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Comparative Study of Mobile Processors Found in Economy, Budget and Premium Level Smart Phones

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ABSTRACT

It is the era of mobile and smart handheld devices. Whenever you try to use these devices for the first time, you are comfortable with it in terms of ease of use and mobile response. Processors play a key role to provide quality in response to mobile and ease of use. People always think about looks of mobile, camera quality and its price at the time of purchase. After some time of use, mobile users get difficulties in using it. Reason behind the difficulties is the presence of low speed & low quality processors. Mobile users do not care about the quality of the processor at the time purchase. This paper helps to recognize mobile processors according to its use and is also very informative for comparison among different segments of mobile processors.

Keywords:— DSP, SoC, GPU

I. INTRODUCTION

Nowadays, smart phone being capable of performing many functions in a more compact way than a desktop or laptop does. This is only possible due to mobile processors. Mobile processor is a chip that processes every instruction that is required to run any application on smart phone. On earlier generation, designs of mobile processors are primarily focused on fast processing of digitized signals for maximizing throughput [8]. They are called as DSP centric. Now Modern SoC (System on Chip) has totally replaced the DSP centric architecture from the market. It integrated all the components like CPU, GPU and DSP on a single chip. It is supposed to give more computational power with improved efficiency. They are also used in embedded systems [10], where

previously micro controllers were used. Overall performance of a mobile processor depends upon each of its components. For example, the CPU performs the main function in a SoC, to process instructions. SoC has another processing component called GPU, it performs functions like computing complex mathematical calculations and screen rendering, which significantly reduces the processing load on a CPU [11]. Along with the performance, a mobile processor has to be power efficient also [9]. Sometimes you bought a smart phone, and you are unsatisfied with its performance. Then possible reason for this could be that the underlying specification of the processor doesn't match with your requirements. Thus, it becomes important for one, to first see processor specifications, before buying any smart phone. In literature very few efforts have been made to compare mobile processors and they are not very helpful from the buyer's point of view. This paper is an attempt to present a systematic approach, which compared various mobile processors available in the market, at the time of a paper published. Section 3 of this paper compared total 18 processors, 9 processors from each, **Qualcomm** [5] and **Mediatek** [6] (main contributors of mobile processor). All processors are categorized into three levels, premium, budget and economy, according to the price range of smart phones, in which they are used (see Table 1). Comparison between processors is done based on, processor performance on every parameter mentioned in Table 2. Performance is measured in terms of grades (A^+ / A, B^+ / B and C^+ / C).

Table 1: Processors for Comparison

Level	Price range	Processors
Pre-mium	30000 Rs and above	1. Snapdragon 865 2. Snapdragon 855 3. Snapdragon 845 4. Helio P90 5. Helio P70 6. Helio P23.
Budget	10000 – 30000 Rs	1. Snapdragon 730G 2. Snapdragon 712 3. Snapdragon 675 4. Helio G90T, 5. Helio P60 6. Helio P65
Econ-omy	2000 - 10000 Rs	1. Snapdragon 636 2. Snapdragon 660 3. Snapdragon 665 4. Helio P22 5. Helio MT6737 6. Helio A22

II. LITERATURE OVERVIEW

In 2014 Kumar, Manoj [1] presented a study of architecture of various mobile processors like ARM, Qualcomm and NVidia processors brands. To compare the architecture of various processors brands he took at least one example from each (ARM Cortex Av8, Snapdragon 600, Snapdragon 800, NVidia Tegra 4 and Tegra K1). From his study, it was found that all the modern mobile processors are basically ARM-based; they are just named differently by the mobile companies.

Lingam, D. G. (2015) [2] compared architecture of Qualcomm Snapdragon 800, NVidia Tegra 4\Tegra 4i, Samsung Exynos 5 Octa and Intel Atom processors.

KP, A., Joseph, D., & Prasad, S. (2016) [3] compared Snapdragon 600 and Snapdragon 800, Snapdragon, 200 and Snapdragon 400 from Qualcomm, Tegra 4 And Tegra 4i from NVidia, Mt6592 from Mediatek, Apple A9, Exynos 5 Octa from Samsung, Atom Z2580 and Atom Z2420 from Intel company. In 2016 A.

Katkar and A. Parab [4], compared same processor brands along with that they have discussed about various GPU's used these mobile processors in detail.

III. COMPARATIVE STUDY OF PROCESSORS

This section compares all 18 processors (given in Table 1). Processors are being compared via analyzing the performance on each parameter (given in Table 2). We have graded each processor from A+ to C; Grade reflects the performance of a processor on a particular parameter.

