IV. Mobile Devices Hardware: Processors and Chipsets

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1. Processors and chipsets

- When talking about processors in smartphones, the term system-on-a-chip (SoC) is usually used - a chipset that includes processor cores, graphics chipset, RAM and ROM, interface controllers (for wireless connection, for USB, etc.), power management controller, etc.
- The idea behind the SoC is to have the critical components for the device located in a relatively small area.
- This reduces the size of the required board, the device can consume less power and run faster. It also reduces assembly costs and is cheaper than an equivalent multi-chip implementation.

1. Processors and chipsets

- The main component in a system on a chip is the central processing unit.
- Most mobile CPUs are built on the ARM architecture, each with a different speed and number of cores.
- Speed is measured in megahertz or gigahertz, with today's smartphones the maximum speed of a single processor (also called the "operating frequency") being over 2 GHz.
- The average number of cores is four, although many smartphones with octa-core processors are now available on the market.

1. Processors and chipsets

- Processors are different. If you take two smartphones with 2 GHz processors, there is no guarantee that both will perform equally well.
- This is due to the different design of the processors, although all the main manufacturers of mobile processors - MediaTek, Nvidia, Qualcomm, Texas Instruments and Samsung - use the company's ARM design as the basis for their processors.
- The differences in the performance of each company's processors is due to the fact that some of them strictly adhere to this design, while others just take the ARM design instruction set and upgrade it according to their vision.

1. Processors and chipsets

- When we hear or read a "dual-core processor," it's taken for granted that it must be twice as fast as a single-core processor. However, this is not exactly the case.
- More cores in one processor does not mean that it will be faster, but that it will simply distribute the different tasks to different cores.
- In practice, this means both faster web browsing and multitasking, but also less power consumption.
- Single-core processors must increase their voltage when they are tasked with more tasks, which in turn increases power consumption.
- With multi-core processors, work is better distributed, the load is less, and battery life is improved.

1. Processors and chipsets

- Modern smartphones have octa-core processors. But different octa-core smartphones handle it differently. The reason is again in the different design approaches.
- Samsung, for example, combines four high-performance cores with four more energy-efficient cores that handle different types of tasks.
- MediaTek, on the other hand, divides its processors into eight identical cores that perform in the same way.

2. ARM mobile architectures

ARM (Advanced RISC Machine)

ARM stands for three things:

- An English company that has been producing the ARM microprocessor architecture since 1983;
- Microprocessor architecture;
- ARM processor core.

2. ARM mobile architectures

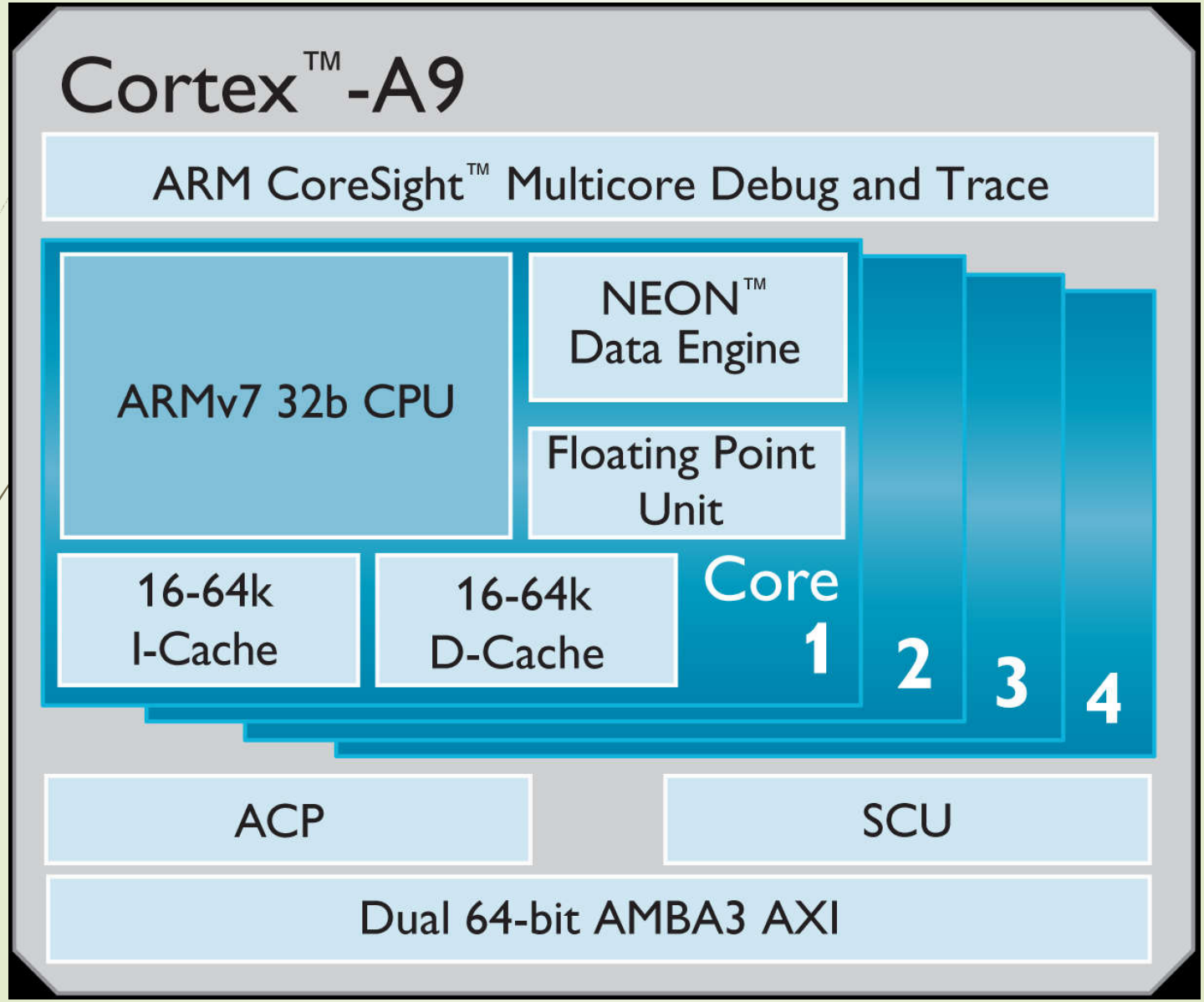
- The ARM mobile architecture is a mobile processor design used by smartphone or tablet companies.
- Some of the manufacturers choose to stick strictly to this design, while others buy only the instruction kit of the design, which they use as a "scaffolding", building on it in their own way.

2. ARM mobile architectures

32-bit ARM architectures

- **Cortex-A7:** this chip is small, simple and relatively power-efficient. It is based on an architecture called big.LITTLE.
- **Cortex-A9:** this multi-core chip can have up to four Cortex-A9 cores and is used primarily in mobile devices, but also in digital TV devices or Internet of Things. The advantage of this architecture is that it is extremely energy efficient.

