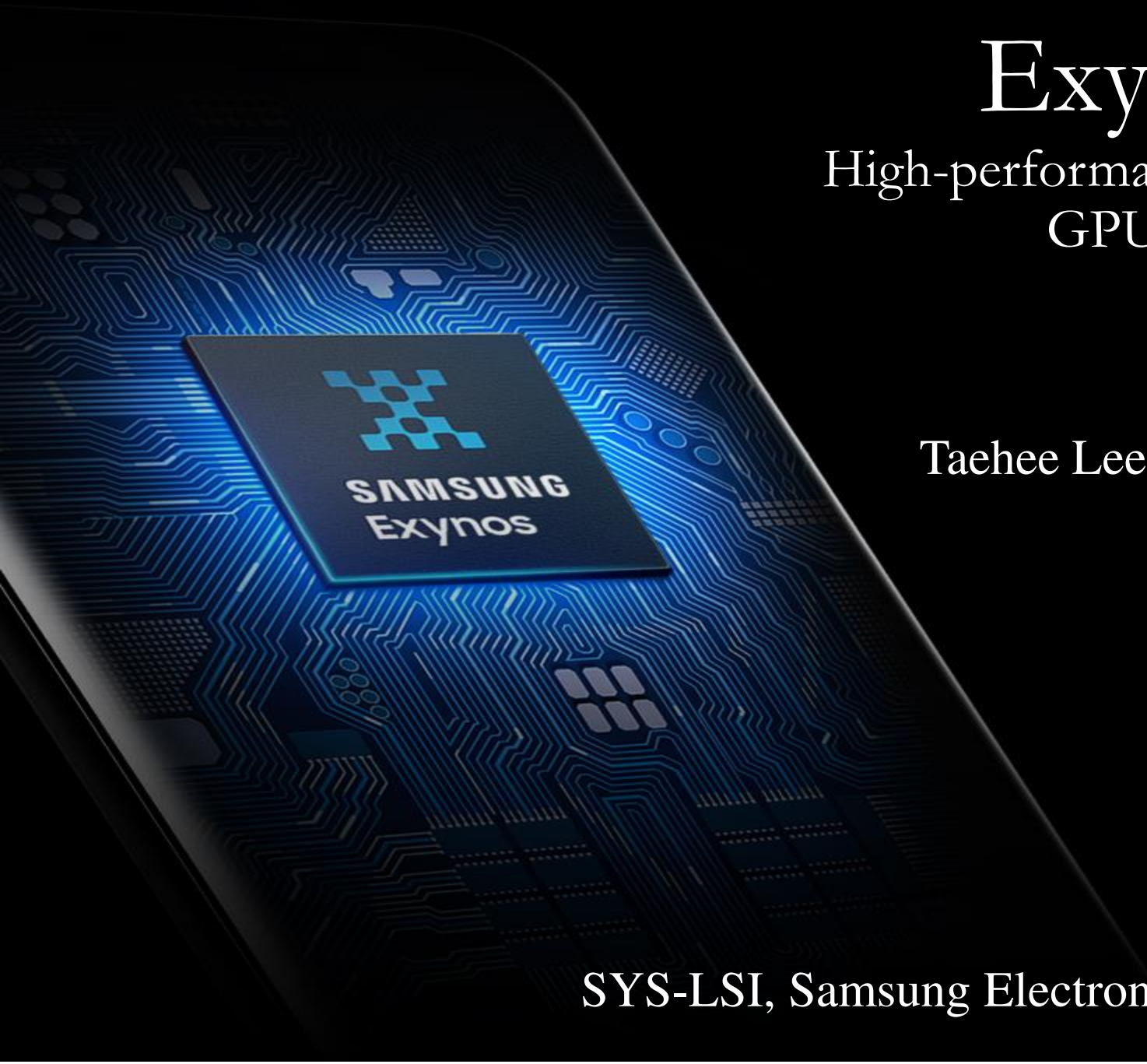


# Exynos 1080

## High-performance, low-power CPU and GPU with AMIGO

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# Abstract

This work presents Exynos 1080, mobile SOC which is productized in Samsung 5nm EUV technology. It is extremely power-efficient SOC which possesses four Cortex-A78 and four Cortex-A55. A Cortex-A78 is clocked at 2.8GHz and three Cortex-A78 cores are clocked at 2.6GHz. Four Cortex-A55 cores run at 2 GHz and handle light tasks. It also features the Mali-G78 MP10 GPU supporting Full HD+ displays with a 144Hz refresh rate or QHD+ displays with a 90Hz refresh rate. High-performance and low-power CPU and GPU in this work empower performance hungry mobile application. We demonstrate the architecture change to improve CPU and GPU performance compared to previous mobile processor, Exynos 980. CPU and GPU are implemented for optimal power efficiency by careful balancing of voltages and leakages, with considering heavy load scenarios.

When a game scene is getting heavier, the utilization of CPU, GPU and memory controller increases and each DVFS driver changes their frequency with own policy to handle the work. Each can try to increase performance without considering other's behavior. It leads total power increase. To solve this problem, we create AMIGO (Advanced Multi-IP Governor). It collects CPU, GPU, and memory controller data and analyzes collected data. It then decides which IP shall be boosted or suppressed to achieve target FPS or optimizes power usages of CPU, GPU, and memory controller. Amigo achieves the game power reduction by 15% on average.