Table 2: Parameters for Comparison

Parameter	Description	Criteria
CPU	Central Processing Unit (CPU) is the main component in SoCs. It is capable of processing from every single instruction generated from a simple touch to a high computational task like gaming.	<ul style="list-style-type: none"> • Cores • No. of cores • Architecture, • Max Clock Speed
Power Efficiency	The Power Efficiency of a CPU is heavily depends upon the process technology.	<ul style="list-style-type: none"> • Process (in nm)
Graphics	Graphics Performance mainly depends upon the GPU. The GPU is another processing unit in SoCs, which reduces load on a CPU by performing complex mathematical calculation and renders images on the screen by itself.	<ul style="list-style-type: none"> • GPU • Max Resolution • Video Capture • Camera Support
Modem Support	The modem is another component in SoCs that connects our smart phone, wirelessly to a base station (Mobile tower).	<ul style="list-style-type: none"> • Category • Max Upload Speed • Max Download speed
Memory Support	Every running application is loaded into RAM (Random access memory), thus memory support determines which type of RAM is supported by the processors.	<ul style="list-style-type: none"> • Type (eg. LPDDR4) • Max speed • Space

Table 3: Comparison table for CPU and power efficiency in premium level processors

Parameter	Criteria	Snapdragon 865	Snapdragon 855	Snapdragon 845	Helio P95	Helio P70	Helio P23
CPU performance	CPU Name	Kryo585	Kryo 485	Kryo 385	ARM	ARM	ARM
	No. of Cores	8	8	8	8	8	8
	Architecture	64	64	64	64	64	64
	ARM Cores	A55, A77	A55, A76	A55, A75	A75, A55	A53, A73	A53
	Max Clock Speed	2.84GHz	2.84GHz	2.8 GHz	2.1GHz	2.1G Hz	2.3GHz
Power efficiency	Process	7nm	7nm	10nm	12nm	12nm	16nm

3.1 Premium Level

3.1.1 CPU performance and power efficiency

In premium level, the CPU performance of processors gradually decreases from Grade A (Snapdragon 865) to Grade C (Helio P23). See Figure 1(a). Snapdragon 865 has an Octa core CPU, made on ARM big. Little architecture, operates with maximum clock speed of 2.84 GHz (see Table 2). It consists of A77 Cores, the latest design from ARM, delivers higher performance than A76 core, which results in the A+ CPU performance of Snapdragon 865. (see Figure 1). After which Snapdragon 855, have A76 Cores, thus it delivers little lower CPU performance (A Grade) than Snapdragon 865. In terms of power efficiency both Snapdragon 865 and Snapdragon 855 have A+ power efficiency. Snapdragon 845 and Helio P95 which are ranked 3rd and 4th have almost same CPU configuration (A55, A55), differs only in their clock speed (see Table 3). Snapdragon 855 has 2.84GHz and Snapdragon 845 has 2.8GHz, thus they have Grade B+ and Grade B CPU performance respectively. In premium level lowest CPU performance and power efficiency is shown by Helio P23.

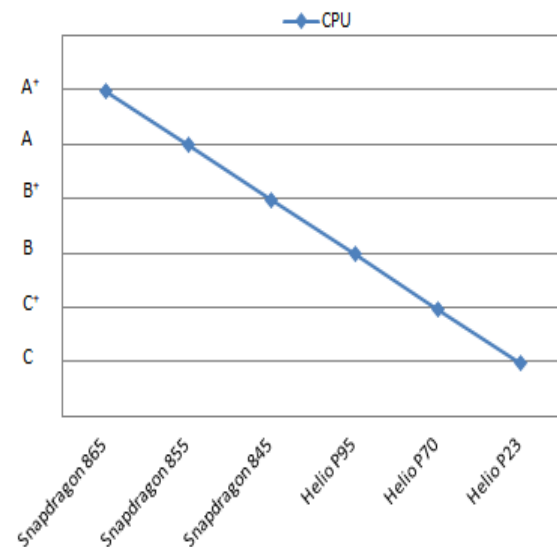


Figure 1: CPU performance

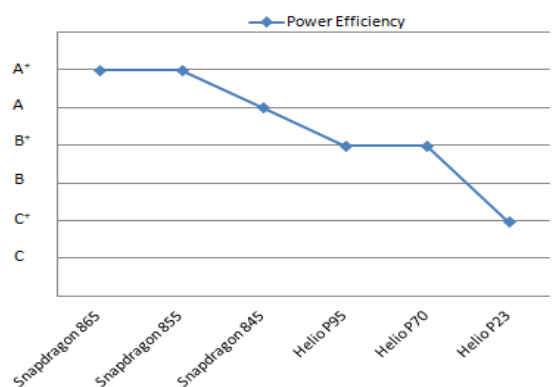


Figure 2: Power Efficiency in Premium Level Processors

Table 4: Comparison for Graphics Performance in Premium Level Processors

Products/ Features	Snapdragon 865	Snapdragon 855	Snapdragon 845	Helio P95	Helio P70	Helio P23
GPU Name	Adreno 650	Adreno 640	Adreno 630	IMGPowerVR GM 9446	Arm Mali- G72 MP3	Arm Mali-G71 MP2
Max Display Resolution	3840 x 2160	3840 x 2160	3840x2160	2520 x 1080	2160 x1080	2160 x 1080
Single Camera Support	Up to 64 MP	Up to 48 MP	Up to 32 MP	Up to 64 MP	Up to32MP	Up to24MP
Dual Camera Support	Up to 25 MP	Up to 22 MP	Up to 16MP	Up to 24MP	Up to 20MP	Up to 13MP
Max Video Capture Reso- lution	8K	4K	4K	4K	1080p	1080p

