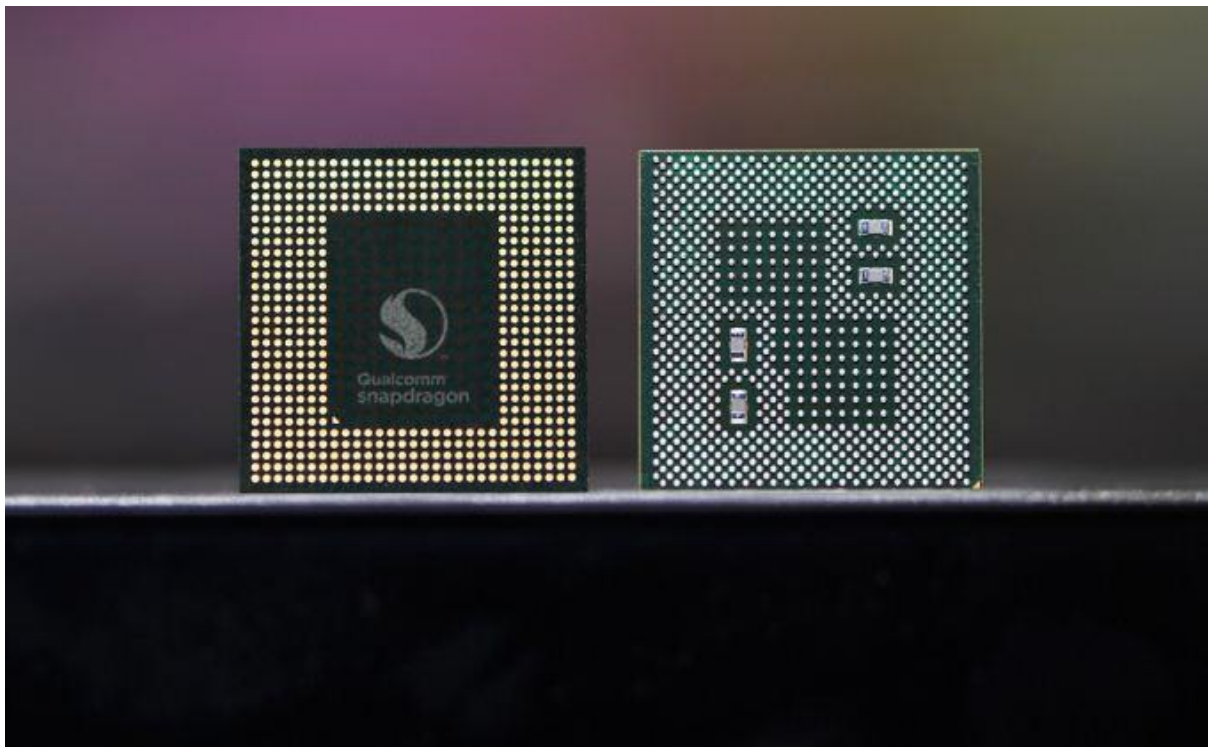




ENGI 6861: COMPUTER ARCHITECTURE

QUALCOMM SNAPDRAGON 845



Name: Viren Sagpariya

Student ID: 201991237

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Abstract

Mobile Computing is one of the most leading and increasing industry in the world. Demand of the smartphones are increasing day by day with its efficiency and more faster devices. In every device **processor** is the most important thing. The capability is different with every kind of processor as new invention of technology comes. Qualcomm is the most emerging **System on chip (SoC)** manufacturer in the world. My report includes the most significant invention of Qualcomm's snapdragon 845 processor.

Introduction

In today's modern era everyone needs a personal assistance that is mobile phone. Technology and with the help of AI (Artificial Intelligence) it is very easy for us to live intelligence life. This is all because of the invention of personal mobile devices. It is the smaller version of computer as compared to performance and efficiency of the processor of CPU.

Each generation of mobile chip is inventing more compact and intelligent functionality in the processors. All these improvements are because of the architecture of these ICs and platform of the processors. Modern and high-tech processors are made only because of the parallel multicore functionality of processors instead of more than one single core processors on a chip. Snapdragon 845 or SD845 is considered as the most efficient and powerful processor in the mobile computing industry. CPU and GPU architecture has a huge contribution in revolutionary invention in the smartphone world.

History and Evolution of snapdragon 800 series

Qualcomm offers a huge number of mobile SoCs and among them the 800 series is the flagship range of processors that means it has very strong performance and efficiency. Company claimed the 800 was the first type of SoC that has clock speed of 2.3 GHz and multicore CPU like 4 cores and 32-bit architecture. By the time this series got improvements in performance, clock speed, architecture and cooling system etc.

After launching the 805 SoC which had improved clock speed at almost 2.7 GHz with improved CPU architecture the graph of demand of these SoCs went up. Those chips were manufactured on 28nm platform and then 808 SoC was introduced with hexacore CPU. It was considered as most efficient at that time with 2 ARM A-57 cores and 4 ARM A-53 cores with 64-bit architecture but major down of that chip was lower clock speed of 2 GHz, after that 810 comes with 8 cores and 4 ARM A-57 cores and 4 ARM A-53. In 2015, Qualcomm announced SD 820 and it has quad core Kryo CPU with 2.2 GHz clock speed, it was built on 14nm FinFET platform.

First mobile device which was using Qualcomm SD 845 was introduced in 2018 as it was made on 10nm FinFET LPP platform. It is 30% more efficient than previous SD that is 835 and more powerful.

The Snapdragon 845 is able to follow up on what ended up being a rather well received Snapdragon 835 platform by introducing a number of important design changes over its predecessor and see if Qualcomm will maintain its momentum.

Architecture

SD 845 is a SoC that has more than one blocks of specific application. Kryo 385 is CPU.



SD 845 Architecture

Other components like hexagon 685 DSP, Adreno 630 GPU with system memory, Spectra 280 ISP and X20 LTE modem that helps with more powerful connectivity on device.

Qualcomm Spectra 280 Image Signal Processor: The

Qualcomm Spectra 280 ISP is designed to deliver a premium camera and XR experience, with high-performance capture of up to 16 MP at 60 images per second. Video enthusiasts will appreciate cinema-like quality video thanks to ultra HD premium capture with richer colour.

Qualcomm Adreno 630 Visual Processing Subsystem:

