Perspective platforms for BOINC distributed computing network

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Abstract

This paper describes perspective platforms that can be used by BOINC for distributed computing: mobile devices (Android, iOS, Windows Phone) and video game consoles (Sony PlayStation, Microsoft Xbox and Nintendo Wii/Switch). For now, BOINC supports Android devices only. During this research, I've found that iOS is not suitable for our purposes because of platform limitations and Windows Phone is not suitable too because of low market share. Video game consoles are more suitable for our purposes. Sony PlayStation, Microsoft Xbox and Nintendo Wii/Switch a good enough to be supported by BOINC distributed computing network.

Keywords: Volunteer Computing, BOINC, Distributed Computing, Mobile Devices, Video Game Consoles, Android, iOS, Windows Phone, Sony PlayStation, Microsoft Xbox, Nintendo Wii/Switch

1   Introduction

Currently BOINC platform supports 4 desktop OSs (Windows, MacOS, Linux, FreeBSD), mobile phones (Android-based), ARM-based devices (Raspberry PI), 3 GPUs (nVidia, AMD Radeon, Intel) and VirtualBox Virtualization technology [1].

As we can see from the 1 not every project supports all available platforms. This is due to complexity of the code and differences between the platforms. In common case scientists need to create and test a separate application for each type of platform. Long term projects such as Asteroids@home [2], Collatz Conjecture [3], Einstein@home [4], SETI@home [5] are presented on all or almost all platforms while other projects with several months of planned lifetime make their calculations on CPU only (e.g. DENIS@home [6], Gerasim@home [7], SAT@home [8]). Such projects with small experiments are not interested in new platforms because this will not give them any advantages and will not decrease overall completion time. New perspective platforms can be interesting to the projects which have massive amount of data to calculate and don't have definite end (processing data from telescopes, searching for prime numbers, etc.).

User interest is also very important. Only 6% of registered users are active now [9]. In average, every active user has 2.5 devices running BOINC. And these users pro-duce 163 583 TFLOPS [9]. New supported platforms can increase the overall power of distributed system and engage more people to join.
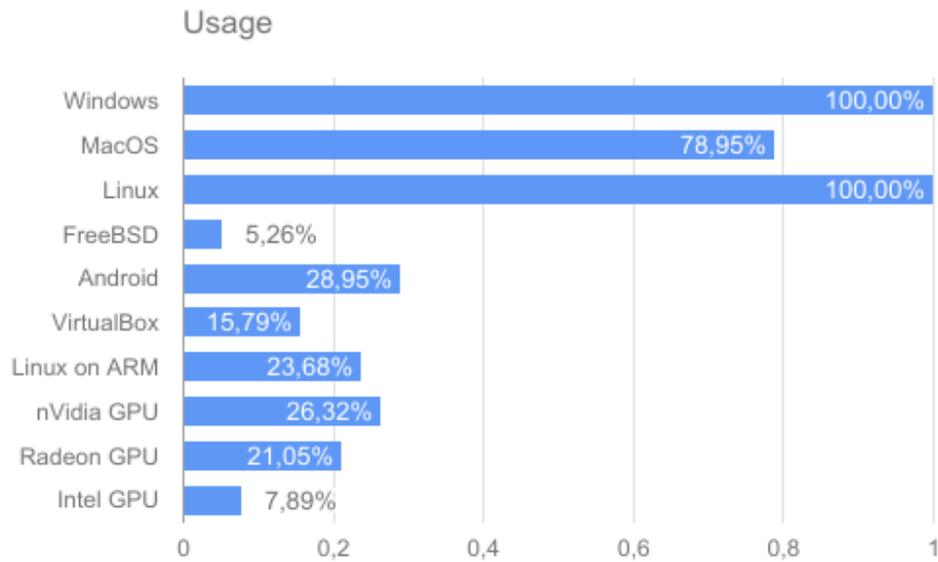
Figure 1: Platform Usage by BOINC Projects.