3.1.2 Graphics performance

The graphics performance in premium level varies from Grade A+ to Grade C+. Snapdragon 865 having Adreno 650 GPU, offers maximum 3840X2160 display resolution, up to 64 MP single camera support, up to 25 MP dual camera support and 8K video capture resolution (see Table 3) thus has A+ in graphics performance (see Figure 2). Snapdragon 855 has Adreno 640 GPU capture which is lower in Adreno series, and have little lower camera support (48MP, 22MP) and video resolution (4K), resulted in its Grade A performance in graphics experience (see Figure 3). Helio P95 having IMG PowerVR GPU, have excellent camera support of 64 MP in single camera and 48MP in dual camera, thus, it has also given a Grade A graphics performance. In premium level Helio P23 delivers lowest Graphics performance (C+).

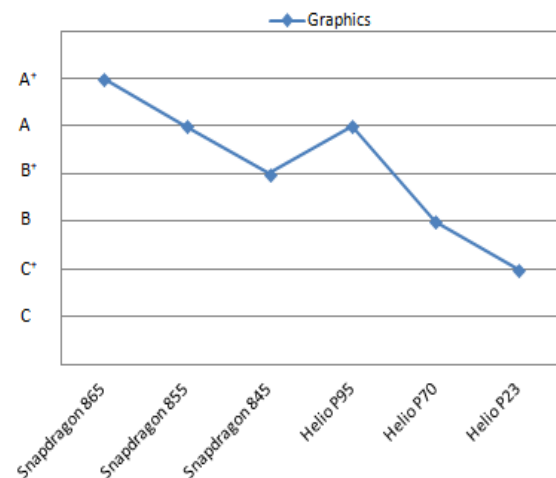


Figure 3: Graphics performance in premium level processors

3.1.3 Modem and memory support

Snapdragon 865 has Cat 24 LTE Category with peak download speed of 7.5Gbps and Cat 22 LTE Category with peak upload speed of 3 Gbps (see Table 6), delivers 5G experience. In memory support, it supports latest memory design called LPDDR5 RAM (up to 16 GB) with 2750 MHz memory access speed. Thus, Snapdragon 865 have highest Grade A+ performance in modem and memory support (see Figure 4). After which Snapdragon 855 offers 3 Gbps upload speed and 2 Gbps download speed and supports LPDDR4x RAM (up to 8GB)

Table 5: Comparison table for modem and memory support in premium level

Parameter	Criteria	Snapdragon 865	Snapdragon 855	Snapdragon 845	Helio P95	Helio P70	Helio P23
Modem Support	Uplink/Downlink Category	Cat22/ Cat 24	Cat22/ Cat 20	Cat13/ Cat 15	Cat13/ Cat 12	Cat13/ Cat-7	Cat13/ Cat-7
	Upload/Download Speed	3Gbps/ 7.5 Gbps	3Gbps/ 2 Gbps	150Mbps/ 1.2 Gbps	150Mbps/ 600 Mbps	150Mbps/ 300Mbps	150Mbps/ 300 Mbps
Memory Support	Name	LPDDR5,. LPDDR4x	LPDDR4x	LPDDR4x	LPDDR4x	LPDDR4x	LPDDR4x, LPDDR3
	Speed	2750MHz, 2133 MHz	2133MHz	1866 MHz	1866MHz	933MHz, 1800MHz	993Hz, 1500MHz
	Space	Upto 16GB	Upto 16GB	Upto 8GB	Upto 8GB	Upto 8GB	Upto 6GB

and offers little lower memory access speed than LPDDR5, which results in its Grade A performance. After which, Snapdragon 845 to Helio P23, performance decreases from Grade B+ to Grade C (see Figure 3).