With high-performance CPU and GPU, Exynos 1080's Antutu score is 89% higher than Exynos 980. The smart phones with Exynos 1080 were successfully launched in DEC 2020.

# Samsung high end mobile processor roadmap

10nm


4 Cortex A73+ 4 Cortex A53
Mali™-G72 MP3
Single Camera up to 64MP
Dual Camera 16MP+16MP
LPDDR4x

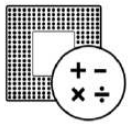
8nm


2 Cortex A77+ 4 Cortex A55
Mali™-G76 MP5
5G NR Sub-6GHz 2.55Gbps (DL) /1.28Gbps (UL)
Single-camera up to 108Mp
Dual-camera 20MP+20MP
LPDDR4x

5nm

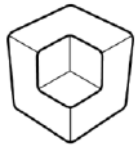

4 Cortex A78+ 4 Cortex A55
Mali G78 MP10
5G NR Sub-6GHz 5.1Gbps (DL) / 1.28Gbps (UL)
5G NR mmWave 3.67Gbps (DL) / 3.67Gbps (UL)
Single-camera Up to 200MP
Dual-camera 32MP+32MP
LPDDR5/LPDDR4x

# Exynos 1080 Features



**CPU**

2.8GHz Single-core (Cortex A78) +
2.6GHz Triple-core (Cortex A78) +
2.0GHz Quad-core (Cortex A55)

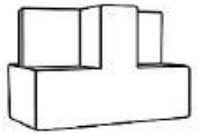


**GPU**

Mali-G78 MP10

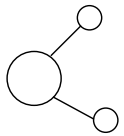

**DRAM**

LPDDR5 /
LPDDR4x



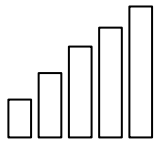
**Process**

5nm



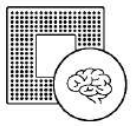
**Connectivity/GNSS**

Bluetooth 5.2, Wi-Fi (802.11ax)
FM Radio GPS, GLONASS
BeiDou, Galileo



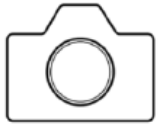
**Modem**

5G NR Sub-6GHz 5.1Gbps (DL) / 1.28Gbps (UL)
5G NR mmWave 3.67Gbps (DL) / 3.67Gbps (UL)