These platforms are not supported by BOINC yet:

- iOS mobile devices

- Windows mobile phones

- Sony PlayStation

- Microsoft Xbox

- Nintendo Wii/Switch

Next, we need to define whether these platforms can potentially produce a significant performance gains to BOINC infrastructure and can be easily used by users.

2 Mobile Devices

There are 3 main mobile platforms: Android, iOS, Windows Phone. Android is the most widespread mobile OS in the world (2), it is installed on 86.8% of mobile phones [10]. On the second place are iOS devices with 12.5% of market share. But despite of this share it is quite significant number of devices in compare with Windows Phone (0.3% of market share).

2.1 Android

Table 1: Potential user interest in BOINC mobile applications

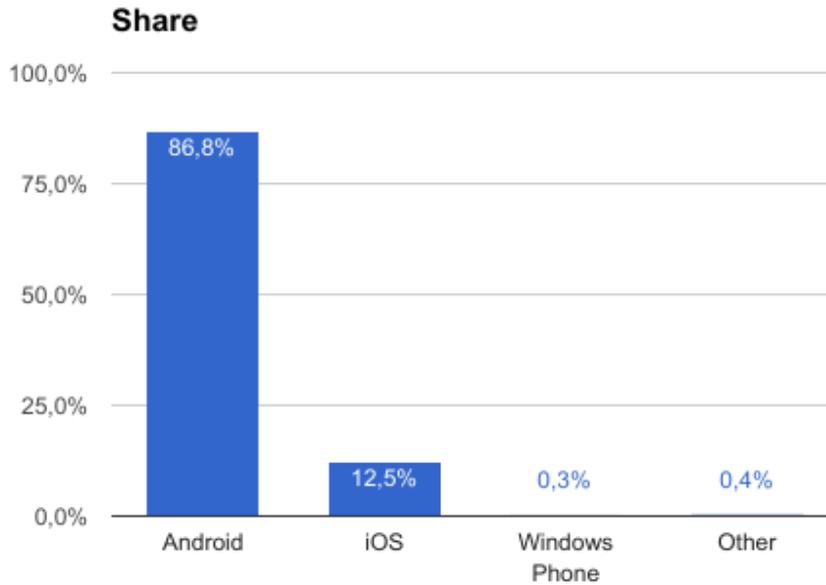| OS	Share	Potential Devices
Android	86,8%	100000
iOS	12,5%	14401
Windows Phone	0,3%	346
Other	0,4%	461

Figure 2: Worldwide smartphone OS share in 2016Q3.

Currently BOINC supports Android based devices only. BOINC for Android is presented as two separate applications: official application [11] and 'HTC Power To Give' application [12]. Last one is preinstalled on HTC devices [13].

Android BOINC application supports CPU calculations only. But all or almost all modern GPUs used in mobile devices supports OpenCL. From one hand adding tasks which will use GPU can increase their performance but from another hand this will lead to device overheat because of GPU intensive tasks which are the most 'hot' one. Such tasks can probably run on those Odroid devices only which have active cooling [14].

There is no possibility to count users who actively run BOINC on their mobile devices especially on HTC because of preinstalled application but official BOINC application has more than 100 000 installations [11]. Using this information, we can presume next potential user interest in iOS and Windows Phone BOINC applications (Table 1).

2.2   Windows Phone

Table 2: Comparison of Android based device and Windows Phone based device

	Meizu Pro 6	HP Elite x3
RAM	4 GB LPDDR3	4 GB LPDDR4
CPU Model	Helio X25	Snapdragon 820
CPU Cores	1.4 GHz x4 + 2.0 GHz x4 + 2.5 GHz x2	2.15 GHz x4
GPU Model	ARM Mali T-880	Adreno 530
GPU Performance	115 GFLOPS	407 GFLOPS

Devices based on Windows Phone same as Android smart phones are produced by several manufacturers. They have different configuration but these differences are not significant. If we will compare one of the top Android smartphone (Meizu Pro 6 [17]) and one of the top Windows Phone device (HP Elite x3 [18]) we will see that their configurations are quite similar (Table 2). As we can see from this table, Android based smartphone has more powerful CPU because of 10 available cores. Even despite of different core frequencies of Android device CPU, in total it can make more calculation than Windows Phone device at the same amount of time.