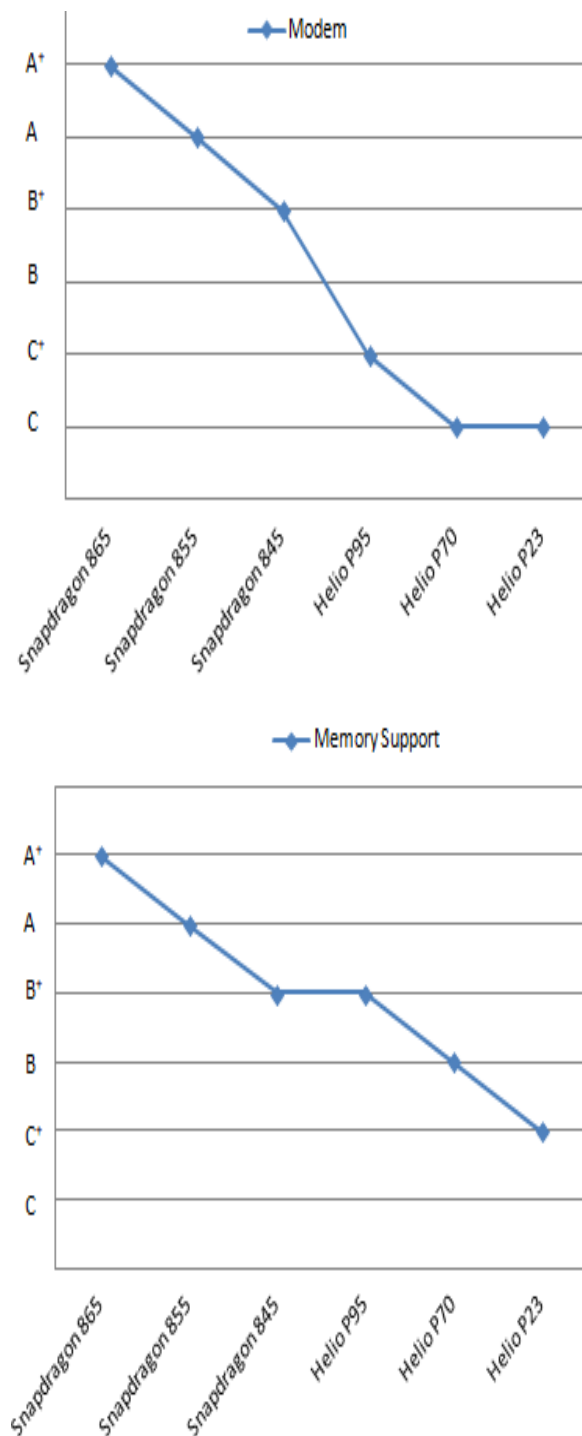


Figure 3: Modem and Memory Support

3.1.4 Overall ranking of premium level processors

As Snapdragon 865 outperforms on each parameter, thus it is ranked top in premium level (see Figure 4). It is one of the latest processors launched by Qualcomm in the year 2020. After which Snapdragon 855, has slightly lower performance, ranked second. Lowest performance is shown by the Helio P23 processor (see Figure 4).

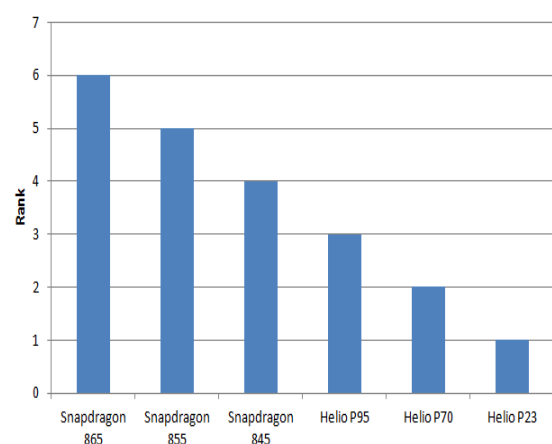


Figure 5: Ranking of premium level processors

3.2 Budget level

3.2.1 CPU performance and power efficiency

In budget level all processors have CPU performance in between Grade A to Grade B+ (see Figure 5). Snapdragon 730G top ranked processor in budget level processors, has Octa core Kryo 470 CPU (see Table 6), which operates with maximum clock speed of 2.2 GHz made on ARM big. Little architecture (A76, A55), delivers A Grade CPU performance. Snapdragon 675 and Helio G90T also have a Grade A CPU performance because their CPUs have almost same configuration (see Table 6). Among all budget level processors Snapdragon 730G with 8nm process technology has a higher A+ Grade in power efficiency after which all other processors either have Grade A or B+ in power efficiency (see Figure 5).

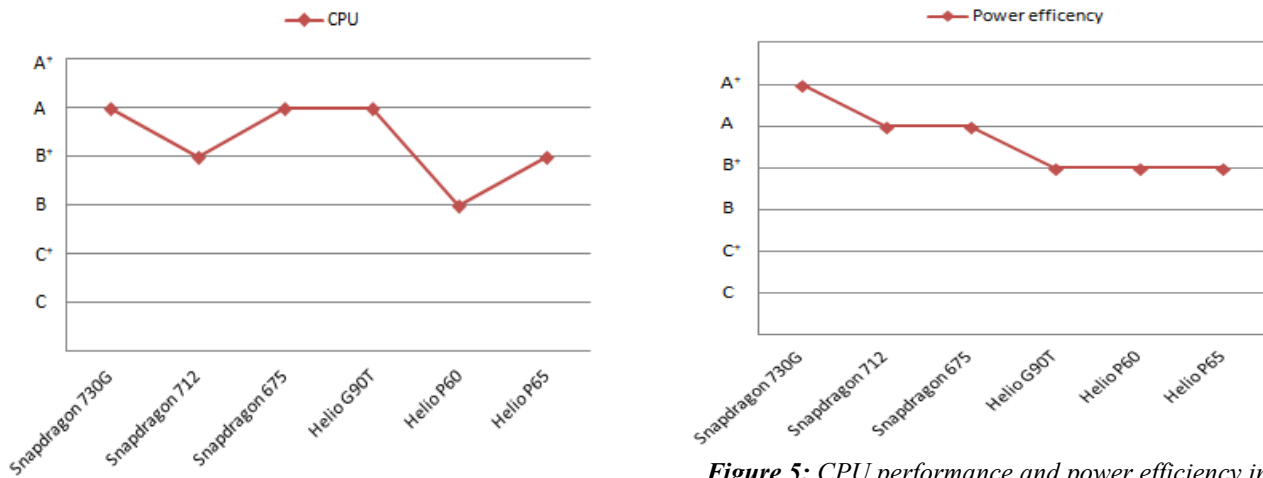


Figure 5: CPU performance and power efficiency in budget level.

