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ODROID-XU4 as a desktop PC and microcontroller development boards alternative

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Abstract: *This paper presents an ODROIN - XU4 SoC computer, for whom even now we can say that has pioneered Nano computer revolution, present computing and the Internet of things.*

Keywords: *ODROID - XU4, information systems, sensor systems, Internet of things.*

1. INTRODUCTION

The idea of a general purpose computer, small in size with an affordable price was born in 2006 by a group of professors from the University of Cambridge. The reason for such computers was concern about the level of prior knowledge of young people who have signed up for computer studies. Unlike students from the eighties and nineties who were working on the ZX Spectrum, Commodore64 and Amiga microcomputers, whom possessed sufficient knowledge in the fields of computer hardware systems and system programming, 21st century students were familiar with the IT world only through the prism of Web applications, PC and gaming consoles.

The basic idea was to develop *something* that would cause interest among young people in the field of computer hardware systems, but at the same time raise the level of knowledge for the software skills. With the advent of the first processor for mobile devices in 2008 it had become clear that the project will get off the ground quickly. The initial idea of teaching aid has evolved, so that today all over the world there are whole armies of programmers from beginners to veterans and hardware enthusiasts. The principle of open source community projects is to exchange ideas aimed at developing mobile and Nettop solutions.

ODROID - XU4 is a SoC computer built by a South Korean company Hardkernel[1]. It was introduced to the market in the summer of 2015 as the most affordable ARM Octa - Core big. LITTLE high performance computer board. Before we move to the presentation of the model, it is important to note that unlike the Raspberry Pi SoC computer[2] which is followed by a large community of users with a host of advanced software applications and programming libraries, ODROID is a platform for experienced professionals which enables the development of applications for the currently most popular operating system Android, and it is supported by Samsung through the implementation of their own Exynos microprocessor.

1.1. ODROID – XU4

ODROID - XU4 is the latest generation of ultra-fast Octo - Core 5422 based compact single board computer. It is powered by ARM big. LITTLE technology the heterogeneous Multi – Processing (HMP) solution. With a smaller form (82x58x22 mm) ODROID-XU4 represents a computing device with more powerful and more energy-efficient hardware. As a product made for the open source community board can run various flavors of Linux, including officially supported Ubuntu Mate 15.10, Android 4.4.4 (v 3.5), also can provide unofficial support for Android 5.1.1 Lollipop, Android 6.0.1 Marshmallow , Kali Linux 2.0, Debian Jessie and others.

A hardware configuration comprises:

Processor: Samsung Exynos 5422 Cortex-A15 2 GHz and Cortex-A7 1.4GHz Octa-Core CPUs made in 28nm technology

GPU: Mali-T628 MP6 with 6x processing units supporting OpenGL ES 3.0/2.0/1.1 and OpenCL 1.1 with Full profile. Clocked at 533MHz it can generate up to 102.4 GFLOPS (FP32)

RAM: 2GB LPDDR3 RAM in 32bit dual-channel configuration at 933MHz provide throughput up to 14.9 GB/s.

Storage devices controllers: eMMC5.0 HS400 Flash Storage in range of sizes from 8 to 64GB and faster microSD UHS1 standard connector (on USB 3.0 controller)

Peripherals I/O: 2 x USB 3.0 Host, 1 x USB 2.0 Host, 4pin Serial UART, Two GPIO ports (30pin and 12pin, 2mm spacing) for I^2C, HSI^2C(High speed), SPI, UART, 2x12-bit analog-to-digital converter,

Network: Gigabit Ethernet port IEEE 802.3ab with RJ45 port

Video and audio out: HDMI 1.4a for display and audio out

2. COMPARATIVE PERFORMANCE ANALYSIS

2.1. Model measurement

In order to present the position of ODROID - XU4 in its characteristics and performance in relation to the Desktop/Laptop PC computers with a microcontroller and SoC development systems on the other side, we will do a series of tests that should provide a more complete picture of the relationship of performance in different applications. It should be noted that in practical applications of microcontrollers it is not expected to exert significant mathematical data processing, since there are DSP and FPGA circuits, so that we will not see them in tests of classic computer processing. In addition, due to limited RAM and flash capacity they are not intended for multimedia and Web content. Their primary role is to provide a reliable process management and support sampling analog electrical quantities in real time. For the above purposes they are equipped with a large number of directly controllable input / output ports aka. GPIO ports. SoC computer systems have similar ports as microcontroller development platforms, but they are less robust with narrower and lower threshold of tolerance for the height and size of electrical oscillations. On the other hand PCs do not have similar hardware input/output ports, and to provide similar functions it would require the purchase of specialized processing card, from that reason PCs will not be discussed in this domain.