**AI**

NPU + DSP
5.7 TOPS

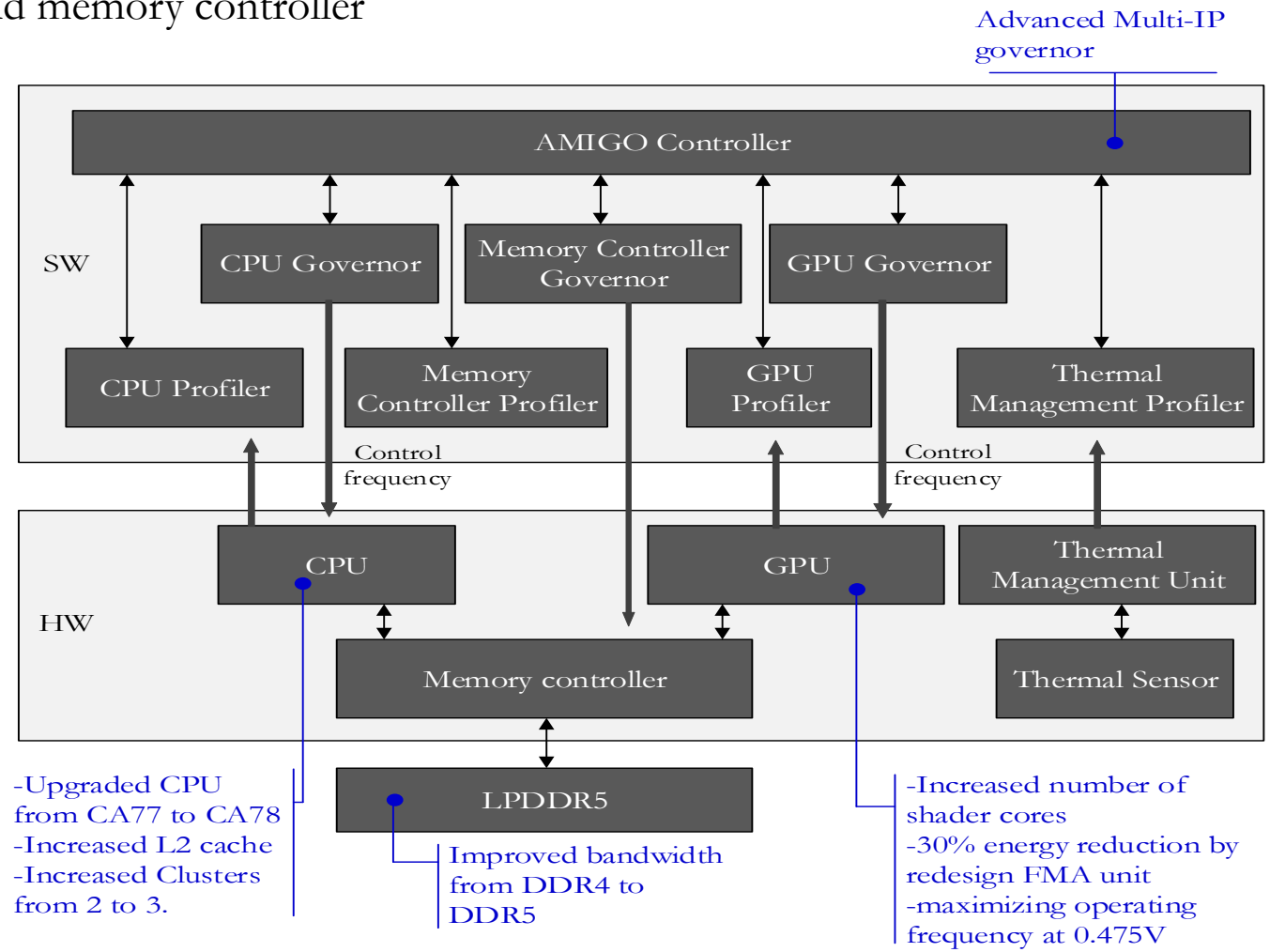


**ISP**

Single-camera Up to 200MP
Dual-camera 32MP+32MP

# CPU and GPU with Amigo

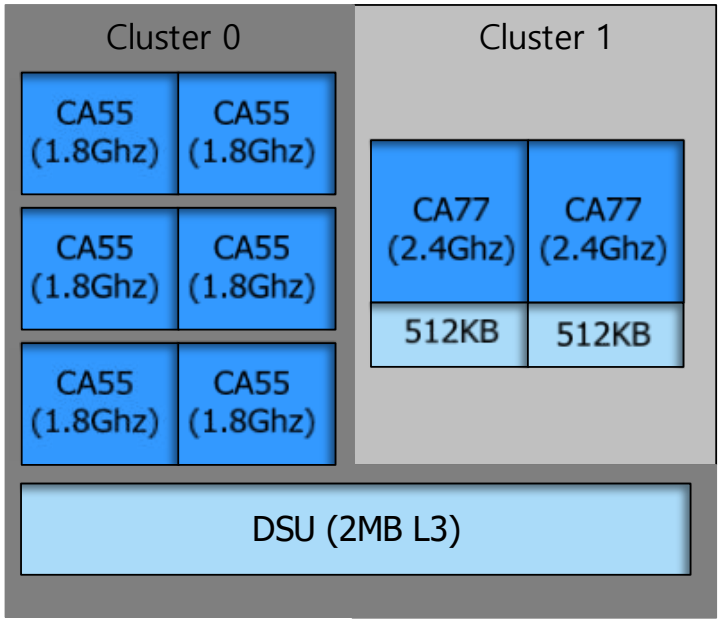
- AMIGO (Advanced Multi-IP Governor) collects CPU, GPU, and memory controller data and analyzes collected data
- It then decides which IP shall be boosted or suppressed to achieve target FPS or optimizes power usages of CPU, GPU, and memory controller



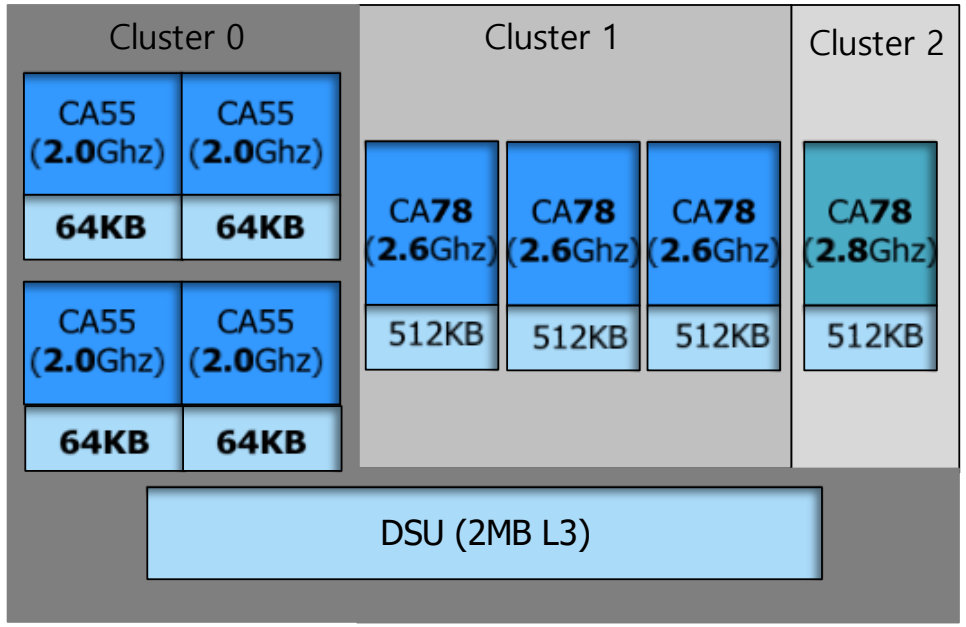
# CPU Architecture Change

- To increases performance requirement, two CA77 are  changed to four CA78
- One out of  four Cortex A78 separated frequency and power from the other three to achieve high performance