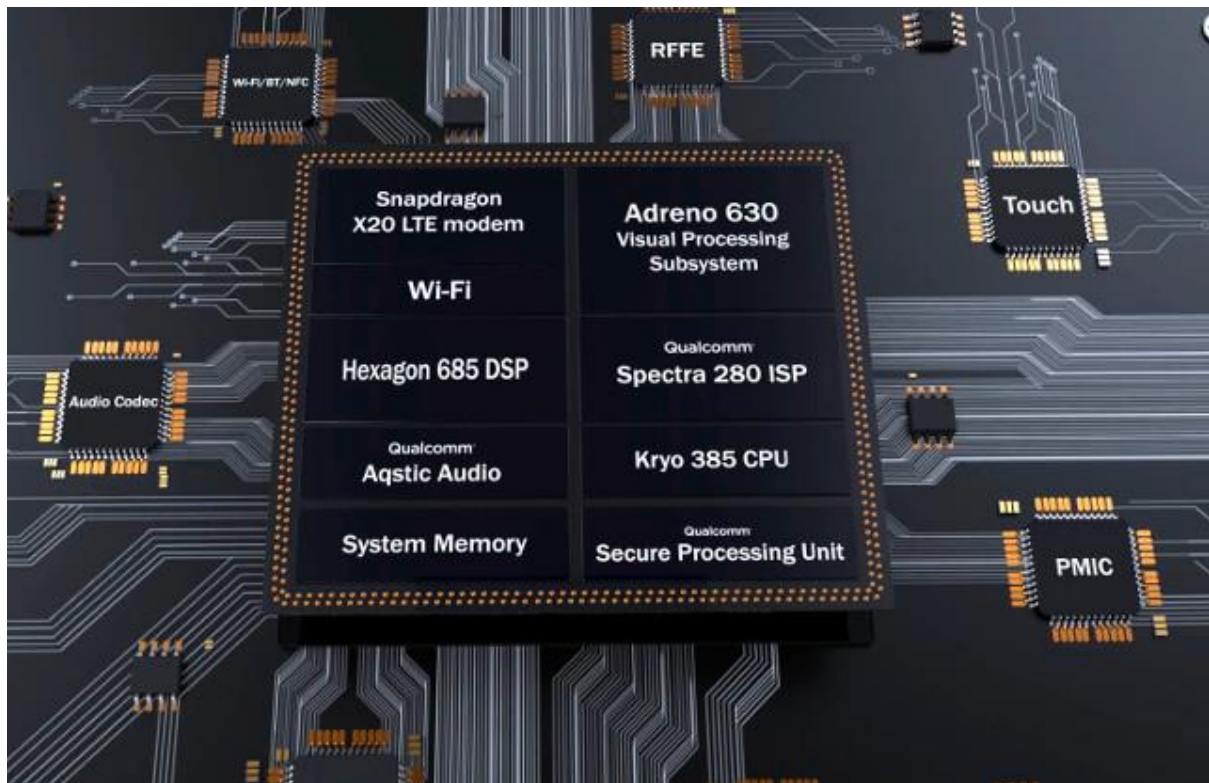
Deliver larger-than-life immersive experiences with the Qualcomm Adreno 630 Visual Processing Subsystem (including GPU, VPU and DPU), featuring room-scale 6DoF with SLAM, Adreno Foveation, and significantly improved graphics rendering and video processing compared to the previous generation.

Qualcomm Hexagon 685 DSP: The 3rd Generation Qualcomm Hexagon 685 DSP supports sophisticated, on-device AI processing, delivering richer camera, voice, XR and gaming experiences.

Qualcomm Snapdragon X20 LTE modem: Blazing fast Gigabit LTE download speeds with 5x carrier aggregation and 4x4 MIMO support, enhanced multi-gigabit 802.11ad with diversity module for robust performance, integrated 2x2 802.11ac Wi-Fi with MU-MIMO, BT5 with audio broadcast and ultra-low power ear bud support.

Qualcomm Kryo 385 CPU: Manufactured in 10nm LPP, optimized across 4 performance and 4 efficiency cores.

A customized off-the-shelf design from Arm, that Qualcomm says promises up to a 25 performance uplift compared with the last generation Snapdragon 835.



Snapdragon 845 SoC Architecture

CPU

KRYO 385

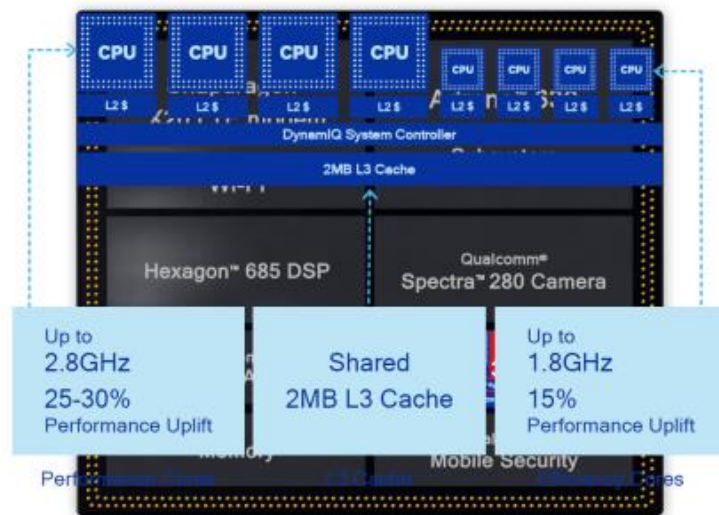
Built on Arm Cortex™ Technology
Latest 2nd Generation 10LPP FINFET

Microarchitecture

- Private per core L2 cache
- Arm DynamIQ technology
- 3 separate clock and voltage domains

Customizations for system integration

- Bus QoS service for memory throughput
- Page table additions for security



KRYO CPU Architecture

This new design does indeed appear to be based on Arm’s DynamIQ technology and latest Cortex-A75 and A55 CPU designs. 2 MB of shared L3 cache, a feature that was introduced with DynamIQ to greatly improve task and memory sharing capabilities between different core types in the shared cluster.

Eight Kryo 385 CPU cores, with four A75 “performance” cores paired with four A55 “efficiency” cores. The four performance cores (Cortex-A75) clock up to 2.8 GHz and are paired with four energy efficient cores (Cortex-A55) that can reach 1.7 GHz. Presumably these are now sat in the same cluster, giving the potential for superior energy aware task scheduling and lower memory latency.

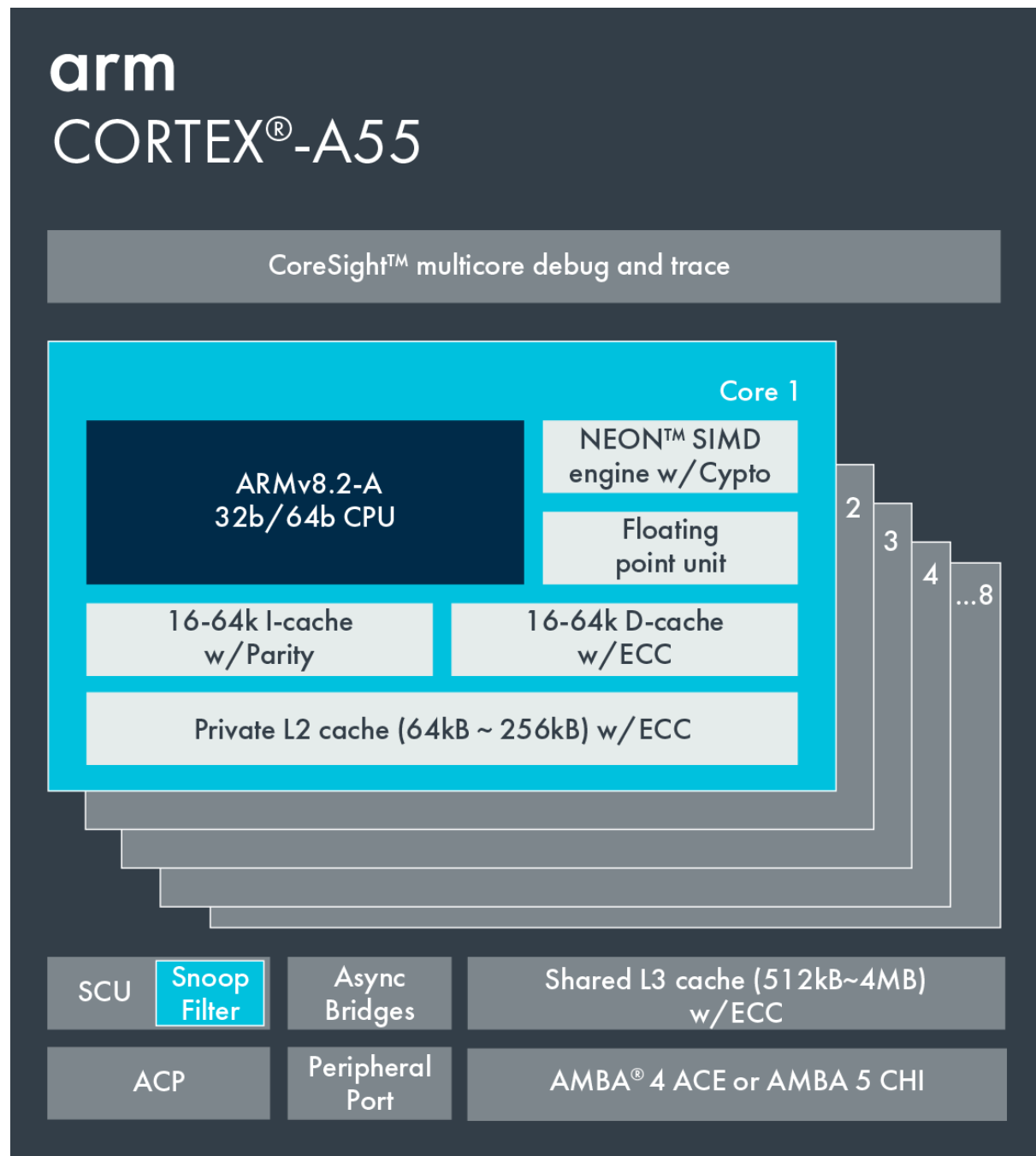
The new processor is said to be around 25 to 30 percent faster compared to Snapdragon 835, the Spectra camera and Adreno graphics architectures are claimed to increase power output by up to 30 percent, and the LTE modem is a bit faster (1.2 Gbps/150Mbps vs 1.0 Gbps/150Mbps).