In applications that require processor performance, i.e. the speed of working with Web content, HTML5 and Java-script application, the use of microcontroller is either impossible or inappropriate for such applications due to their performance levels, which are usually below a 100MIPS. Another limiting factor is the small working memory, which does not allow them the luxury of the classic PC Web browser with the memory requirements of tens or hundreds of MB.

Given that, computers and SoC development systems (such as Raspberry Pi, ODROID etc.) are used on both sides their value as a learning tool will grow. Through their use, students are given the opportunity to gain a broader insight from computer hardware technology all the way to the Web application levels.

2.2. Comparative results

In the field of direct process control application i.e. electronic circuits and sensors for sampling electrical quantities, we will try to present and compare the performance of microcontroller development system and SoC computers. The main emphasis will be comparing the performance that are achieved using microcontrollers versus SoC computer development systems while controlling individual input/output GPIO ports successive setting and deleting its condition[3]. In addition we will compare the speed at which systems can sample analog values and their electrical voltage through use of analog digital converters.

It should be noted, that from the microcontroller unlike SoC computers it is expected to provide real-time response to the trigger time and its end, which makes them suitable for use in real-time mission critical applications. Unlike them SoC systems are multi core SMP computers in which multiple processes are taking place at the same time. In SoC systems OS avoids providing exclusive rights to certain processes over resources, otherwise it could stop or significantly impede the work of all other threads. Besides microcontrollers have a much wider area of tolerance to input/output value of the operating voltage compared to SoC systems.

Using a simple sequence in programing code directly sets the state of GPIO port 11 to 1 and then deletes it i.e. set to 0 with the help of an oscilloscope SainSmart DDS140 and frequency-UNI-T UT61E, we have monitored generated sequence values, and the summarized measurement results are presented in Table 1.

A key part of the sequence of code that is executed by the C (or like it in Python) is:

```
INP_GPIO(11);
OUT_GPIO(11);

  while(1) {
    GPIO_SET = 1<<11;
    GPIO_CLR = 1<<11;
  }
```

Table 1. *GPIO performance comparison of major SoC and 32bit MCU dev. Platforms*

Platform		***Raspberry Pi 1 B+***	***Pi 2***	***Pi 3***	***Odroid XU4***	***Arduino DUE***	***PIC32MX 250Fxx***
Language (Used Library) for control of GPIO	Shell	2.8 kHz	6.2 kHz	12.92 kHz	125Hz	/	/
	Python (RPi.GPIO)	70 kHz	190.23 kHz	322.5 kHz	/	/	/
	Python (wiringpi)	28 kHz	105 kHz	168.9 kHz	206 kHz	/	/
	C (Native library) /Asembler for MCU	22 MHz	42.16 MHz	55.8-57 MHz	22.5MHz hardware limit	201.7kHz <45 MHz for all GPIO port	<40MHz (>33ns, <25ns)
	C (WiringPi normal GPIO)	4.1 MHz	9.76 MHz	13.83 MHz	710kHz (max 3.9-5.25MHz)	/	/
Analog to digital converting	ADC port numbers and resolution	/	/	/	2ch, 12bit	16ch, 12bit	9ch, 10bit
	Speed of conversion	/	/	/	600kSPS	1MSPS	1.1MSPS
Computing power	Instruction speed in DMIPS[1]	875	2019.41	3039.87	8302.97	125	66-83
Working range	Voltage	3.3V +/- 5%	3.3V +/- 5%	3.3V +/- 5%	1.8V +/- 3%	2.0-3.6V	2.3-3.6V
	Current	max 16mA per port max 50mA for all GPIO	max 16mA per port max 50mA for all GPIO	max 16mA per port max 50mA for all GPIO	max 4mA per port	15mA per pin, 130mA max for all I/O pins.	25mA per port, 300mA for all port pins

From Table 1. it shows that the SoC computer systems may somewhat be paralleled with 32-bit industrial microcontrollers performance[4][5] in the field of direct control of the input/output ports. This provides an opportunity for the development of projects in which students develop creativity through play, but also acquire the basics in the field of electronics. Since SoC systems have network connectivity and sufficient processing capacity to host internet services and applications students are given the opportunity to develop sensor networks and IoT systems[6]. Another area of application is the ability to work with the Internet Web development environment and programming code. SoC systems in this area provide energy-efficient (low-power) alternative to the traditional PC systems, which can be seen from Table 2. where they presented the performance of SoC and the PC system through the Web benchmark tests.