Table 6: Comparison table for CPU performance and power efficiency in budget level processors

Parameter	Criteria	Snapdragon 730G	Snapdragon 712	Snapdragon 675	Helio G90T	Helio P60	Helio P65
CPU performance	CPU Name	Kryo470 CPU	Kryo 360 CPU	Kryo 460 CPU	ARM Cortex	ARM Cortex	ARM Cortex
	No. of Cores	8	8	8	8	8	8
	Architecture	64	64	64	64	64	64
	ARM Cores	A76 A55	A75	A76, A55	A76, A55	A73, A53	A75, A55
	Max Clock Speed	2.2GHz	2.3GHz	2GHz	2.05GHz	2GHz	2GHz
Power efficiency	Process	8nm	10nm	11nm	12nm	12nm	12nm

Table 7: Comparison table for graphics performance in Budget level processors

Parameter	Snapdragon 730G	Snapdragon 712	Snapdragon 675	Helio G90T	Helio P60	Helio P65
GPU Name	Adreno 618	Adreno 616	Adreno 612	Arm Mali-G76 MC4	Arm Mali-G72 MP3	Arm Mali-G52 MC2
Max Display Resolution	2560x1440	2560x1440	3,840 x 2160	2520 x 1080	2160 x1080	2520 x 1080
Single Camera Support	Up to 36 MP	Up to 32 MP	Up to 25 MP	Up to 64 MP	Up to32MP	Up to48MP
Dual Camera Support	Up to 22 MP	Up to 16 MP	Up to 16MP	Up to 24MP	Up to 24MP	Up to 16MP
Max Video Capture Resolution	4K	4K	4K	4K	1080p	4K

3.2.2 Graphics performance

In budget level all processors having Graphics performance in between Grade B to A (see Figure 6). Helio G90T having Mali G76 GPU, supports 2520X1080 display resolution, and with extreme quality camera quality support of 64MP with a single camera and 24MP with dual camera (see Table 6), results in Grade A Graphics performance. After which Snapdragon 730G, 712 and Helio P65 gives a B+ Graphics performance. The lowest graphics performance in budget level is shown by Helio P60.

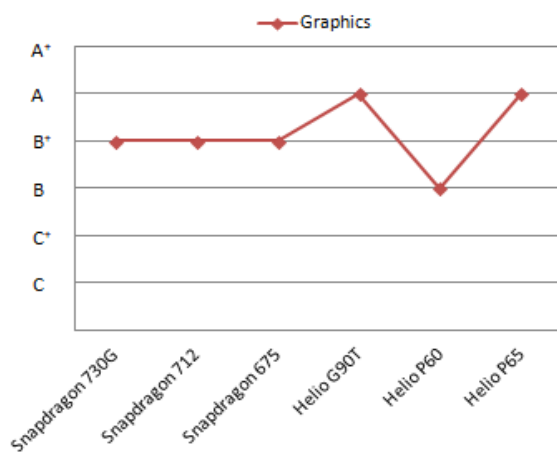


Figure 6: Graphics performance in Budget level processors

3.2.3 Modem and Memory support

In budget level processors either have Grade B+ or Grade B performance in modem and memory support (see Figure 7). From Snapdragon 730G to Helio G90T offers peak download speed between from 800Mbps to 600Mbps and upload speed of 150Mbps (see Table 8), gives B+ performances in modem support. After which Helio P60 and Helio P65 offers peak upload speed Of 300Mbps and download speed of 150Mbps, results in Grade B modem support. In terms of memory all processors support LPDDR4x with speed ranging from 1800MHz to 1866MHz and with a maximum capacity of 8GB, delivers

B+ performance in memory support except G90T have memory speed of 2133MHz and capacity of 10GB which results in its Grade A.