ARM Cortex-A9

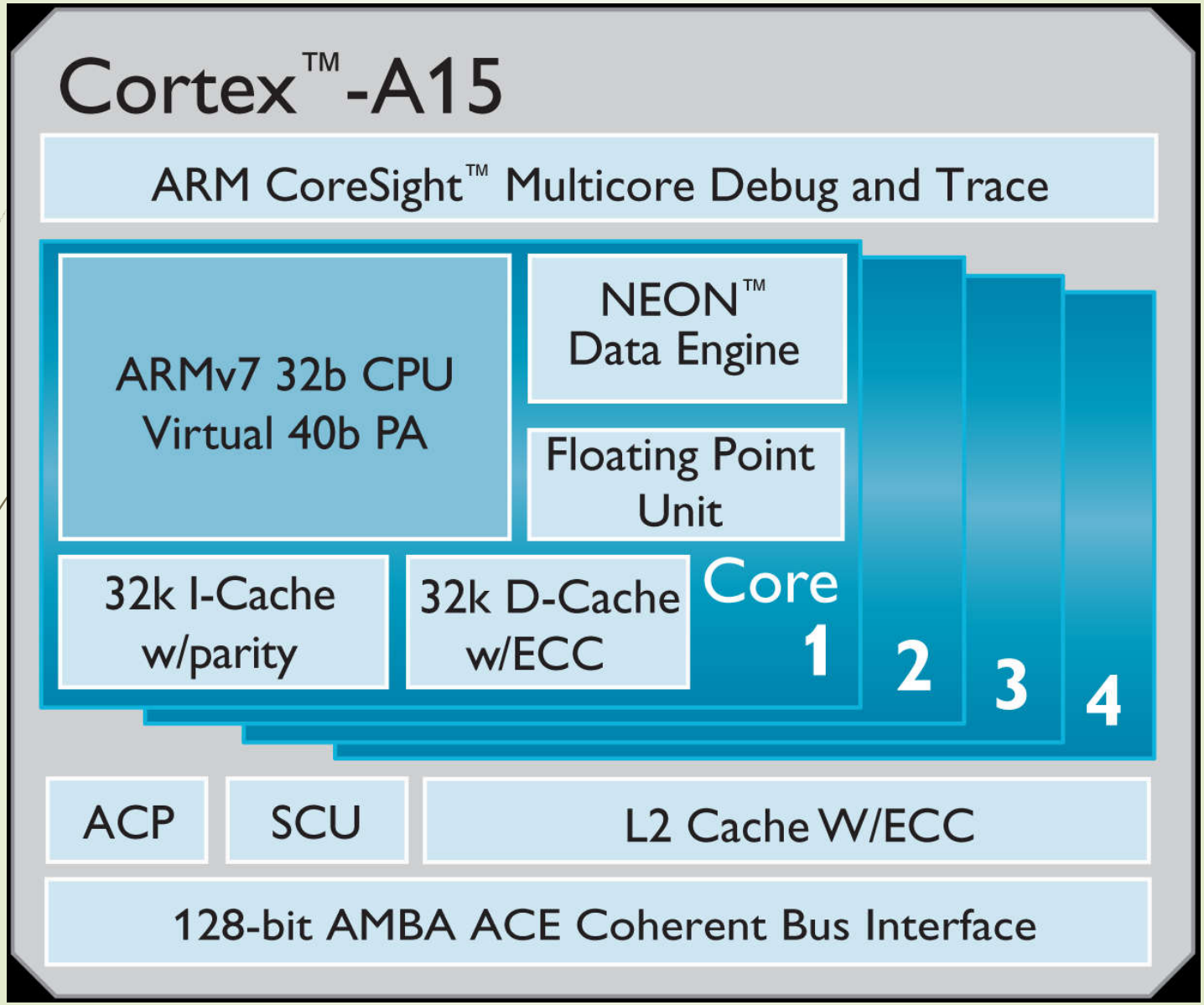


2. ARM mobile architectures

32-bit ARM architectures

- **Cortex-A15:** this powerful 32-bit processor is also based on big.LITTLE technology and is used by high-end smartphones or tablets.
- This chip can easily handle up to 1 TB of physical memory (which also explains why it is also used in servers).
- The different types of tasks are distributed between the different cores, with usually the Cortex-A15 combined with the more energy-efficient Cortex-A7 cores.
- This approach ensures increased performance and increased battery life.

ARM Cortex-A15



ARM Cortex-A15

2. ARM mobile architectures

64-bit ARM architectures

- ARM's 64-bit family contains three chip models that are collectively called ARMv8-A and handle both 64-bit and 32-bit applications.

2. ARM mobile architectures

64-bit ARM architectures

- **Cortex-A53** – This is the most energy-efficient member of the ARMv8-A family, supporting both 32-bit and 64-bit code.
- It is mostly used by both mid-range and high-end smartphones. The chips are typically smaller than Cortex-A9 and use less power, making them attractive to 64-bit mobile device manufacturers.
- It can have several identical cores or, using big.LITTLE technology, be combined with another group of cores for heavier tasks (usually combined with Cortex-A72 or Cortex-A57).

2. ARM mobile architectures

64-bit ARM architectures

- **Cortex-A57** – this chip is used by the most powerful smartphones and tablets on the market.
- Processors based on this architecture allow mobile devices not only to reproduce, but also to create multimedia content.
- A smartphone using such a processor can be connected to a screen, keyboard and mouse and act as a mini computer.
- In mid-range or lower-end devices, it is usually combined with a group of more energy-efficient cores (usually Cortex-A53).

2. ARM mobile architectures

64-bit ARM architectures

- **Cortex-A72** – this is ARM's most advanced and highest performing chip to date.
- This processor is designed for only the most powerful smartphones on the market and allows them to record and play super high definition video, play console-quality games and work with documents with the speed and efficiency that PC processors offer.
- This chip can also be configured with weaker Cortex-53 cores for use in slightly more affordable devices.

3. Intel x86

- In 2012, Intel announced its intention to adapt its x86 computer architecture to the mobile market, introducing improved Intel Atom chips for tablets and smartphones.
- For several years, Intel has been trying to become a competitor to ARM, thanks to the greater energy efficiency of its own chips.
- Mobile Atom processors are conditionally divided into three types.