	Snapdragon 845	Snapdragon 835	Snapdragon 821
CPU Core	Semi-custom ARM Cortex - Kryo 385	Semi-custom ARM Cortex - Kryo 280	Fully-custom - Kryo
CPU Config	4x 2.8GHz (Cortex-A75) 4x 1.7GHz (Cortex-A55)	4x 2.45GHz (Cortex-A73) 4x 1.9GHz (Cortex-A53)	2x 2.35GHz Kryo 2x 1.6GHz Kryo
GPU	Adreno 630	Adreno 540	Adreno 530
DSP	Hexagon 685 with HVX	Hexagon 682 with HVX	Hexagon 680
Process	10nm LPP FinFET	10nm LPE FinFET	14nm LLP FinFET

Difference between SD 845, 835 and 821

ARM Cortex-A55

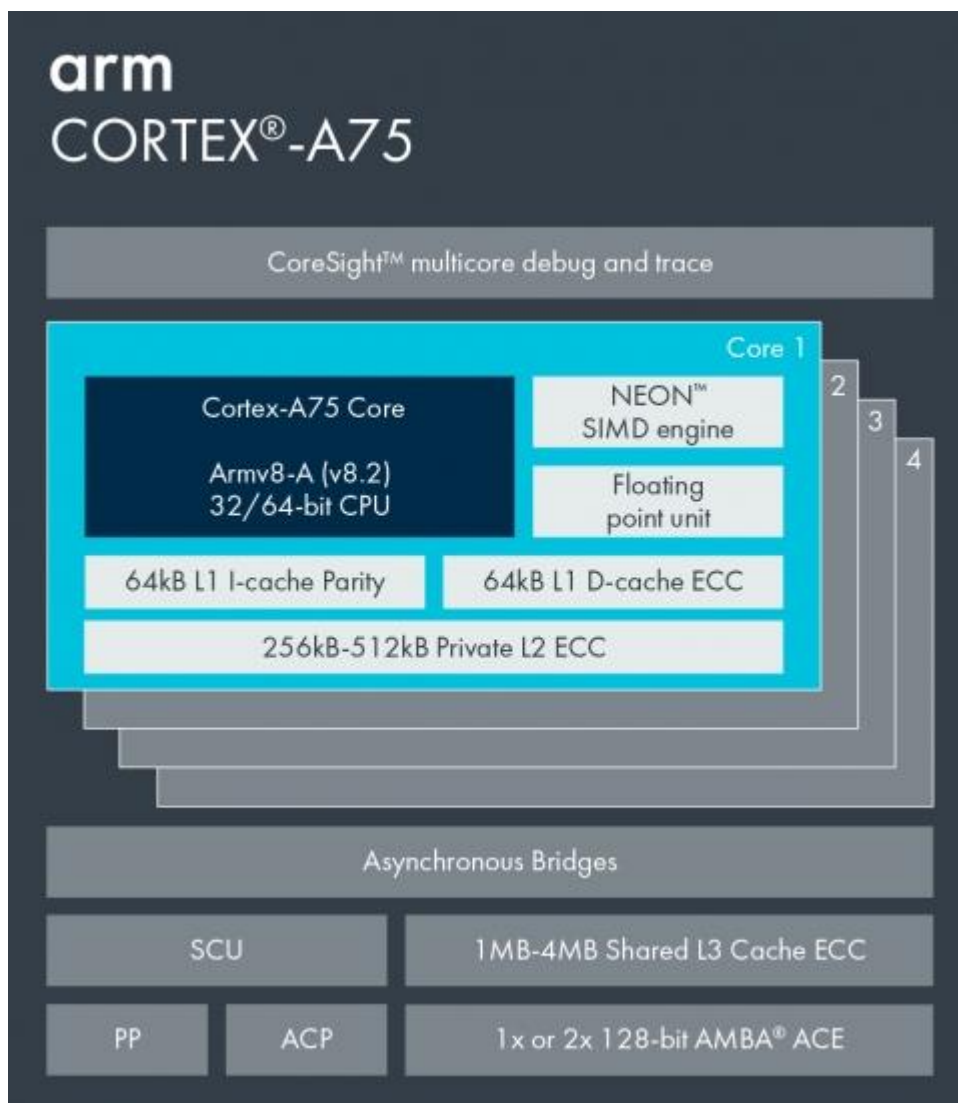
The ARM Cortex-A55 is a microarchitecture developed by the Cambridge design center of ARM Holdings to implement the ARMv8.2-A 64-bit instruction set. The Cortex-A55 is a superscalar2-wide decoding pipeline.