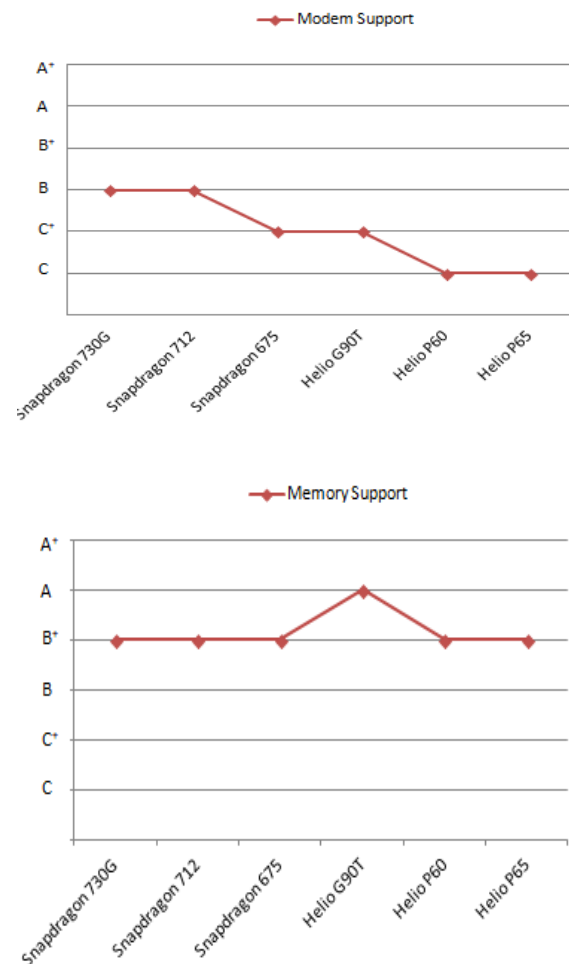


Figure 7: Modem and Memory support in Budget level processors

Ranking of budget level processors

Processors in this level are appealing, because having slightly lower performance than premium level processors at affordable cost. From the above comparison, Snapdragon 730G has the highest performance, and Helio P65 has the lowest performance in budget level (see Figure 8).

Table 8: Comparison table for modem and memory support in budget level processors

Parameter	Criteria	Snapdragon 730G	Snapdragon 712	Snapdragon 675	Helio G90T	Helio P60	Helio P65
Modem Support	Uplink/ Downlink Category	Cat-15/ Cat 13	Cat-15/ Cat 13	Cat-12/ Cat-13	Cat-12/ Cat-13	Cat-7/ Cat-13	Cat-4,7/ Cat-13
	Upload/ Download Speed	800Mbps/ 150Mbps	800Mbps/ 150Mbps	600Mbps/ 150Mbps	600Mbps /150Mbps	300Mbps/ 150Mbps	300Mbps/ 150Mbps
Memory Support	Type	LPDDR4/4x	LPDDR4x	LPDDR4x	LPDDR4x, LPDDR3,	LPDDR3, LPDDR4x	LPDDR4x
	Speed	1866 MHz	1866 MHz	1866 MHz	2133MHz	933MHz, 1800MHz	1800 MHz
	Space	Upto 8 GB	Upto 8 GB	Upto 8 GB	Upto 10GB	Upto 8GB	Upto 8GBB

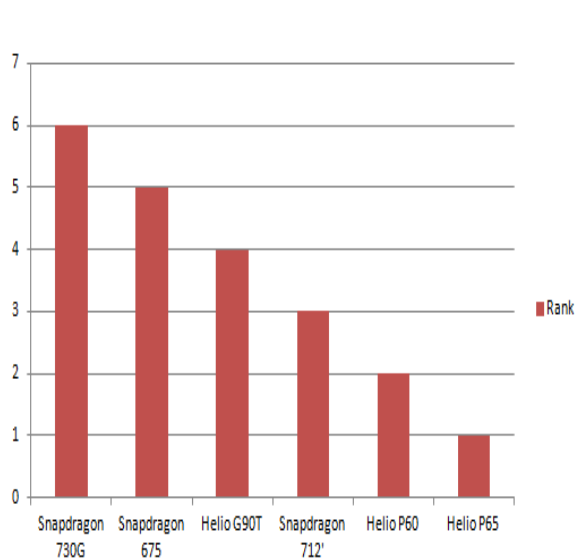


Figure 8: Ranking of Budget level processor

3.3. Economy level

3.3.1 CPU performance and power efficiency

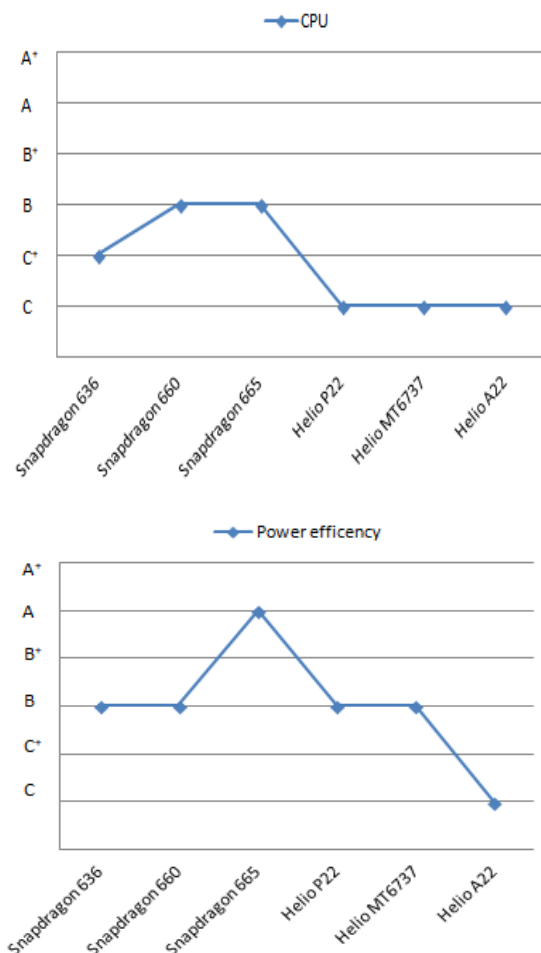


Figure 9: CPU performance and power efficiency in economy level

Table 9: Comparison table for CPU performance and power efficiency in economy level processors