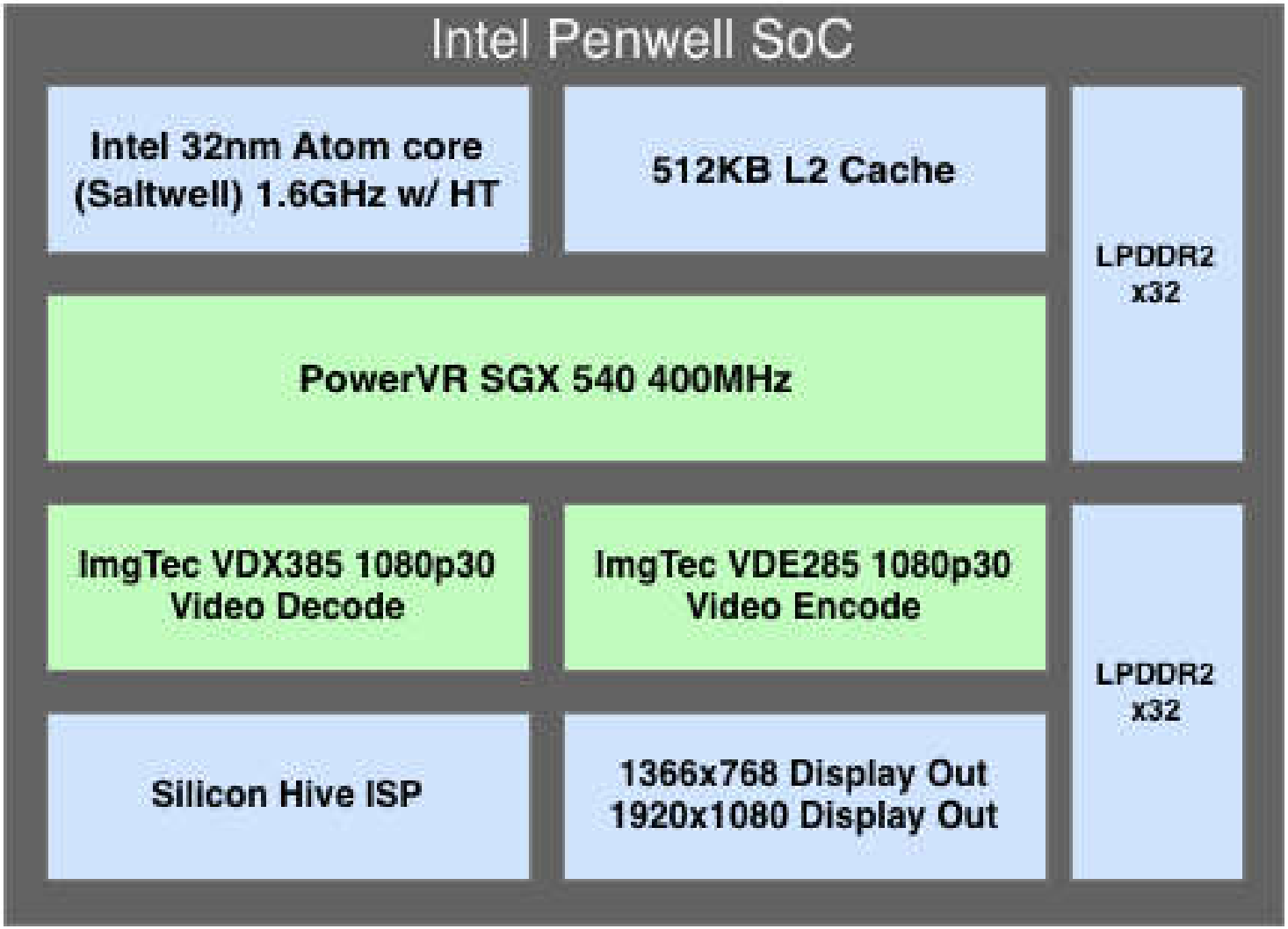
3. Intel x86

- **Built on a 32-nanometer process with an x86 instruction set:** Intel's first two platforms, Medfield and Clover Trail, are based on this process. The maximum frequency of processors in this process reaches 2 GHz, and the maximum number of cores is also two.
- **Built on a 22-nanometer process with an x86-64 instruction set:** these are the processors of the Bay Trail, Merrifield and Moorefield series, which now support up to four cores and a maximum speed of 2.13 GHz. Many tablets, including hybrids (which come with a keyboard) currently use exactly such chips.

3. Intel x86

- **Built on a 14-nanometer process with an x86-64 instruction set:** these are the latest Intel processors, which can be divided into two subspecies.
- One subspecies uses Airmont microarchitecture and will be called Moorefield for smartphones and Cherry Trail for tablets.
- The second subspecies uses a microarchitecture called Goldmont and will be called Morganfield for smartphones and Willow Trail for tablets.

Intel Atom Z2460



4. Other manufacturers of processors and chipsets

4.1. Qualcomm processors and Snapdragon SoCs

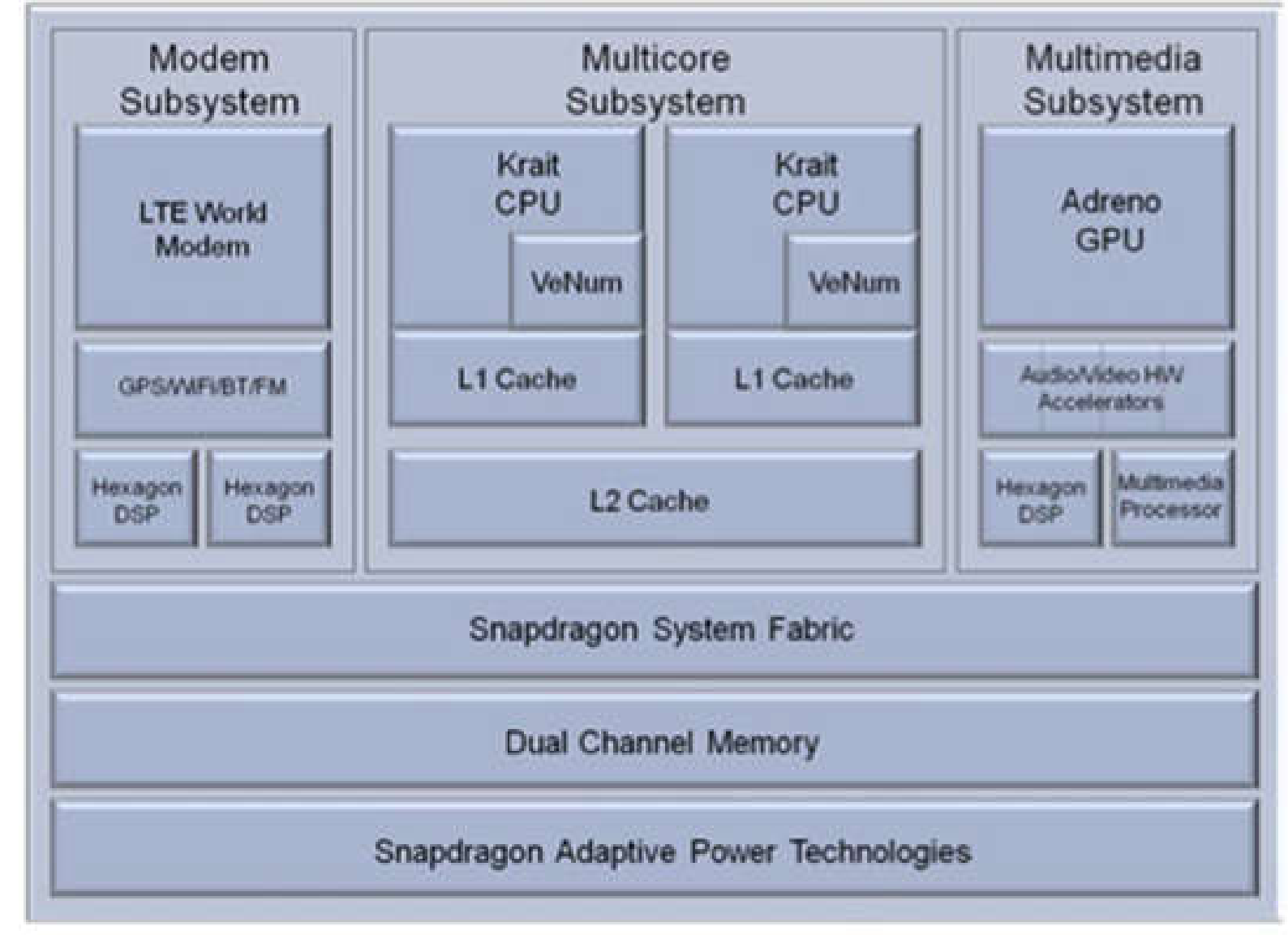
- Qualcomm differs from other SoC manufacturers in that they don't actually use the original ARM processor design.
- Instead, based on ARM, they make improvements and create their own processors (for example, Scorpion and Krait). In this way, better performance of media playback operations is achieved and consumption management is more efficient.