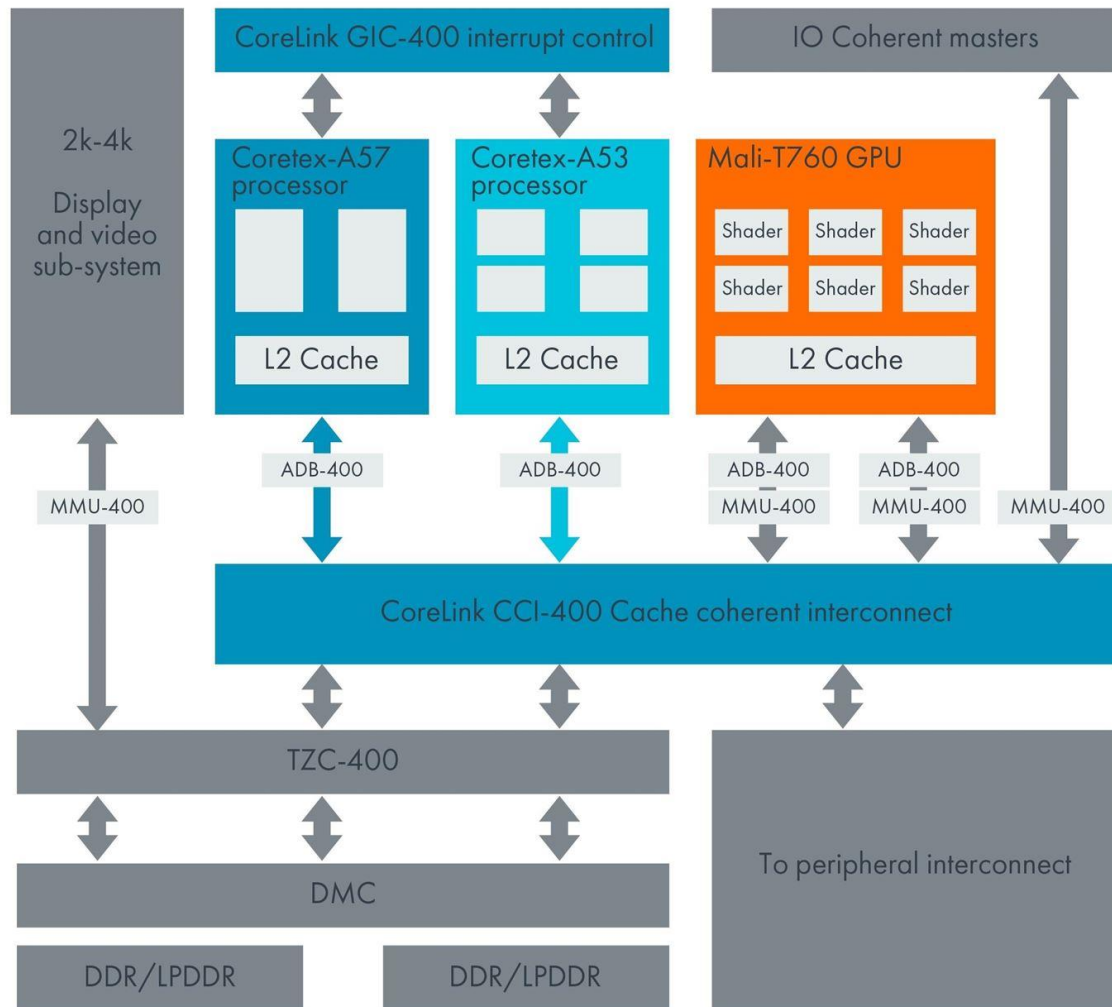
ARM Cortex-A55

ARM Cortex-A75

The ARM Cortex-A75 is a microarchitecture designed by the Sophia design center of ARM Holdings to implement the ARMv8.2-A 64-bit instruction set. The Cortex-A75 is a superscalar pipeline with 3-wide decoding out of order.



ARM Cortex-A75



SD Memory Architecture

Cortex A53 and A57 processors used in previous generation of SD architecture with cache memory and GPU with other components.

Graphical Processing Unit (GPU)

This is the most important part of SoC processor and computing architecture. Adreno series is used by Qualcomm in its SoCs. In SD845 Adreno 630 GPU is used

The GPU performs the processing of images and generates the final frame pixels. GPU reads the memory graphics data and produces pixel values. Tasks such as physics and AI include the use within the CPU of floating-point units.

A fresh GPU architecture is one of the bigger changes that the Snapdragon 845 carries with it. Qualcomm has historically been very discreet when sharing specifics of their Adreno GPUs, and here the Adreno 630 is no different. The only real sign we are looking at is the transition from the Adreno 5xx series to the Adreno 6xx series, reality to be told.

Adreno 630
Visual Processing Subsystem:
Significant upgrades in power
and performance

30%

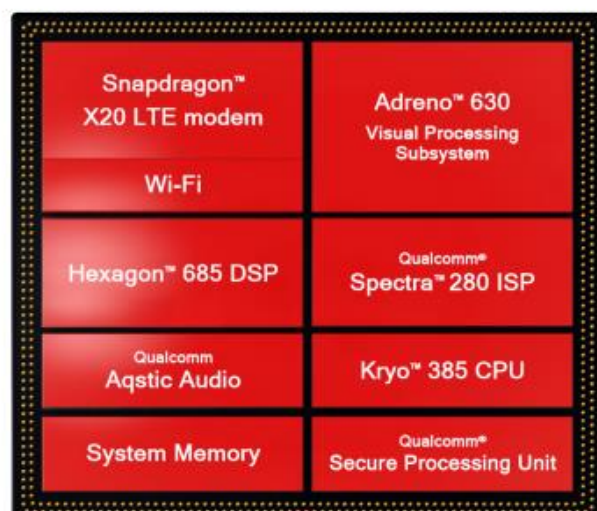
Better graphics performance

30%

power reductions

2.5x

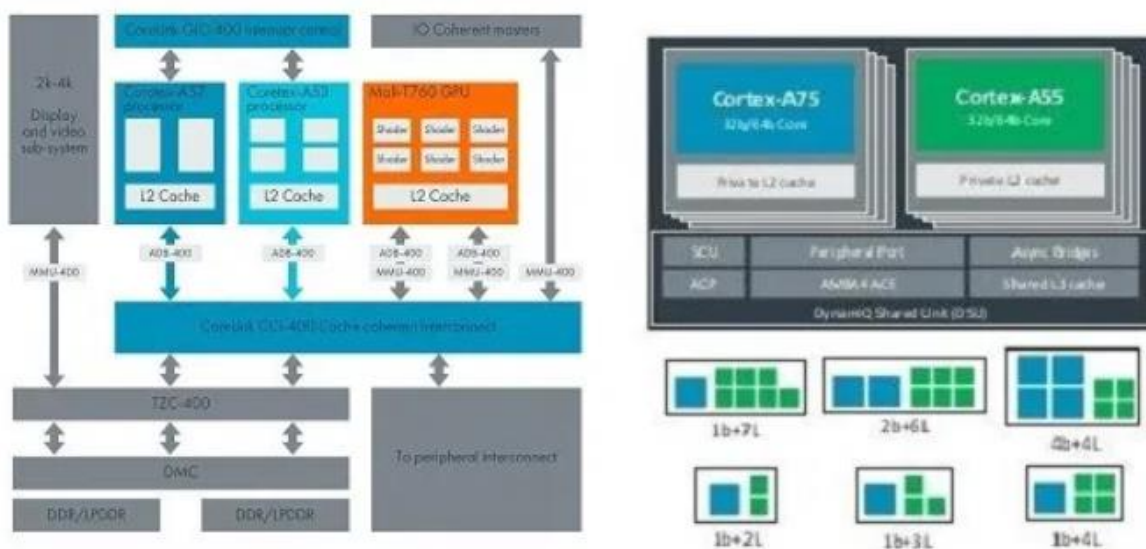
faster display throughput



Adreno 630 GPU

Although the Adreno 630 remains largely a black box, we know what the GPU claims of Qualcomm are. Overall, we are looking at 30% better performance and a 30% increase in energy. The latter point is something that Qualcomm wanted to highlight both in the announcement of the Snapdragon 845 and in this benchmarking case, but it needs to be explained that the increase in power is calculated.

The Snapdragon 845 is the first SoC to employ the latest DynamIQ cluster technology from ARM, as we mentioned earlier. The multiple CPU cores are no longer located in separate cluster subsystems, but are now merged into a larger cluster of DynamIQ. This change means that the cluster cache called the L2 cache is now the L3 cache and the individual CPU cores are now given a new private cache.



On the left we have big.LITTLE architect whereas on the right we have the DynamIQ SoC layout. Image Credit: ARM

Memory

Qualcomm SD 845 uses LPDDR4x memory that is 4x16-bit and 1866 MHz with 8 GB of RAM

The DDR-SD RAM (Low Power Double Data Rate Synchronous Dynamic Random-Access Memory) lower power variant is the LP-DDR memory. LP-DDR reduces the voltage from 2.5 to 1.8V, which is very important in mobile applications, in order to reduce power consumption.

The LPDDR memory development has now taken voltage levels in LPDDR 4 from 1.8V to 1.1V. The LPDDR4X reduces the power consumption by almost 20% compared to the LPDDR4. Power Consumption is lower with high performance with this RAM and this is the one of reasons to use this type of memory in SoC.

Hexagon 685 DSP

To understand what makes the Hexagon DSP so unique, it helps to know that AI is driven by the kind of math college engineering majors are intimately familiar with. Machine learning involves computation with large vectors, which poses a challenge for smartphone, tablet, and PC processors. It's hard for general-purpose chips to compute algorithms like stochastic gradient descent — the sorts of algorithms that are at the core of AI-powered apps — quickly and efficiently. Qualcomm's Hexagon DSP was introduced in part to solve this: It's great at handling image and sensor data, especially photography.