Exynos 980

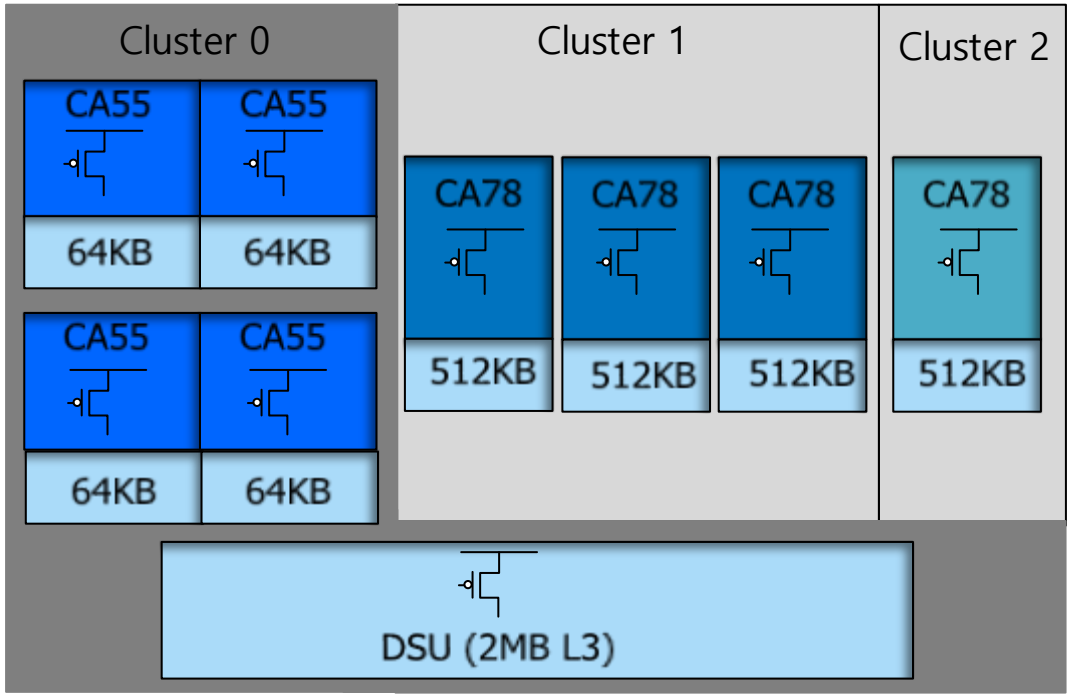



Exynos 1080



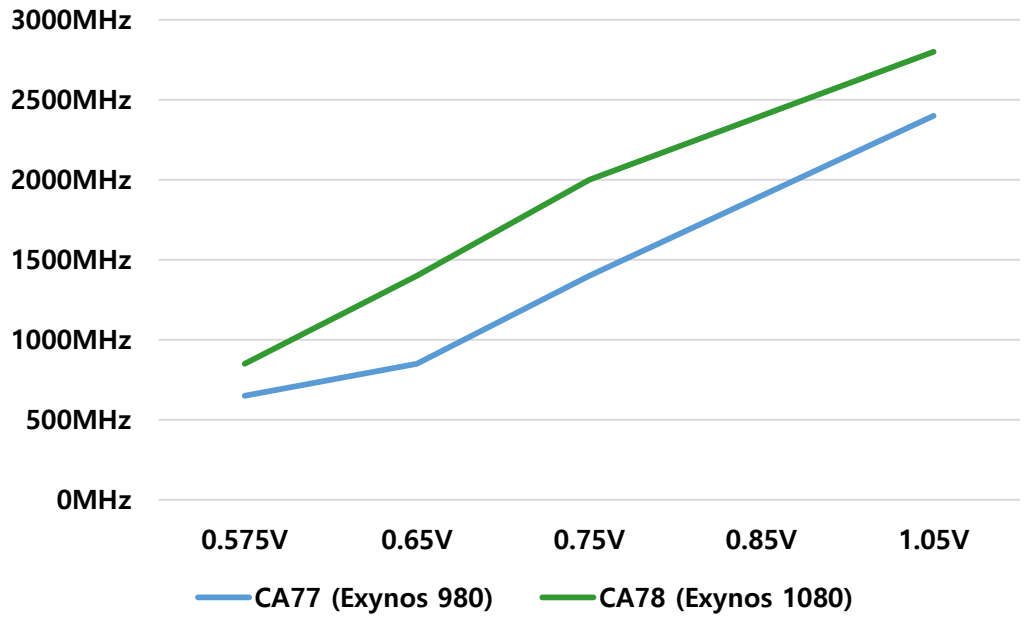
# CPU Power Domain

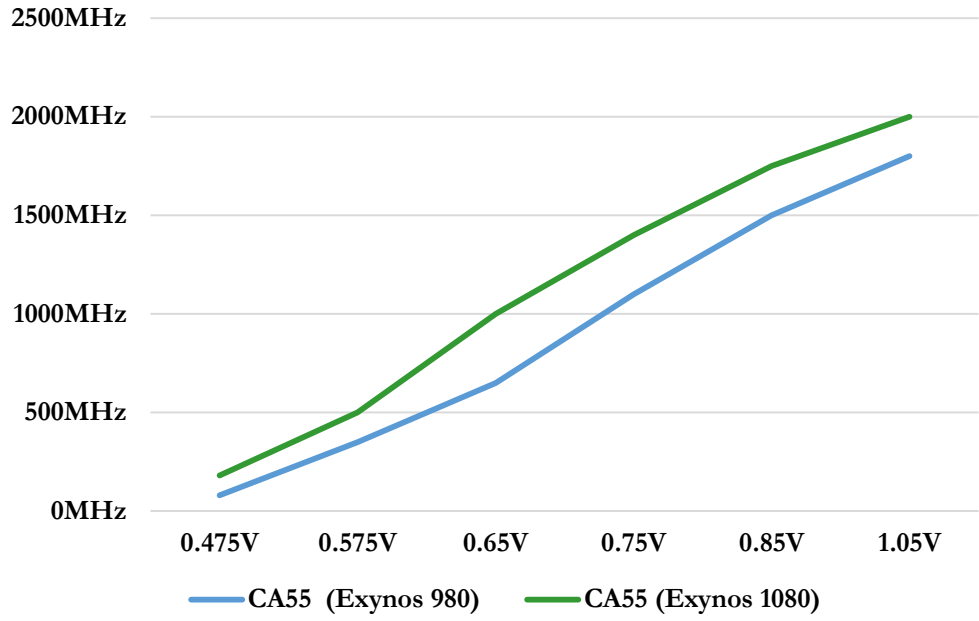
- Power of three clusters is supplied by each PMIC buck
- Each cluster has a power gating cell so that power can be turned on or off efficiently



# CPU Physical Optimization Method

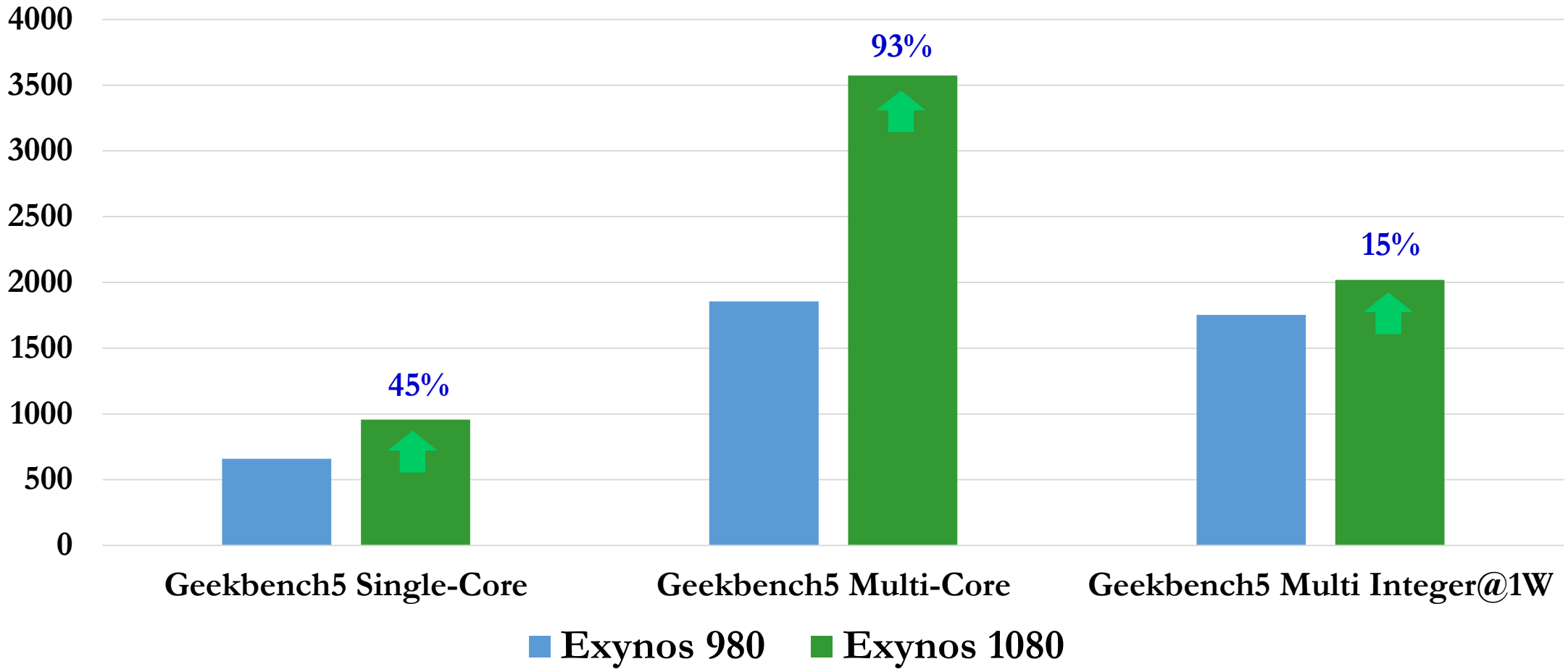
- The CA78 cores are optimized to reach the maximum frequency of super overdrive voltage (1.05V) and overdrive voltage (0.85V) , and the CA55 is optimized to reach the maximum frequency in normal voltage (0.75V) and under drive voltage (0.65V)
- With the help of process technology shrink, Exynos 1080 can increase the target frequency comparing with Exynos 980



# CPU Geekbench

Compared to the Exynos 980, Geekbench single core, multi core and multi core integer @ 1W in the Exynos 1080 have improved by 45%, 93% and 15%, respectively