4. Other manufacturers of processors and chipsets

4.1. Qualcomm processors and Snapdragon SoCs

- These processors are used in the series of chipsets Qualcomm 's Snapdragon, with each series having a number. The higher the serial number, the more powerful and newer the chipset.
- Each new series of chipsets, in addition to improvements in processors and graphics chips, also improves other capabilities such as camera resolution, screen resolution and media performance.
- Many of the devices that are based on Snapdragon SoCs do not support the full capabilities of the chipset.

Block diagram of Snapdragon S4 SoCs using Krait processors



4. Other manufacturers of processors and chipsets

4.2. Texas Instruments OMAP SoCs

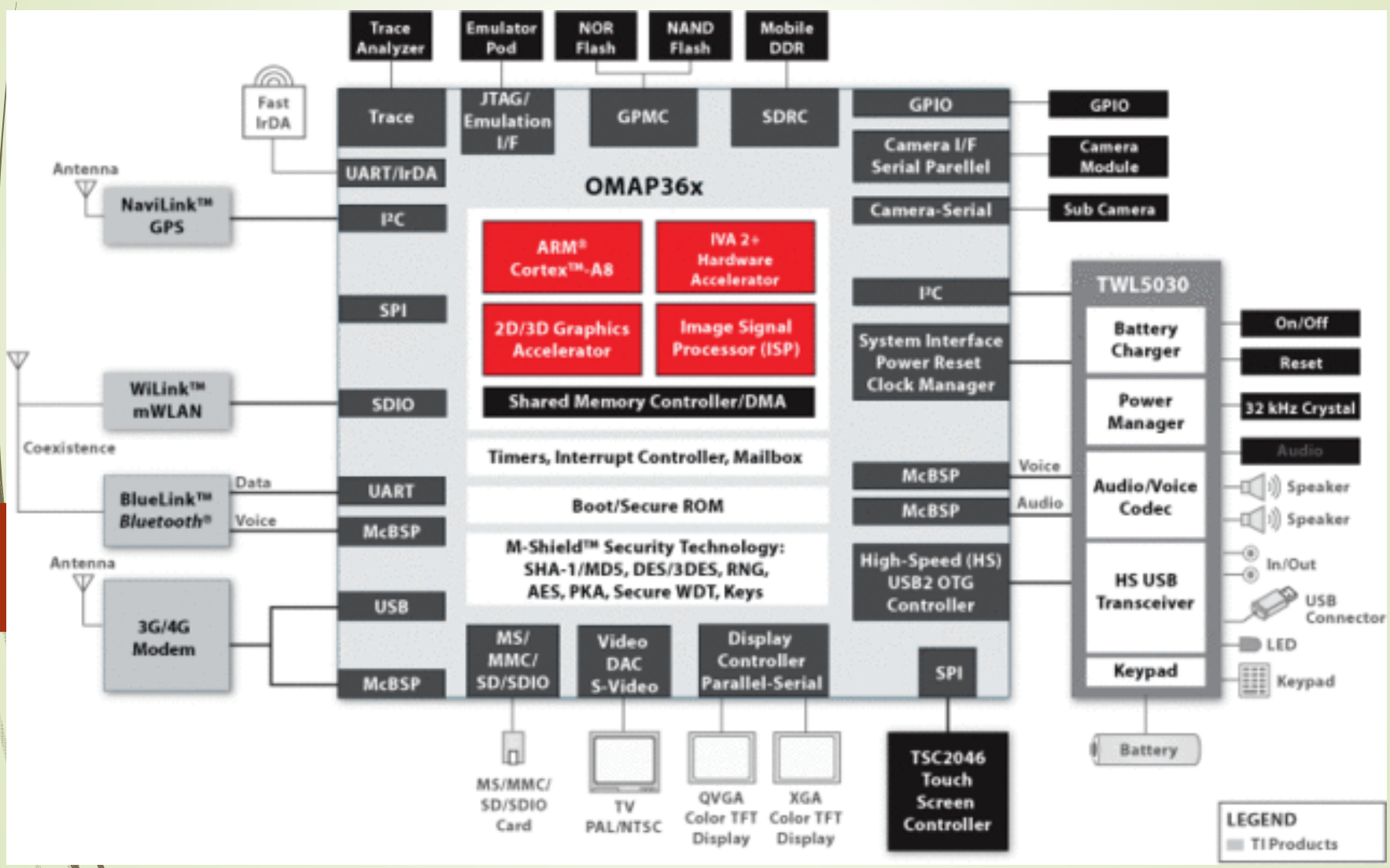
- Texas line of chipsets Instruments ' is called OMAP (Open Media Applications Platform) and are also widely distributed. They are mostly used by the Motorola company in their Android devices.
- Like Snapdragon, TI OMAP SoCs have different implementations. The OMAP series names are in ascending order, with a larger SoC number indicating better performance.
- The first digit always indicates the series, with new series always being faster than old ones. For example, OMAP4430 is better than OMAP3630, which in turn is better than OMAP3430.