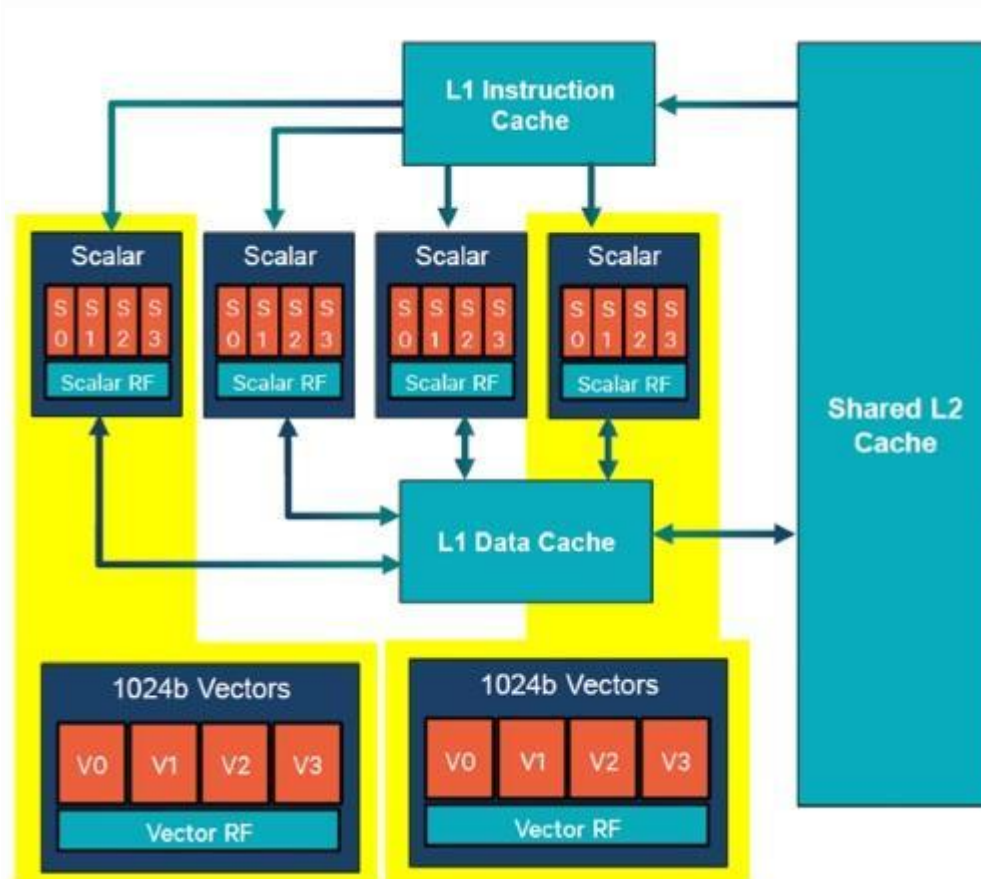
But the Hexagon DSP is capable of much more than sprucing up selfies. The included HVX contexts (more on those later) give it the advantage of both general-purpose processors and fixed-function cores; the Hexagon 685 DSP is terrifically efficiency at computing the math behind on-device machine-learning, but retaining the flexibility of more-programmable processors.

AI chips like the Hexagon 685 DSP, which are sometimes referred to as “neural processing units”, “neural engines”, or “machine learning cores”, are tailored specifically to AI algorithms' mathematical needs. They're much more rigid in design than a traditional CPUs, and contain special instructions and arrangements (in the Hexagon 685 DSP's case, the aforementioned HVX architecture) that accelerate certain scalar and vector operations, which become noticeable in large-scale implementations.

The Snapdragon 845's Hexagon 685 DSP can handle thousands of bits of vector units per processing cycle, compared to the average CPU core's hundreds of bits per cycle. That's by design. With four parallel scalar threads for Very Long Instruction Word (VLIW) operations and multiple HVX contexts, the DSP is capable of juggling multiple execution units on a single instruction and blazing through integer and fixed-point decimal operations.

Rather than pushing performance through raw MHz, the Hexagon 685's design aims for high levels of work per cycle at a reduced clock

speed. It includes hardware multi-threading that works well for VLIW, as multi-threading hides pipeline latencies enable better utilization of VLIW packets. The multi-threading of the DSP means it can service multiple offload sessions — i.e., concurrent apps for audio, camera, computer vision, and so on — and accelerate various tasks concurrently, preventing applications from having to fight for execution time.



Hexagon DSP Architecture

X20 LTE Modem

Qualcomm's wireless tech has also got a shot in the arm with the Snapdragon X20 LTE modem, which is Qualcomm's second-generation Gigabit LTE solution. The modem supports LTE Category 18 peak download speeds of 1.2 Gbps, up to 5x carrier aggregation, License Assisted Access (LAA), Dual SIM-Dual VoLTE as well as 4x4 MIMO on up to 3 aggregated carriers.

On the wireless front, the Snapdragon 845 also supports the 60GHz 802.11ad standard along with an integrated 802.11ac Wi-Fi.

Bluetooth 5.0 will allow you to broadcast audio simultaneously to multiple wireless speakers, smartphones or other devices. Qualcomm also promises battery drain reduction on wireless earbuds by up to 50 percent over the previous generation.

Downlink: LTE Cat 18 up to 1.2 Gbps, 5x20 MHz carrier aggregation, up to 256-QAM, up to 4x4 MIMO on three carriers.

Uplink: LTE Cat 13 up to 150 Mbps, Upload+ (2x20 MHz carrier aggregation, up to 64-QAM).

Secure Processing Unit (SPU)

It will add vault-like characteristics to existing layers of Qualcomm's mobile security solutions. It will provide biometric authentication (voice, fingerprint, iris, face), user and app protection and use-cases such as integrated SIM, payments, among other things.

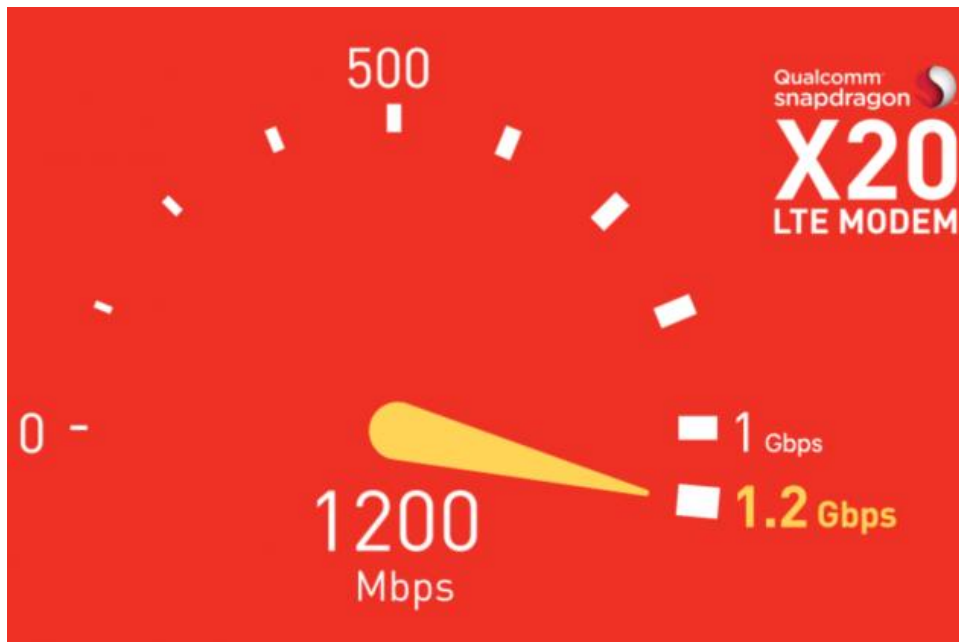
Comparing with other architectures

The new 845 Snapdragon is 14% faster than its predecessor, Snapdragon 835 (2.8GHz vs. 2.45GHz). In addition, an additional performance increase would result from the inclusion of modern, enhanced cores and new architecture. Qualcomm claims an improvement of **25-30 percent** compared to Snapdragon 835.

Artificial intelligence is the cornerstone of the Qualcomm Snapdragon 845 chipset. Qualcomm claims 3X improvement in AI performance compared to Snapdragon 835 with the new Hexagon 685 DSP.