# GPU Architecture

Exynos 1080 employs Mali-G78 which is the 2nd generation GPU of ARM Mali architecture

Performance improves 28% as the number of shader cores increases from 5 to 10 with increasing cache size

**Exynos 980**

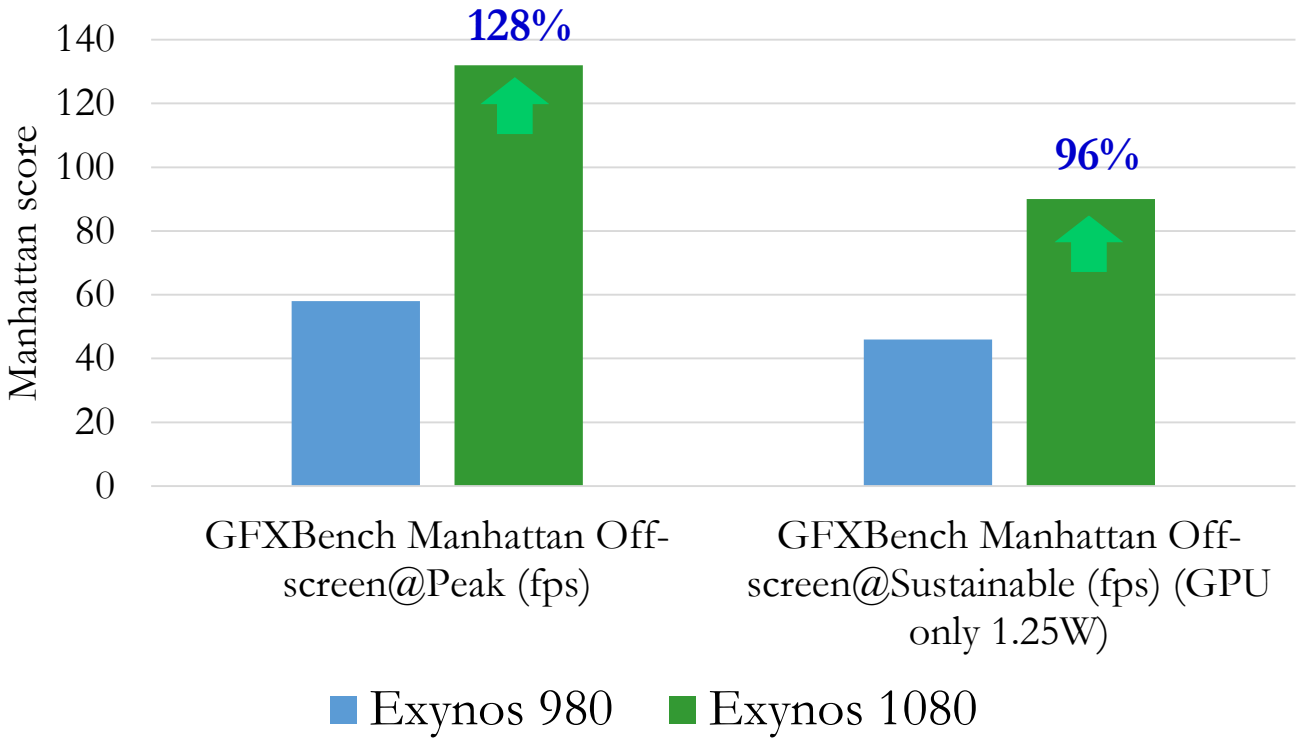
Mali G76
5 shader cores
512KB Cache

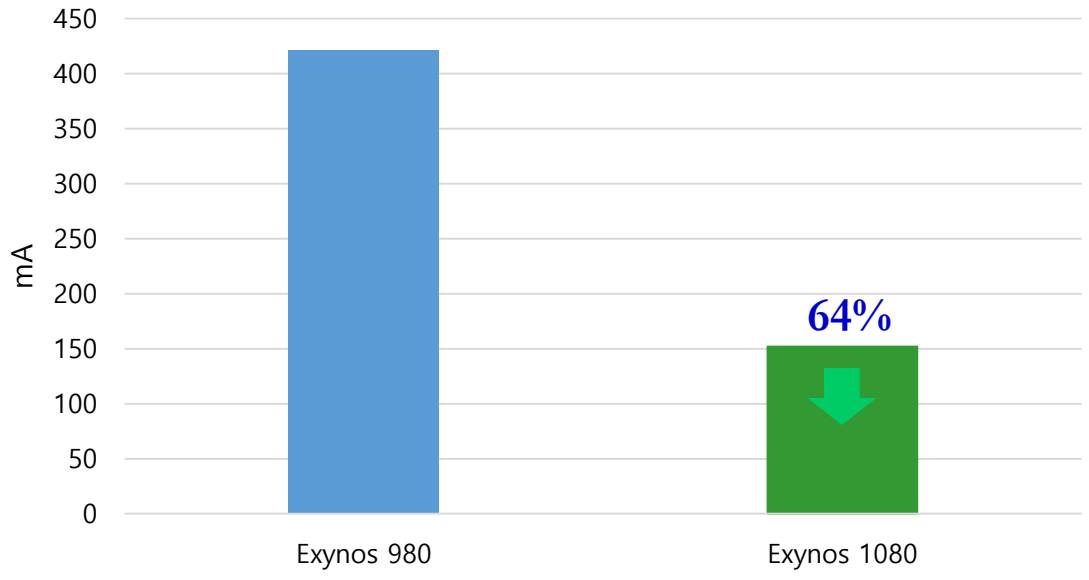
**Exynos 1080**

Mali G78
10 shader cores
1MB Cache
30% energy reduction by redesigning FMA unit in execution engine.