4. Other manufacturers of processors and chipsets

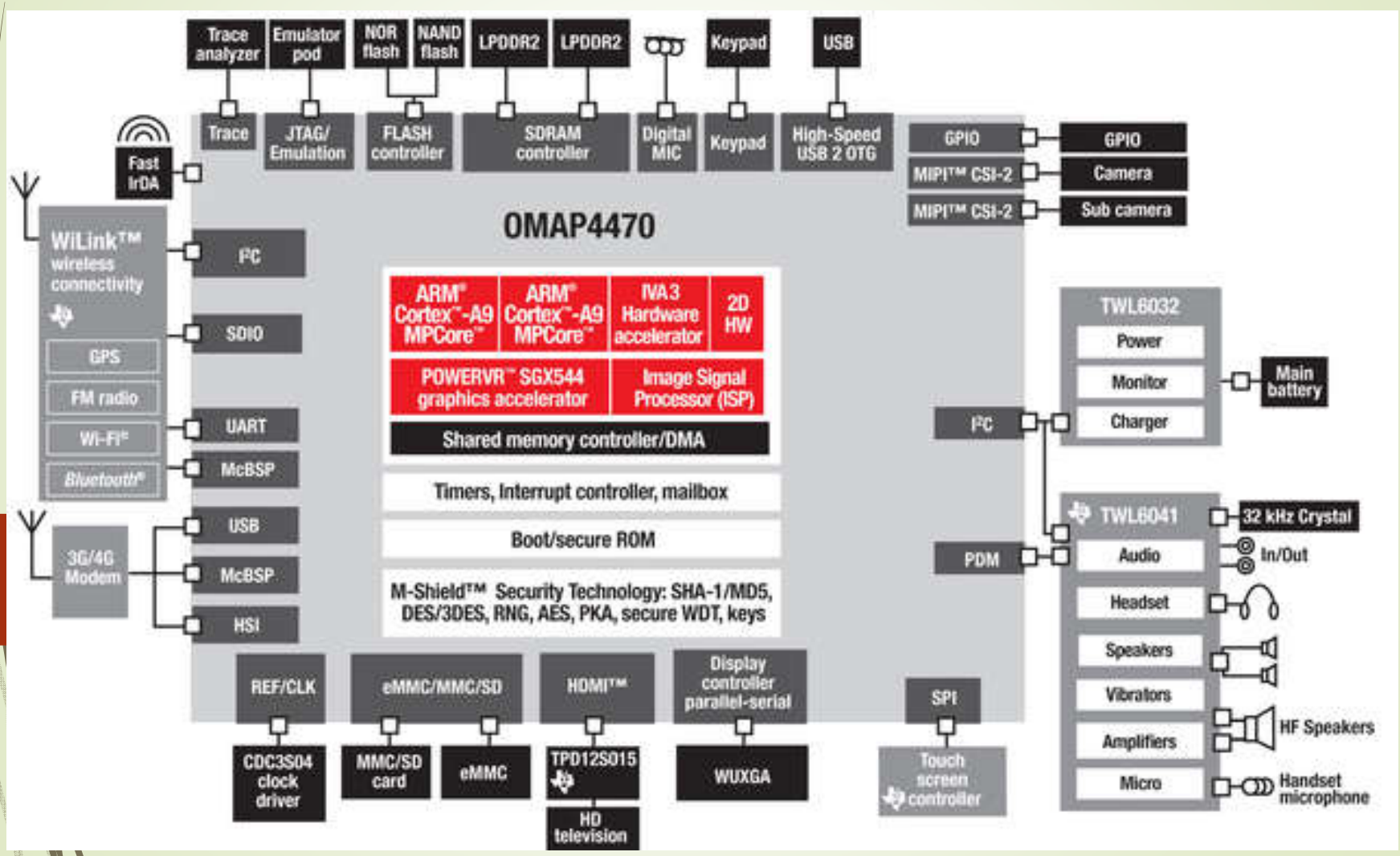
4.2. Texas Instruments OMAP SoCs

- A major drawback of TI OMAP SoCs is that the wireless components are not included in the chipset as with Snapdragon SoCs.
- This provides the flexibility to easily add a desired communications technology in a device (e.g. LTE), but also increases the board size in the device.

Block diagram of OMAP36xx SoCs. Many external components are required!