Like Apple's A11 bionic chip and Huawei Kirin 970, Qualcomm Snapdragon 845 does not have a separate **neural system**. The Hexagon DSP on the 845 will have to do both image processing and image analysis on its own, placing SD 845 at a disadvantage compared to SoCs with **dedicated NPU**.

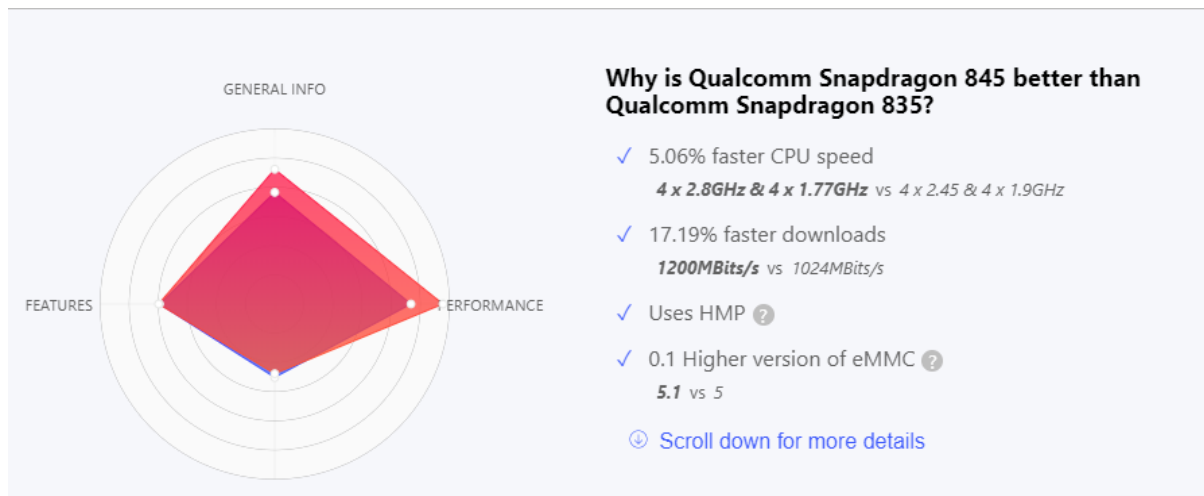
Multi-frame noise reduction (MFNR) is the main highlight. Using MFNR, SD 845 phones can successively capture multiple images and then reduce noise by using algorithms without losing a great deal on performance.



	Qualcomm Snapdragon 845	Qualcomm Snapdragon 835 (8998)	Qualcomm Snapdragon 808 MSM8992
	Qualcomm Snapdragon	Qualcomm Snapdragon	Qualcomm Snapdragon
	Cortex-A75 / A55 (Kryo 385)	Kryo 280	Cortex-A53/A57
: Snapdragon Cortex-A75 / A55 (Kryo 385)	Qualcomm Snapdragon 850 2960 MHz / 8 MB » Qualcomm Snapdragon 845 2800 MHz / 8 MB		
	2800 MHz	2450 MHz	2000 MHz
	8 / 8	8 / 8	6 / 6
	10	10	20
	X20 LTE Modem, Adreno 630 GPU	X16 LTE Modem, Adreno 540 GPU, Hexagon DSP, Spectra 180 Camera, Aqstic Audio, IZat Location, Haven Security	Adreno 418, LTE CAT6/7, UMTS, GSM, WCDMA, Dual-SIM, eMMC 5.0, UHS-I, 802.11a/b/g/n/ac (2.4/5 GHz) + MIMO, Bluetooth 4.1, USB 3.0, Dual-Channel LPDDR3-1866 Memory Controller (14.9 GB/s)
iGPU	Qualcomm Adreno 630	Qualcomm Adreno 540 (- 710 MHz)	Qualcomm Adreno 418 (- 600 MHz)
	= 655 days old	= 982 days old	= 2062 days old

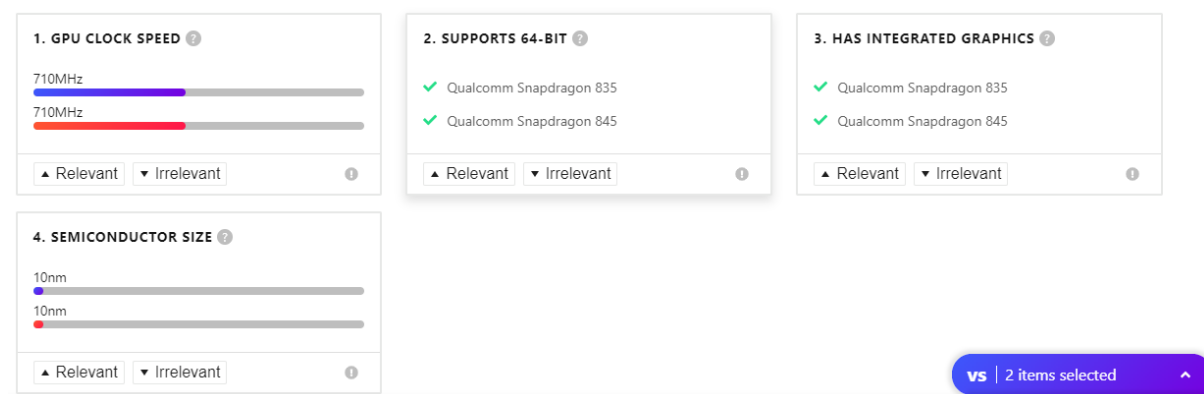
Here in this picture the snapdragon 845, 835 and 808 are compared with each other in GPU and memory as well as other components which can processor handle.

Snapdragon 845 and Snapdragon 835

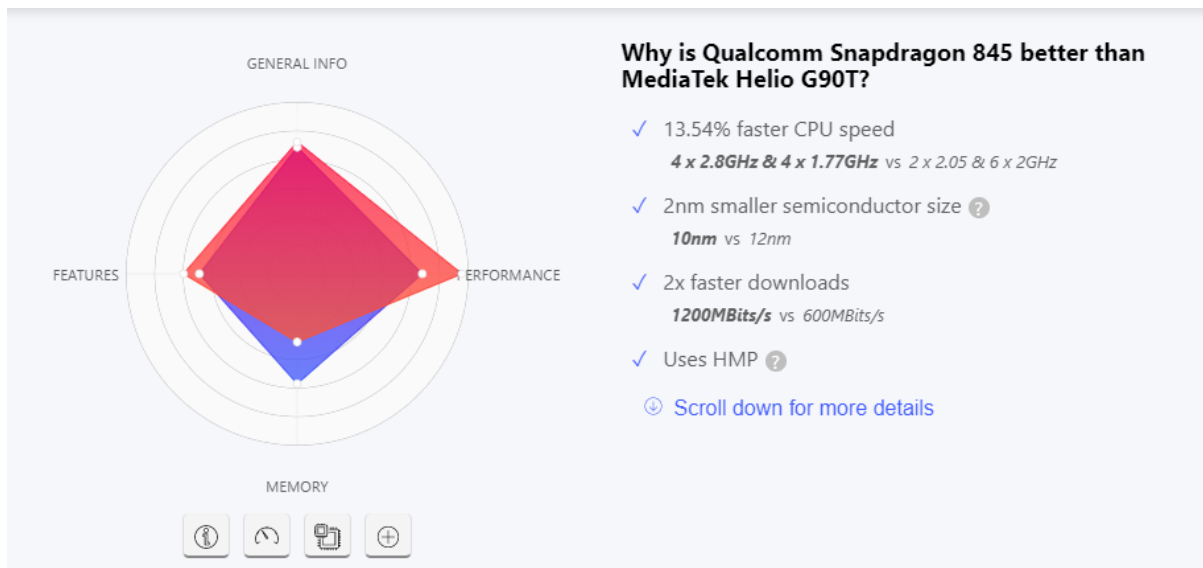


In this picture snapdragon 845 and 835 are compared and how 845 is better than 835 is showed.