Parameter	Criteria	Snapdragon 636	Snapdragon 660	Snapdragon 665	Helio P22	MT6737	Helio A22
CPU performance	CPU Name	Kryo 260 CPU	Kryo 260 CPU	Kryo 260 CPU	ARM	ARM	ARM
	No. of Cores	8	8	8	8	4	4
	Architecture	64	64	64	64	64	64
	ARM Cores	A53, A73	A53, A73	A53, A73	A53	A55	A53
	Max Clock Speed	Up to 1.8 GHz	Up to 2.2 GHz	Up to 2.0 GHz	Up to 2.0GHz	Up to 1.3GHz	Up to 2.0GHz
Power efficiency	Process	14nm	14nm	11nm	14nm	14nm	28nm

In economy level CPU performance varies from Grade B to Grade C (see Figure 9). Snapdragon 665 has Octa Core Kryo 260 CPU, which is made on ARM big.Little Configuration (A53, A73), operates with a maximum clock speed of 2GHz (see Table 9) delivers Grade B CPU performance. After which Snapdragon 660 and Snapdragon 636 having almost same CPU configuration differs only in clock speed shave B and C+ CPU performance respectively. Helio P22, MT6737 and Helio A22 have Grade C CPU performance. Power efficiency varies from Grade A to Grade C. Snapdragon 665 built on 11nm process technology has Grade B power efficiency. After which Snapdragon 636, Snapdragon 660, Helio P22, MT6737 with 14nm process technology have low Grade B power efficiency. Helio A22 gives lowest performance in power efficiency due to 28nm process technology.

3.3.2 GPU performance

Snapdragon 665 has GPU Adreno 610, maximum display resolution of 2520X1080, 4k video capture, single camera supports up to 25MP and dual camera supports up to 16MP (see Table 10) thus it delivers B+ performance in Graphics (see Figure 12).

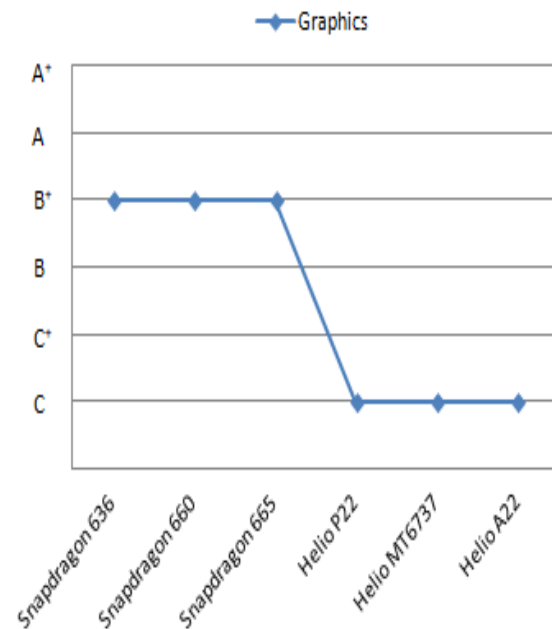


Figure 10: Graphics Performance in economy level

Snapdragon 660 and Snapdragon 636 which are second and third ranked processor in economy level also delivers same B+ Graphics performance. After which Helio P22 and MT6737 and Helio A22, supports lesser display resolution (1600×720), low video capture resolution (1080p) and low Mega pixel camera support as compared to Snapdragon processors which results in their C Grade performance in Graphics. (see Figure 10)

Table 10: Comparison table for Graphics performance in economy level processors

Parameter	Snapdragon 636	Snapdragon 660	Snapdragon 665	Helio P22	MT6737	Helio A22
Gpu Name	Adreno 509	Adreno 512	Adreno 610	IMG PowerVR GR8320	ARM Mali-720 MP2	IMG PowerVR
Max Display Resolution	2160X1080	2560X1600	2520X1080	1600X720	1280X720	1600X720
Single Camera Support	24MP	25MP	25MP	21MP	13MP	21MP
Dual Camera Support	16MP	16MP	16MP	13MP	8MP	13MP
Max Video Capture Resolution	4K	4K	4K	1080p	1080p	1080p