Block diagram of the TI OMAP4470

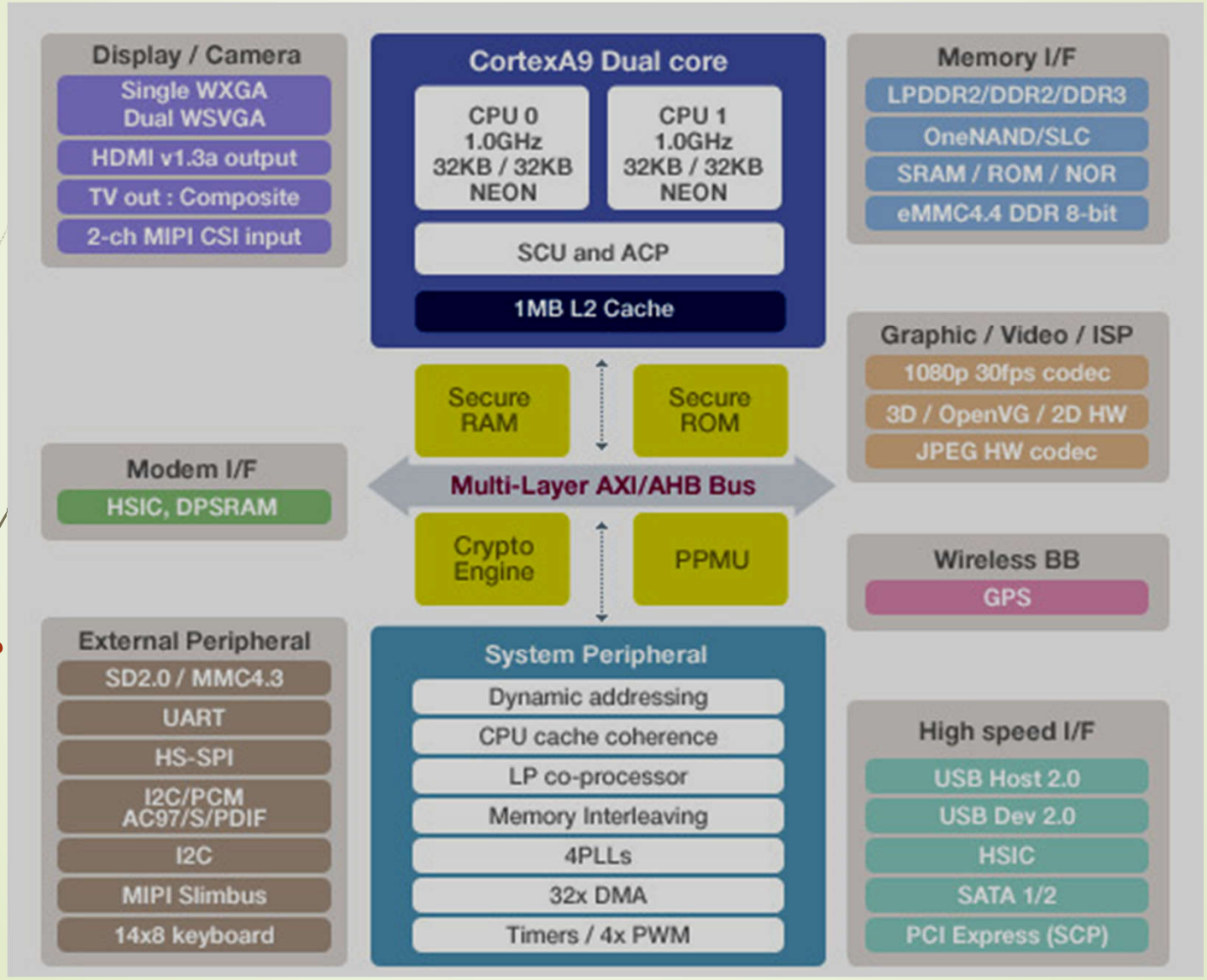


4. Other manufacturers of processors and chipsets

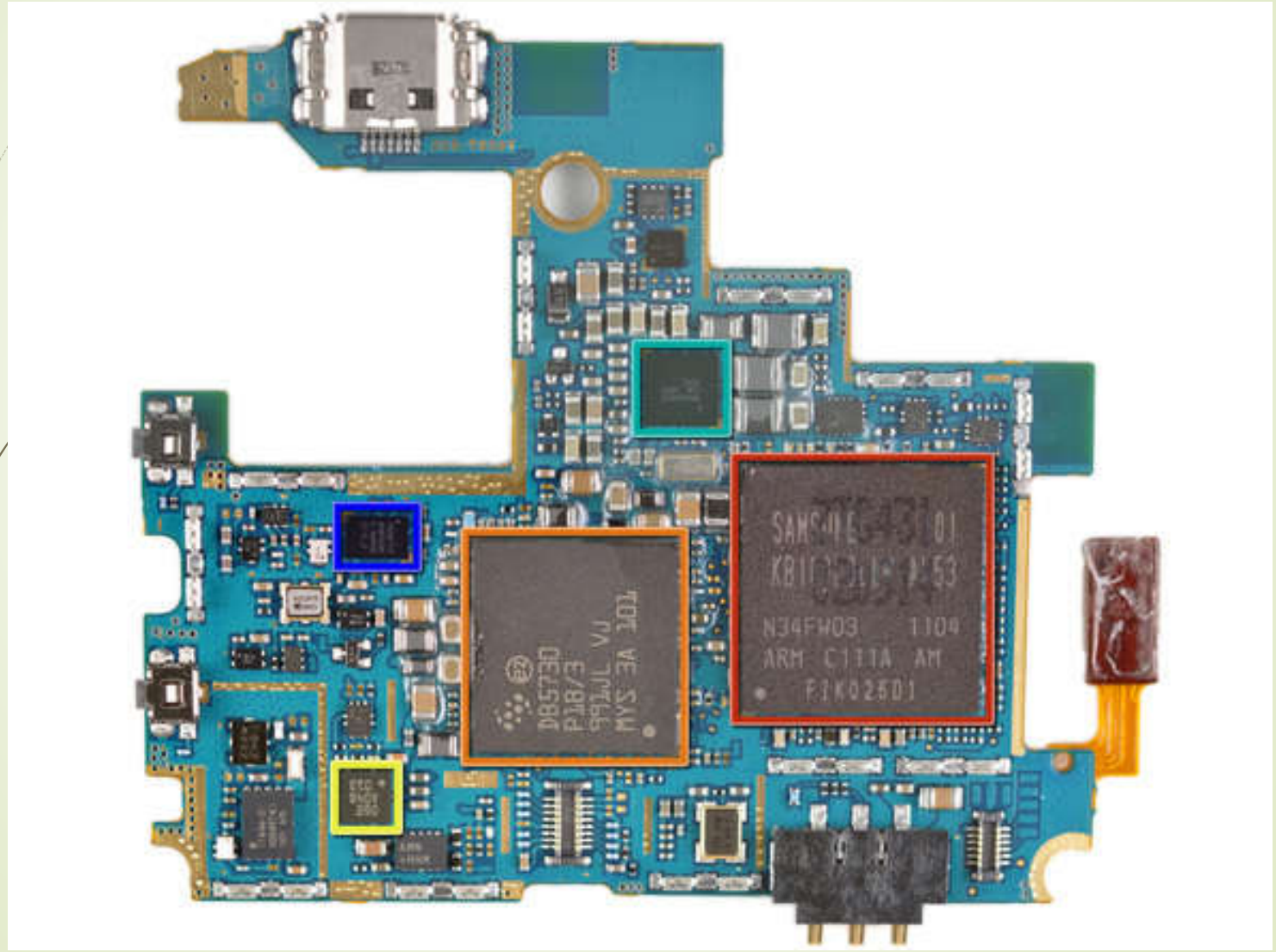
4.3. Samsung Exynos SoCs

- The Samsung Exynos family of SoCs is small and positioned between simpler SoCs (TI OMAP) and those with the most complete capabilities (Snapdragon).
- Samsung products are used only in their best smartphones and tablets (with one exception - the Chinese manufacturer Meizu).
- Although Samsung manufactures their own SoCs, they don't use them in all their products, instead using Qualcomm's when the Exynos chips don't meet requirements such as LTE and cost efficiency.