SD845 is 5.06% faster in term of CPU speed and 17.19% faster in download speed in term if Mbits per second.



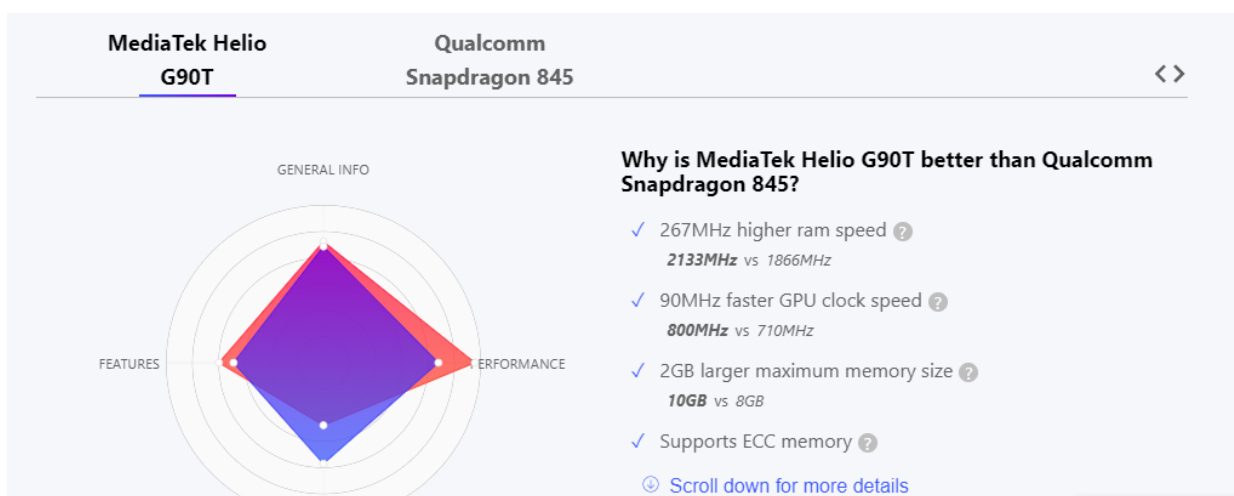
Snapdragon 845 and MediaTek Helio G90T

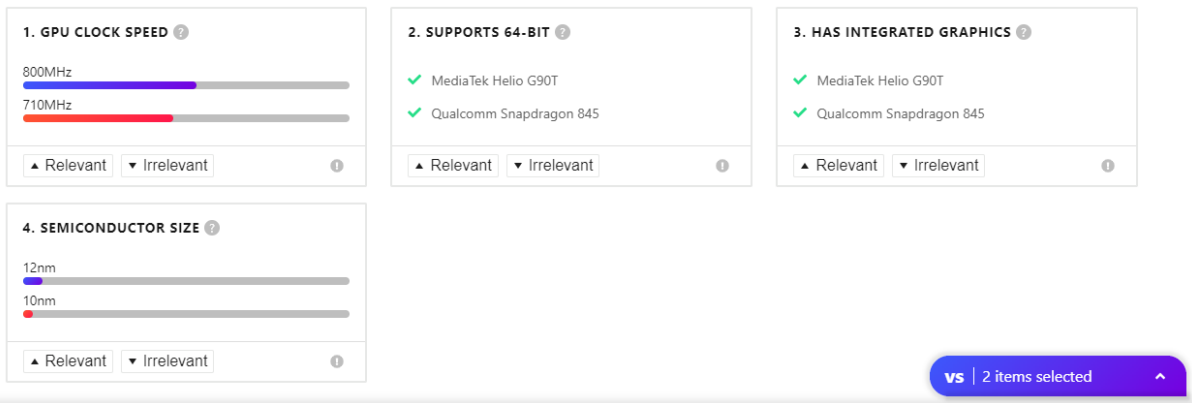


As shown in this picture SD845 is compared with MediaTek Helio G90T and SD845 is 13.54% faster in terms of CPU speed because SD uses 4 2.8GHz cores as MediaTek is using only 2 cores.

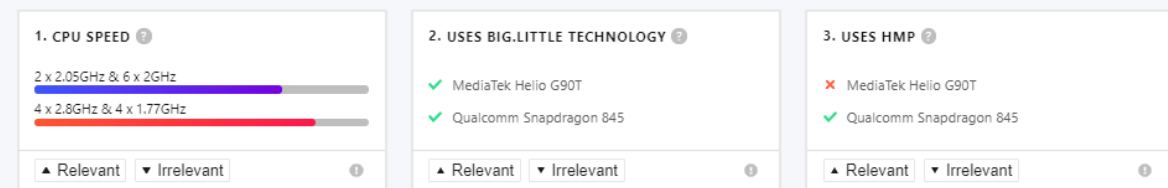
SD is made on 10nm size platform where MediaTek is made on 12nm

SD is almost 2X faster in terms of download speed, in SD 1200 Mbits per second where as in MediaTek Speed is 600 Mbits per second.