# GPU Manhattan

Compared to the Exynos 980, Manhattan Off-screen@Peak, Manhattan Off-screen@Sustainable and Manhattan 3.0 @ Offscreen in the Exynos 1080 have improved by 128%, 96% and 64%, respectively

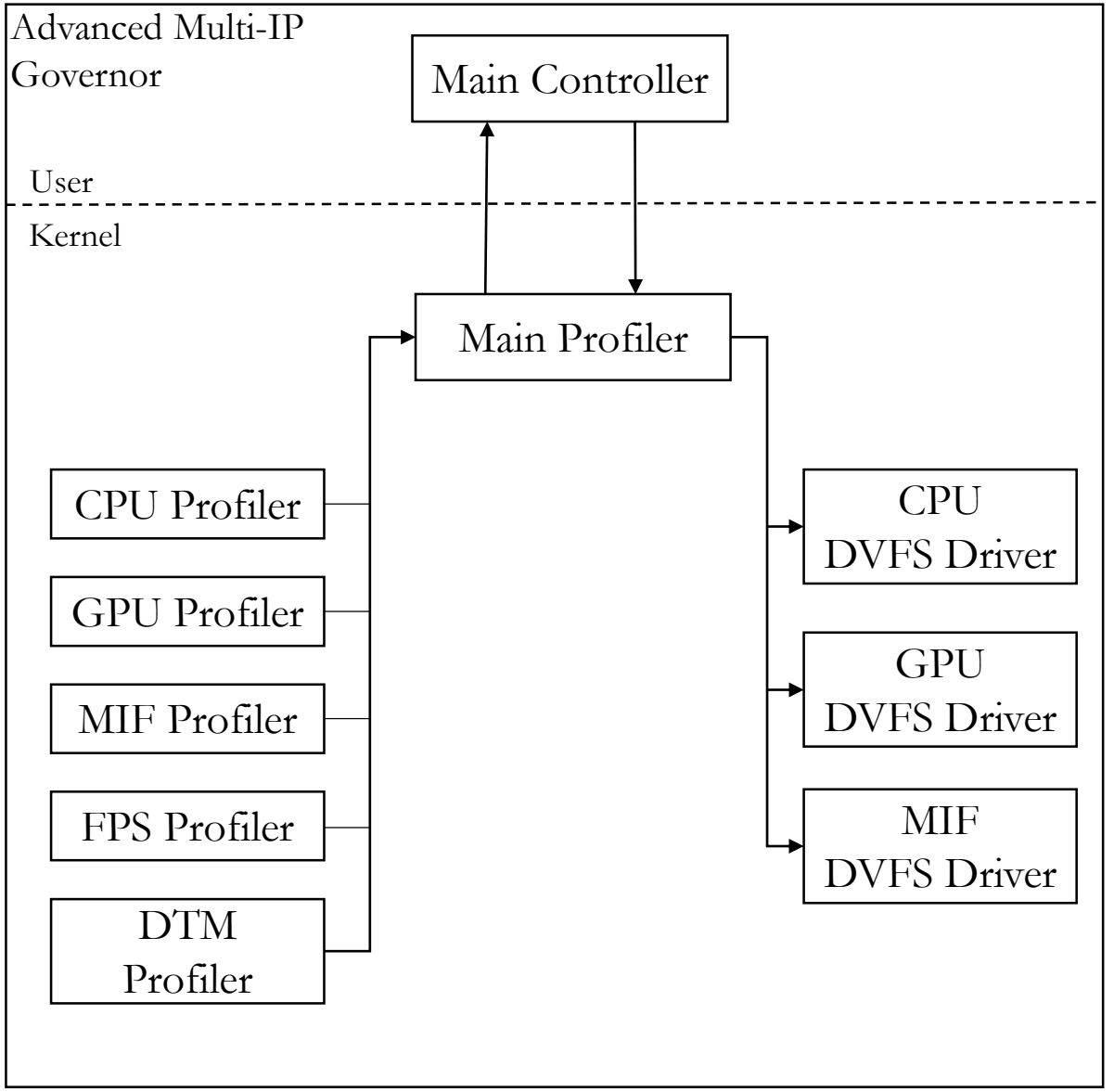


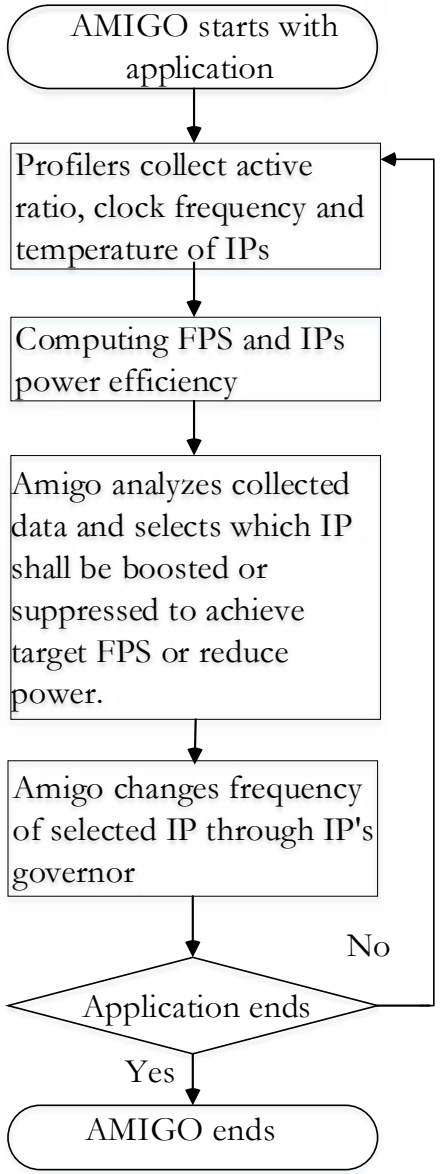




Power consumption @ Manhattan Offscreen 49fps

# AMIGO (Advanced Multi-IP Governor)

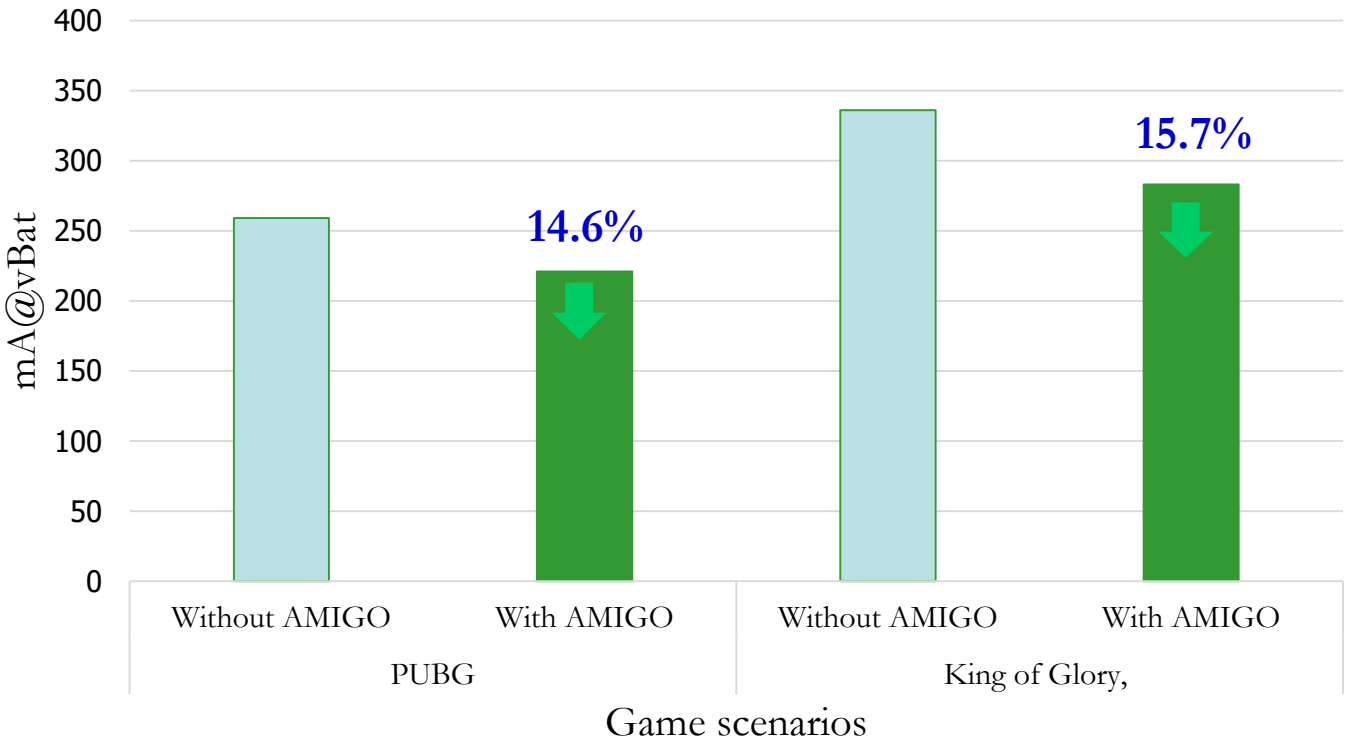
- Amigo is consisted of profilers which collect CPU/GPU/MIF/FPS/DTM data and the controller
- Each IP's active ratio, frequency, and temperature are being collected and the current FPS and screen refresh rate too
- Main controller analyze collected data and decide which IP shall be boosted or suppressed to achieve target FPS or reduce Power
- Once the IPs are identified, Main controller changes the frequency of selected IP through IP's DVFS driver



# Game Power Reduction

Amigo achieves the game power reduction by 15% on average



# Result

With high-performance CPU and GPU, Exynos 1080's Antutu score is 89% higher than Exynos 980

| | Exynos 980 | Exynos 1080 | Improvement |
|---|---|---|---|
| AnTuTu v8 | 330241 | 625281 | **89%** |
| CPU | 120146 | 174199 | 45% |
| GPU | 88635 | 239455 | 170% |
| Memory | 62029 | 114724 | 85% |
| UX | 62998 | 93301 | 48% |