Exynos 4210 chipset



Exynos chipset (in red) in the Samsung Galaxy S4

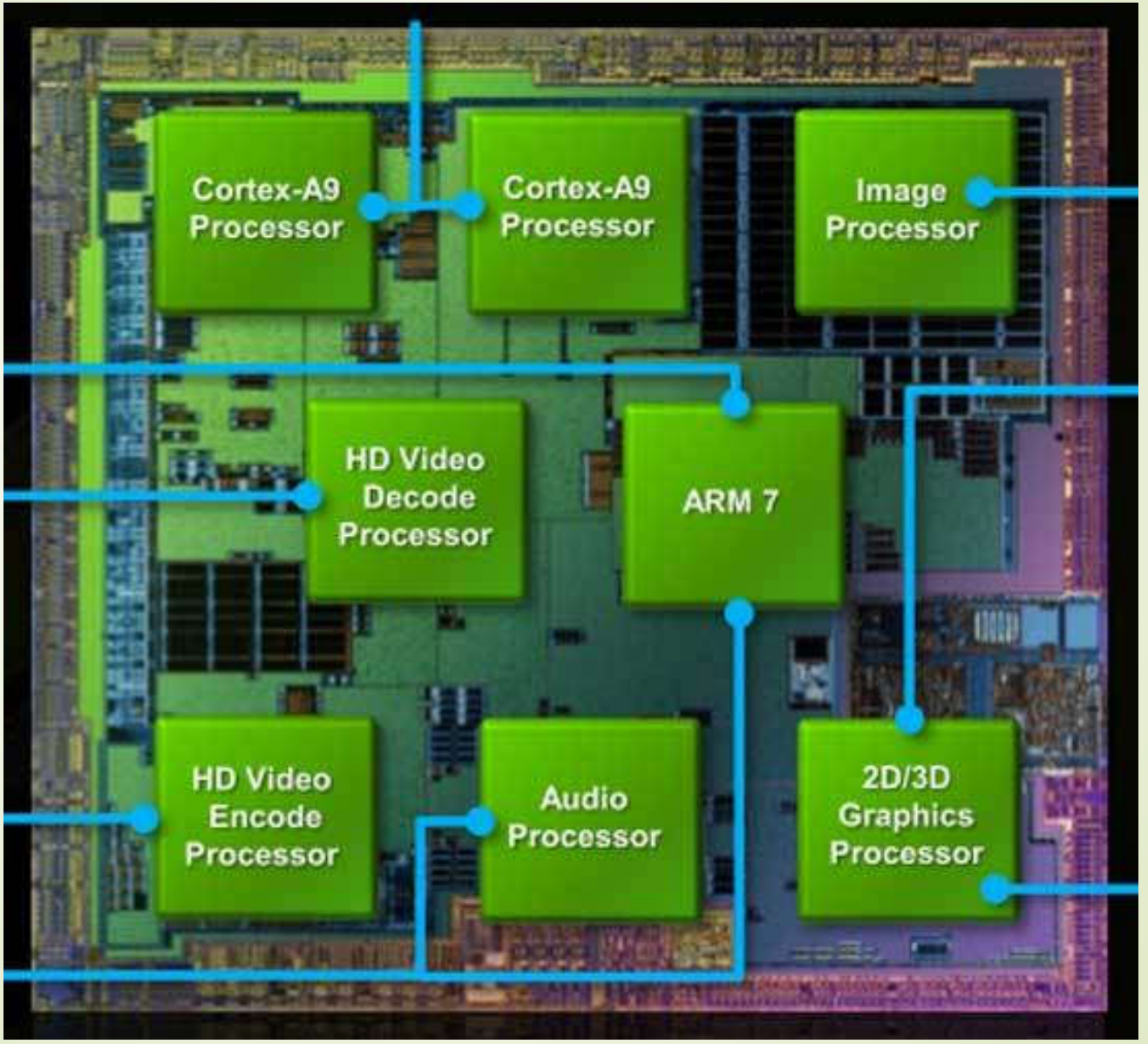


4. Other manufacturers of processors and chipsets

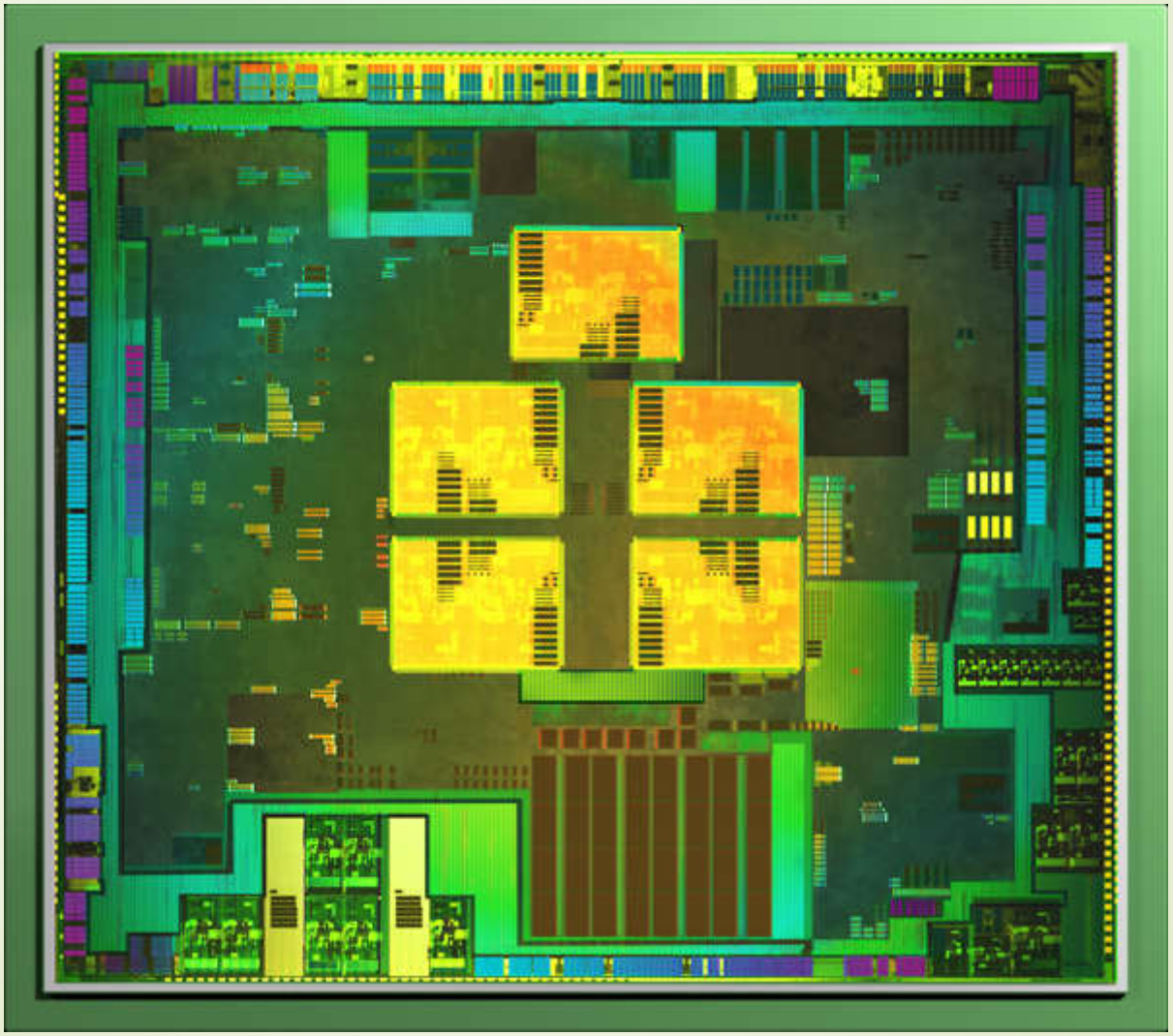
4.4. NVIDIA's Tegra SoCs

- Currently, different types of Tegra SoCs can be used in smartphones and tablets.
- GeForce graphics processor with very low power consumption is used.