From the other hand, Windows Phone device has 4 times more powerful GPU than Android device [19]. But as it was mentioned above, GPU tasks are hot and can lead to device overheat so GPU tasks can't run all the

available time.

But using the information from Table 1 we can assume that share (0.3%) and potential user interest (346 installations) in BOINC for Windows Phone is too low and the development for this platform is inadvisable even despite of powerful GPU.

2.3 iOS

Table 3: Comparison of Android based device and Apple smartphone

	Meizu Pro 6	**iPhone 7 Plus**
RAM	4 GB LPDDR3	3 GB LPDDR4
CPU Model	Helio X25	Apple A10
CPU Cores	1.4 GHz x4 + 2.0 GHz x4 + 2.5 GHz x2	2.3 GHz x4
GPU Model	ARM Mali T-880	PowerVR Series 7XT GT7600 Plus
GPU Performance	115 GFLOPS	300 GFLOPS

iOS devices have 12.5% share (Table 1) and potential user interest (14401 installations) are rather less than Android one but much bigger than Windows Phone share and potential user interest.

Unlike Android and Windows Phone based smartphones iOS devices are manufactured by Apple only so there are no variety in device configurations of the same generation. As we can see from Table 3, the situation with the top iOS smartphone iPhone 7 Plus is the same as with Windows Phone HP Elite x3: it has less powerful CPU but more powerful GPU [20].

In normal mode BOINC works when device is not used by user, plugged into a power source and the battery is charged 90% or more to prevent reducing battery life or increasing recharge time [16]. This means that BOINC science applications need run in background. But iOS has limitations for background tasks: only audio players, audio recorders, VoIP applications, or applications which send, receive or process small packets of data from time to time, can run in background [21]. If the application will intensively use resources it will be terminated by the system. These limitations can be solved by creating a BOINC application which will run by user in fore-ground only. Screen of the device should be always on to prevent iOS send application to the background. Also, iOS applications have another limitation: they cannot execute downloaded binaries. In this case BOINC applications should include all project binaries.

The way proposed in [15] to run applications in Python virtual machine is nice for testing but is not acceptable for wide use because of complexity: user need to 'jail break' iOS device and install BOINC from non-official package source. And in this case applications should run in foreground too.

2.4 Conclusion

Both iOS and Windows Phone platforms are unsuitable to run BOINC applications: iOS has many limitations to run background applications and downloaded binaries and Windows Phone device are not so widely spread as Android devices. So, development of BOINC applications for these platforms is inadvisable.

3 Video Game Consoles

Table 4: Comparison of latest video game consoles

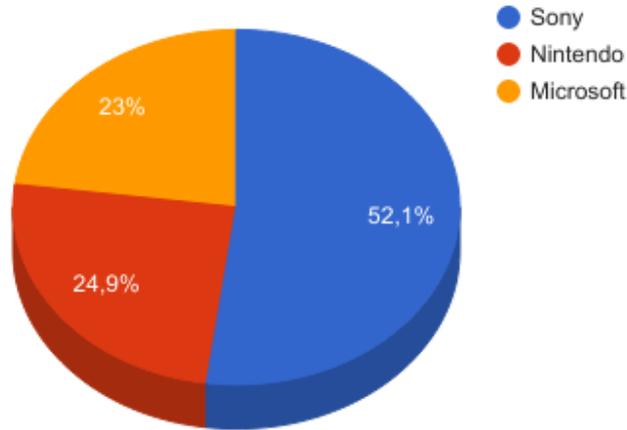|	**PlayStation 4 Pro**	**Xbox One S**	**Nintendo Switch**
CPU, MHz	2100	1750	1020
CPU, Cores	8	8	4
CPU, GFLOPS	134	112	Unknown
RAM, MB	8192	8192	4096
GPU, GFLOPS	4200	1404	1024
OpenCL	Yes	Yes	No, CUDA only

Figure 3: Video Game Console Market Share in 2016.