3.2.3 Modem and Memory Support

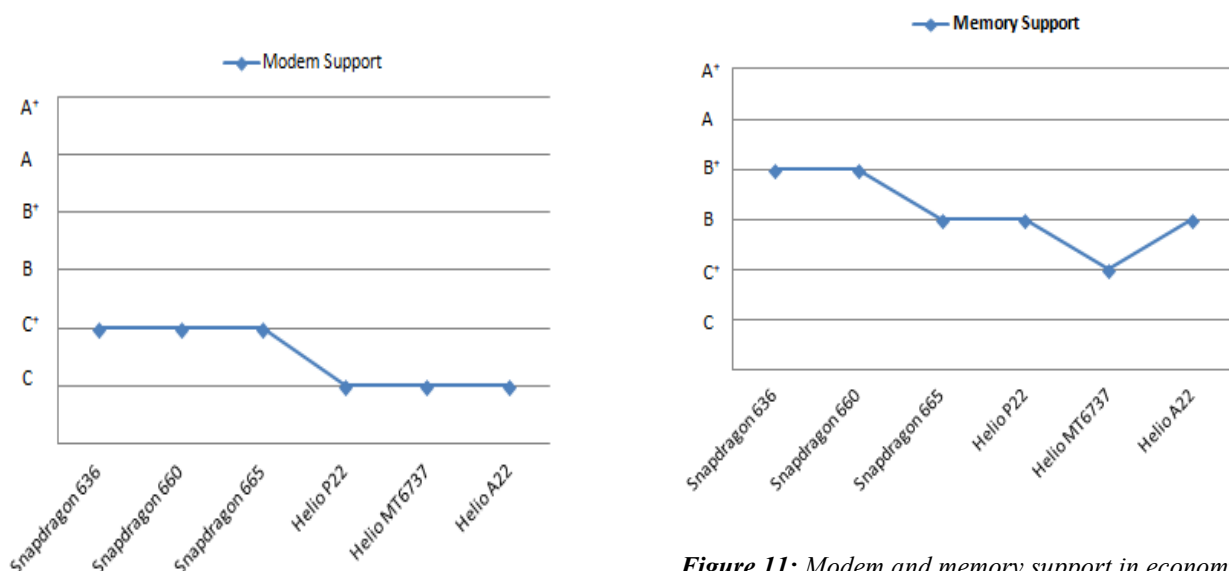


Figure 11: Modem and memory support in economy level

Snapdragon 665, Snapdragon 660 and Snapdragon 636 have C+ Grade performance (see Figure 11) in modem support (600Mbps/150 Mbps).

Helio P22, MT6737 and Helio A22 have slightly low (B Grade) performance in modem support (300 Mbps/150 Mbps). In memory support Snapdragon 660 and Snapdragon 636 and has highest B+ Grade performance (LPDDR4/4x, Up to 8GB). After that Snapdragon 665, Helio P22 and Helio A22 have Grade B performance in memory support (LPDDR3/4x, Up to 6GB). MT6737 has C+ performance in memory support (LPDDR2/3, Up to 3GB).

Table 11: Comparison table for modem and memory support in economy level processors

Parameter	Criteria	Snapdragon 636	Snapdragon 660	Snapdragon 665	Helio P22	MT6737	Helio A22
Modem Support	Uplink/ Downlink Category	Cat-12/ Cat-13	Cat-15/ Cat-13	Cat-12/ Cat-13	Cat-7/ Cat-13	Cat-4/ Cat-4	Cat-4/ Cat-13
	Upload/ Download Speed	600Mbps /150Mbps	600Mbps /150Mbps	600Mbps /150Mbps	300Mbps /150Mbps	150Mbps /150Mbps	300Mbps /150Mbps
Memory Support	Name	LPDDR4/ LPDDR4x	LPDDR4/ LPDDR4x	LPDDR3/ LPDDR4x	LPDDR3, LPDDR4x	LPDDR2, LPDDR3	LPDDR3, LPDDR4x
	Speed	1333MHz	1866MHz	1866 MHz	933MHz, 1600MHz	640MHz	933MHz, 1600MHz
	Space	8GB	8GB	8GB	4GB; 6GB	3GB	4GB 6GB

3.2.4 Ranking of economy level processors

Economy level processors are used in low range smart phones. From the above comparison Snapdragon 665 processors is at top (see Figure 12). And lowest performance in economy level is shown by Helio A22 in our ranking.

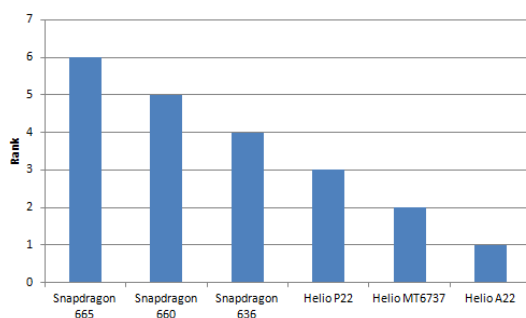


Figure :12 Ranking in economy level processors

IV. CONCLUSION

All Snapdragon processors have performed well in each level. Snapdragon 865, Snapdragon 730G and Snapdragon 665 is top processors in premium, budget and economy respectively. Mediatek processors performed well specifically in budget level. Kryo 585 is the only CPU with A+ performance. Similarly Adreno 650 is the only GPU, which offers A+ Graphics

performance. From our comparison results it is found that all budget level processors tend to give the same performance as premium level processor at lower cost. This research suggests a systematic method to compare any two processor.

V. LIMITATION AND FUTURE WORK

We have not compared all processors from Qualcomm and Mediatek. One can compare other processors also using same parameters for comparison. Grades given to a processor are purely based on processor specifications given in official website of Qualcomm [5] and Mediatek [6]; we have not tested any of these processor, thus performance may differ in practical situations.

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