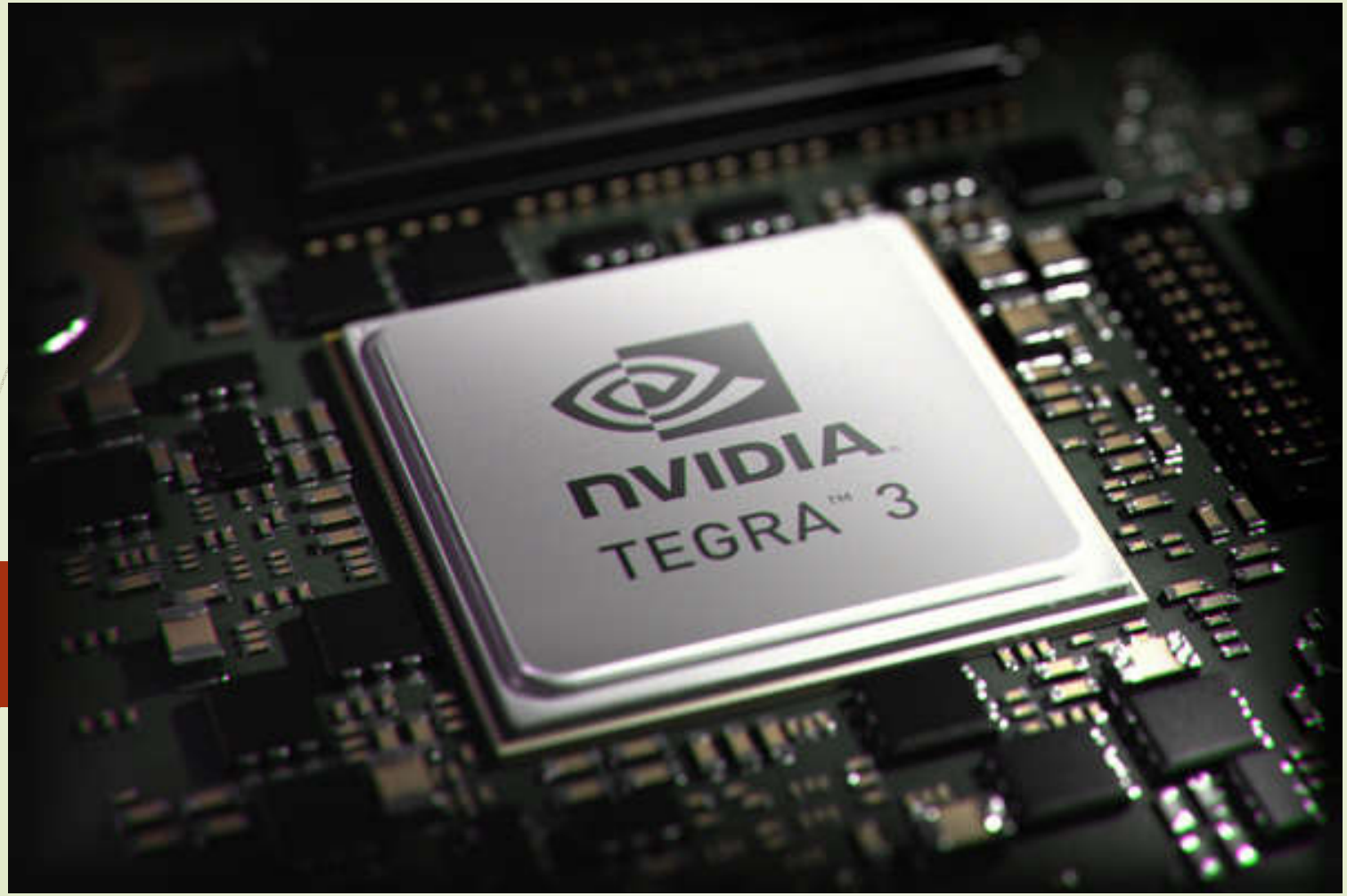
NVIDIA Tegra 2



NVIDIA Tegra 3
It has full four cores and one additional one (they are colored yellow)



NVIDIA Tegra 3

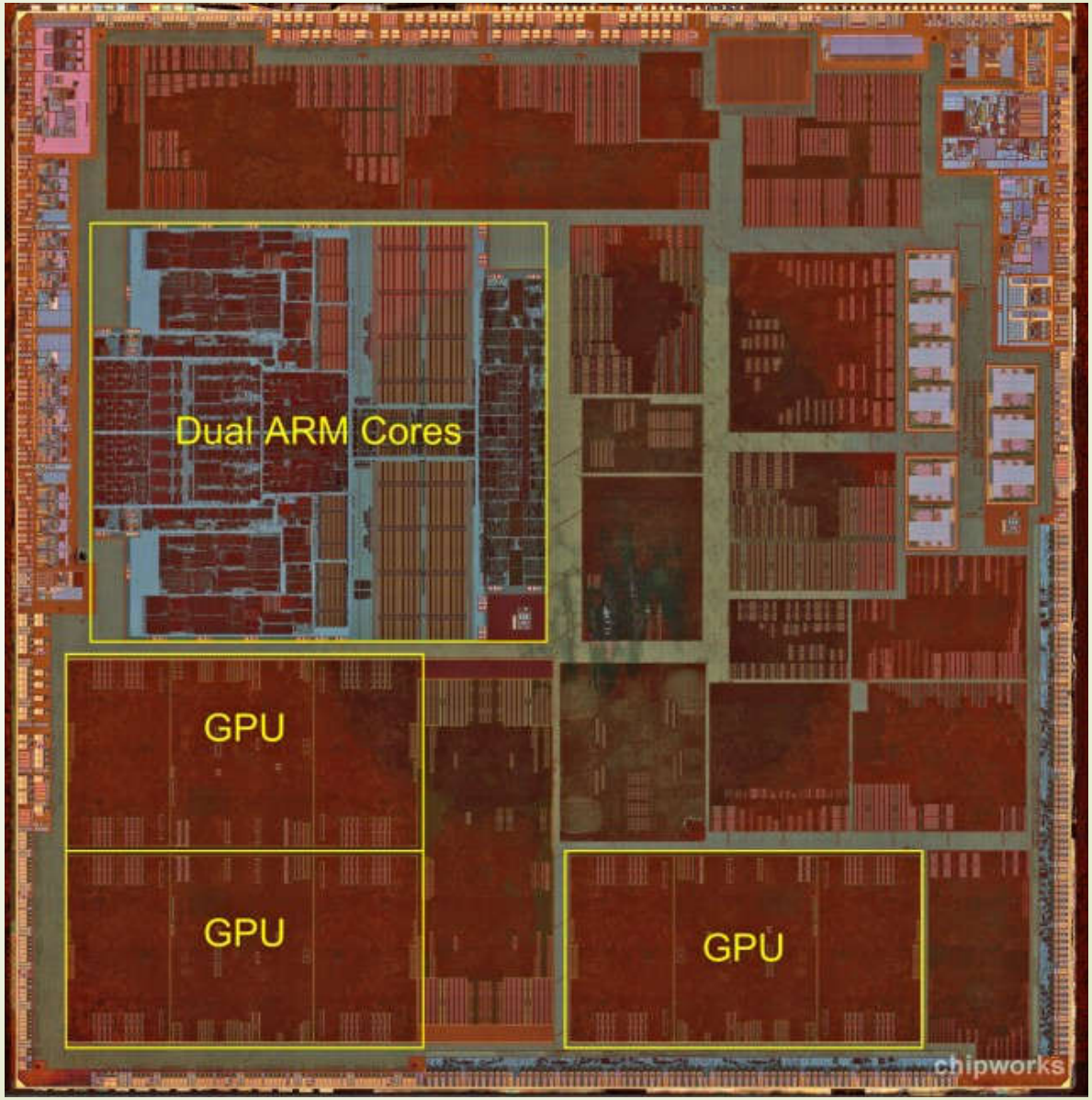


4. Other manufacturers of processors and chipsets

4.5. Apple SoCs

- SoCs models from the Apple Ax series are distinguished from each other by their internal architecture, constructive implementation of the module, resources, technology, speed and consumption.
- Unlike other SoCs, Apple chipsets are not licensed and are used only in iPhone, iPad, Apple TV and iPod Touch products.

Apple A6 SoC



Apple iPhone 5 A6 SoC

5. Advantages of 64-bit processors

64-bit processors have several main advantages over the previous 32-bit ones:

- 64-bit processors can support more RAM. The more RAM a device has, the faster it loads any content.
- 64-bit processors can run heavier applications for professional purposes, such as data management services, digital content processing programs, drawing and 3D modeling programs, and more.

5. Advantages of 64-bit processors

- 64-bit processors are considered more efficient and more reliable.
- 64-bit processors have more registers – these are places in the processor where frequently used instructions and data are stored. Thanks to the increased number of registers, the time to read and write data from/to memory is reduced.