There are 3 main giants in video game console industry: Sony, Nintendo, Microsoft [22]. Sony is the biggest one. This company sold 13.94 million devices during 2016 year (52% of all sold video game consoles). Nintendo has almost the same market share as Microsoft: 6.66 (24.9%) and 6.14 (23%) million devices sold respectively (3).

As we can see from the Table 4 PlayStation 4 Pro has the most powerful GPU [27] and it has OpenCL support as well as Xbox One S [36]. Both Xbox One S [35] and PlayStation 4 Pro have similar CPUs. Nintendo Switch [44] is less powerful in CPU and in GPU calculations and it is the only one who has no OpenCL support [45]. Using this information only we can say that PlayStation video game console looks the most preferable for BOINC. Next, we will try to define whether other generations of video game consoles also can be usable for BOINC or not.

3.1   Sony PlayStation

Table 5: List of Sony PlayStation video game consoles

Model	CPU, MHz	CPU, Cores	CPU, GFLOPS	RAM, MB	GPU, GFLOPS	OpenCL
1	33,8688	1	Unknown	2	-	No
2	299	1	6,2	32	-	No
3	3200	8	218	256	400,4	No
4	1600	8	102	8192	1840	Yes
4 Pro	2100	8	134	8192	4200	Yes
Portable	222	2	2,6	32	-	No
Vita	444	4	Unknown	512	51,2	Yes

Sony has several models of their famous video game consoles (Table 5): PlayStation, PlayStation 2, PlayStation 3, PlayStation 4 and PlayStation 4 Pro. There are also 2 portable models: PlayStation Portable and PlayStation Vita.

First generation of PlayStation video game consoles has very slow CPU (33.8688 MHz) and only 1 core [23]. So, these devices can't be used by BOINC.

CPU used in PlayStation 2 is better (299 MHz) [24] and can be compared to Intel Pentium III used in the first generation of Xbox video game consoles [31]. These devices are no longer supported by Sony and have no

possibility to load applications from the Internet. This makes these video game consoles are not suitable for BOINC too.

PlayStation 3 has very powerful Cell BE CPU (3.2 GHz, 8 cores) and 256 MB of RAM [25]. It has powerful RSX GPU also but unfortunately it doesn't support OpenCL [26] so this GPU can't be used in calculations. PlayStation 3 has access to PlayStation Network [46] and BOINC application can be distributed on these devices using this service. It is the only legal way to run BOINC on PlayStation 3. Previously when there was a possibility to install Linux on these devices there were at least 2 projects that used PlayStation 3 as a node in distributed computing network: PS3Grid used BOINC to run calculation modules [47] and Folding@home used their own application [48].

PlayStation 4 has less powerful AMD CPU (1.6 GHz, 8 cores) than PlayStation 3 but has 8 GB of RAM [27]. Also, it has AMD GPU (1840 FLOPS) with OpenCL sup-port. Both CPU and GPU make this device very attractive for BOINC. As well as PlayStation 3 this generation of video game consoles has access to PlayStation Net-work [46] so BOINC application can be distributed to these devices using this service too.

PlayStation 4 Pro has the same configuration as the previous one but has more powerful both CPU (2.1 GHz, 8 cores) and GPU (4200 GFLOPS) [27]. Currently this generation of video game consoles suits best for BOINC application.

