5nm
Process node

SoC [3]	Snapdragon 865	Snapdragon 855
Model/ Part Number	SDM865, SM8250	SDM855, SM8150
CPU Cores	Octa-core, Qualcomm Kryo 585	Octa-core, Qualcomm Kryo 485
CPU Clock Speed	Up to 2.84 GHz	Up to 2.84 GHz
CPU Combination	1x Kryo 585 (ARM Cortex A77-based) @ 2.84GHz 3x Kryo 585 (ARM Cortex A77-based) @ 2.4GHz 4x Kryo 385 (ARM Cortex A55-based) @ 1.8GHz	1x Kryo 485 (ARM Cortex A76-based) @ 2.84GHz 3x Kryo 485 (ARM Cortex A76-based) @ 2.42GHz 4x Kryo 385 (ARM Cortex A55-based) @ 1.8GHz
CPU Architecture	64-bit	64-bit
GPU	Adreno 650 ; Vulkan 1.1	Adreno 640 @ 600MHz ; Vulkan 1.1
Process	7nm	7nm
Memory Type	LPDDR5 @ 2750MHz	LPDDR4 @ 2133MHz
Storage Type	UFS 3.0	UFS 3.0
5G Modem	2nd Gen Snapdragon X55 4G LTE and 5G	Snapdragon X50 5G , Snapdragon X24 4G LTE
Download Speeds	7.5Gbps over 5G(X55) & 2.5Gbps over 4G LTE(X55)	5Gbps over 5G(X50) & 2Gbps over 4G LTE(X24)
AI	5th generation AI Engine Hexagon 698 with 15 TOPS	4th generation AI Engine Hexagon 690 with 7 TOPS
ISP	Dual 14-bit Spectra 480 ISP	Dual 14-bit Spectra 380 ISP
Camera	Single: Up to 64MP; ZSL or Up to 200MP	Single: Up to 48MP
Charging	Qualcomm Quick Charge 4+ & Quick Charge AI	Qualcomm Quick Charge 4+
Display	Max On-Device Display: 4K @ 60 Hz, QHD+ @ 144 Hz Max External Display: 4K @ 60 Hz HDR: HDR10+, HDR10	Max On-Device Display: 4K Ultra HD Max External Display: 4K Ultra HD HDR: HDR10+

Performance Benchmarking [2]



References

1. https://www.qualcomm.com/media/documents/files/qualcomm-snapdragon-865-5g-mobile-platform-product-brief.pdf

2. https://hothardware.com/photo-gallery/Article/2932?image=big_snapdragon-865-specs.jpg&tag=popup

3. https://www.dealntech.com/snapdragon-865-vs-855/[Comparisons]

4. https://www.androidauthority.com/arm-cortex-a77-cpu-990172/

5. https://www.youtube.com/watch?v=Ic8nMpGWFd0