[1] Dhrystone Benchmark 2.1 Opt 3 32 Bit, VAX MIPS rating, compiled for ARM v7

Table 2. *Performance SoC and PC computer systems, applicative web application*

Tests	Platforms				
	Raspberry Pi 2 *32bit 4x core ARM Cortex A7 - 1GHz*, RAM 1GB DDR2 500MHz, V.Core IV, 32GB uSD UHC1 100Mbit NIC)	**Raspberry Pi 3** (64bit 4x core ARM Cortex A53 - 1.2GHz, RAM 1GB LPDDR2 900 MHz, V.Core IV 32GB uSD UHC1, 100Mbit NIC)	**Odroid XU4** 8x core ARM Cortex A15 1.4-2.0GHz, RAM 2GB LDDR3 933MHz, Mali-T628, 64GB eMMC v5, Gbit NIC	**Desktop PC** Intel P4 D 3GHz, 4GB DDR2, HDD 500GB 7200rpm, ATI HD6850, Gbit NIC	**Laptop PC** Intel Core 2 Duo 2.2GHz 8GB DDR3 , HDD 500GB 7200rpm, ATI HD 5650, GbitNIC
SunSpider 0.9.1	1923.6ms +/- 2.2%	1300.9ms +/- 7.9%	726.3ms +/- 1.7%	406.3ms +/- 1.8%	367.1ms +/- 1.1%
Sunspider 1.0.2	1901.4ms +/- 1.9%	1240.7ms +/- 2.5%	683.9ms +/- 1.4%	408.2ms +/- 1.2%	362.9ms +/- 1.0%
JetStream 1.1 (score)	12.944 ± 1.0765	17.443 ± 0.80750	37.443 ± 2.1004	73.583 ± 0.56971	72.783 ± 2.8112
Octane 2.0 benchmark	1794 Points	2895 Points	6896 Points	12533 points	11359 Points
Peacekeper	413 points	656 Points	1000 Points	1544 Points	1766 Points
OS	Raspbian Jessie (Debian Linux 4.1) 32bit		Ubuntu Mate 15.10 armhf	Ubuntu Mate 15.10 64bit x86	
Network transfer	94.2 Mbit/s	94.1 Mbit/s	672 Mbit/s	868 Mbit/s	841 Mbit/s

All tests were done in Mozilla Firefox v45.0 and Iceweasel v38.7.1 for Raspberry Pi, and Raspberry Pi2* was overclocked to 1GHz. Transfer speed is measured on client with "`sudo iperf -c`" server was a PC with 1GB NIC server for PC measurements was Odroid-XU4. Table 2. The difference in performance is further decreased if compared to the same PC systems under Windows 7sp1, 8.1 and 10, as Java script based Octane 2.0 benchmark on the specified PC laptop system in the same Web browser gives no more than 7500 points

Figure 1. *Odroid XU-4 SoC and Arduino DUE ARM-M3 based microcontroller development board*

3. CONCLUSION

The paper presents the comparison, usable SoC development of computer systems with Desktop / Laptop PC computers and Microcontroller / SoC development systems. With two built-in 12bit ADC port Odroid-XU4, initially provides features like microcontrollers, while in the field of web-desktop computer application a significant lead over other active SoC solutions from Raspberry Pi family. Following the results Odroid-XU4 is on average 2-3x faster than Raspberry Pi 3 and less than 50% slower than the full PC platform. Time is on among the ideal solution that can not only take over other SoC solutions and 8bit microcontroller, but also weaker PC workstations in laboratories and classrooms.

The main advantage of Odroid-XU4 platform is the ability to develop solutions that it would enable direct hardware and software compatibility with the Samsung netbook, and tablet platforms under the Android OS, as a most popular global operating system for smart devices.

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