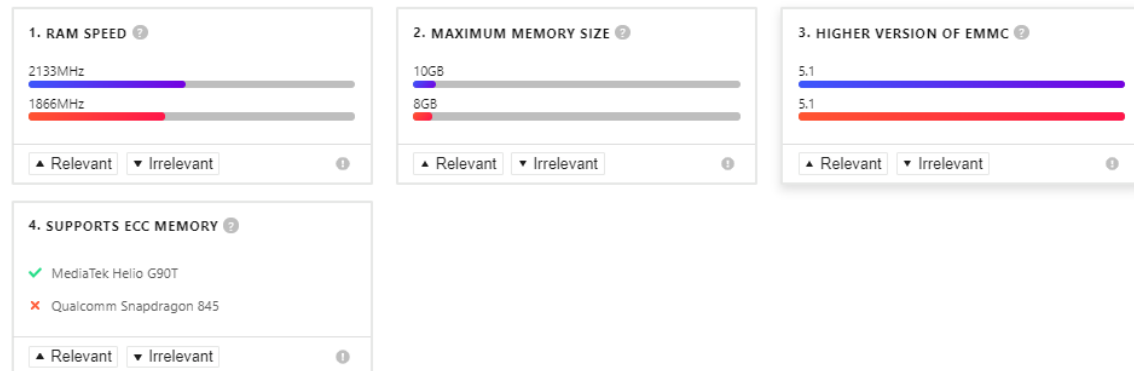




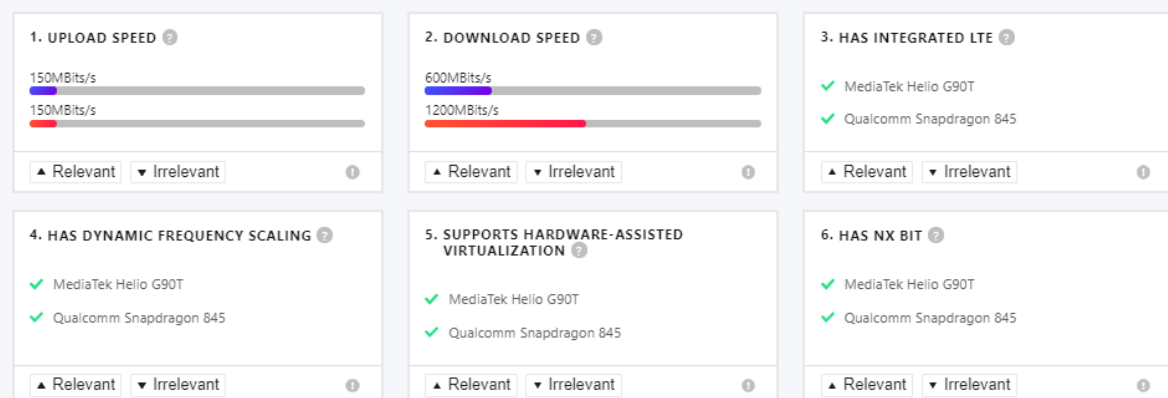
Performance



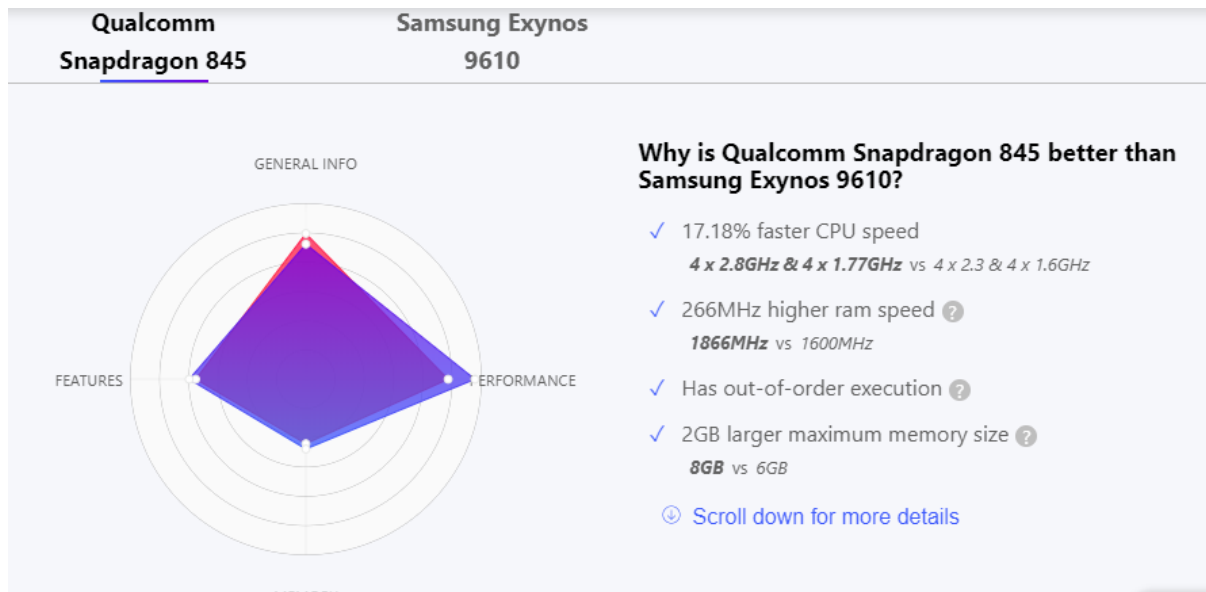
Memory



Features



Snapdragon 845 and Exynos 9610

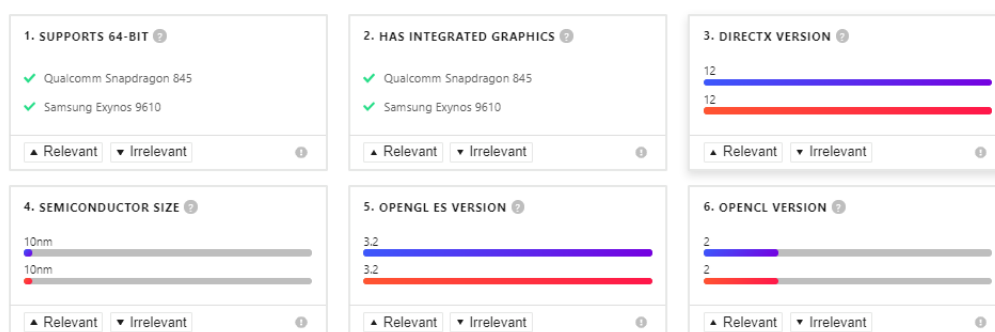


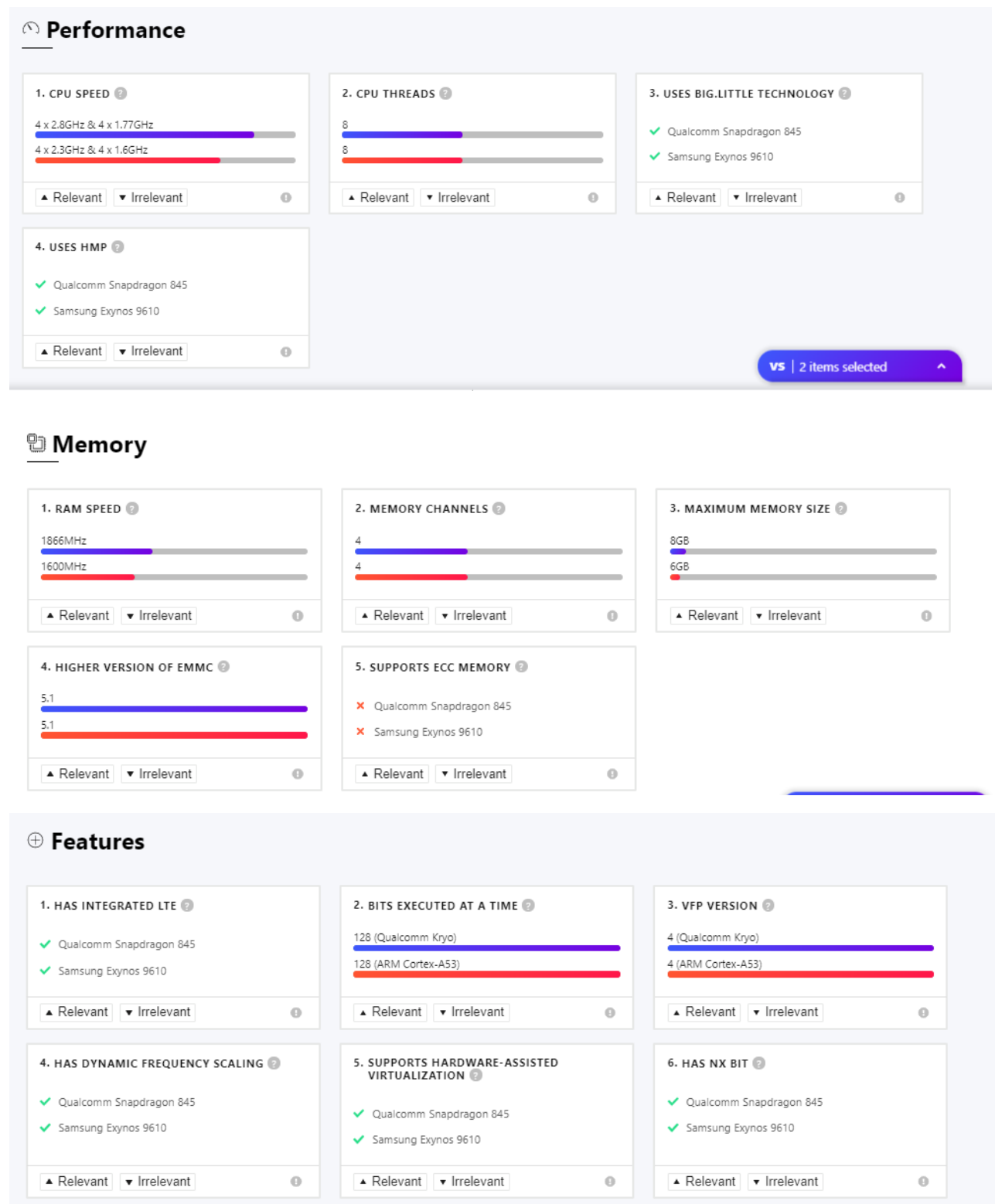
In this picture SD845 is compared with Samsung's Exynos 9610. In terms of CPU speed SD is 17.18% faster than Exynos as the GHz of multicore is more in SD than Exynos.

In terms of ram speed SD is 266MHz more than Exynos.

In memory size SD has 2GB larger size than Exynos as SD has 8GB of memory size and Exynos has 6GB of memory size.

General info





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