Currently only 2 models of PlayStation portable video game consoles are present-ed: PlayStation Portable and PlayStation Vita. Both have very slow CPU: 222 MHz, 2 cores in PlayStation Portable [28], [29] and 444 MHz, 4 cores in PlayStation Vita [30]. Even despite of the GPU in PlayStation Vita with OpenCL support [19] these devices are not profitable for BOINC in comparing with the regular models (PlayStation 3, PlayStation 4 and PlayStation 4 Pro).

But there is also one issue: BOINC application should be run manually by user as there is no possibility to run applications in background because of the architecture and the main purpose of the video game consoles.

Using the information listed above we can conclude that only 3 PlayStation mod-els are suitable for the BOINC application: PlayStation 3, PlayStation 4 and PlayStation 4 Pro. The BOINC application for this platform should be published on PlayStation Network to let users download and run it without any unusual actions.

3.2 Microsoft Xbox

Table 6: List of Microsoft Xbox video game consoles

Model	CPU, MHz	CPU, Cores	CPU, GFLOPS	RAM, MB	GPU, GFLOPS	OpenCL
Xbox	733	1	0,75	64	5,8	No
Xbox 360	3200	6	96	512	240	No
Xbox One	1750	8	112	8192	1310	Yes
Xbox One S	1750	8	112	8192	1404	Yes

Microsoft produced 4 generations of their video game consoles: Xbox, Xbox 360, Xbox One and Xbox One S (Table 6). First generation of these devices has very slow CPU (733 MHz, 1 core) [31] and it is less powerful (0.75 GFLOPS) [32] than the CPU used in PlayStation 2 (6.2 GFLOPS). Also since April 15, 2010 Microsoft discontinued Xbox Live [50] service for original Xbox [49] so there is no possibility for user to download applications from the web. As it was mentioned before the best way to distribute BOINC applications to video game consoles is standard services provided by console manufacturers. User can't install BOINC application in an easy way without this service.

Xbox 360 has the same architecture of the Xenon CPU as PlayStation 3 with one difference: it has 3 physical cores and 6 logical cores (96 GFLOPS) [33], [34], [37]. Unfortunately, Xenos GPU doesn't support OpenCL so BOINC can't use it for calculations [38]. Xbox Live supports Xbox 360 so this device is a good candidate for BOINC application.

Both Xbox One and Xbox One S have almost the same configuration (1.75 GHz, 8 cores, 8 GB RAM) [35]. The latest model has a little bit more powerful GPU (1404 GFLOPS) than previous one (1310 GLOPS) [36]. Both generations have OpenCL and Xbox Live support and can be used by BOINC.

Xbox devices as well as PlayStation devices have the same issue: BOINC need to be run manually by user and it can't be started automatically in background because of the main purpose of the game consoles. As a conclusion, we can say that BOINC can be created and installed using Xbox Live service for next Xbox models: Xbox 360, Xbox One and Xbox One S.

3.3 Nintendo Wii / Switch

Table 7: List of Microsoft Xbox video game consoles

Model	CPU, MHz	CPU, Cores	CPU, GFLOPS	RAM, MB	GPU, GFLOPS	OpenCL
Wii	729	1	2,9	88	-	No
Wii U	1240	3	14	1024	352	No
Switch	1020	4	Unknown	4096	1024	No, CUDA only

Nintendo company has 2 generation of their Wii video game console: Wii and Wii U. First generation has very slow Broadway CPU (729 MHz, 1 core, 2.9 GFLOPS) [40] and no OpenCL support by Hollywood GPU [39]. This model is no longer sup-ported by Nintendo but still has a possibility to download applications from Shop Channel. So, it is possible to create BOINC application for this.

Next generation of Nintendo video game consoles is Wii U [41]. It has more powerful Expresso CPU (1.24 GHz, 3 cores, 14 GFLOPS) [42] but still no OpenCL support by Latte GPU [43]. It has access to Nintendo eShop service to download applications [51] so BOINC application can be created and distributed through this service.

The latest Nintendo video game console is Switch [44]. It is a hybrid video game console based on Nvidia Tegra X1 System-on-chip (1.02 GHz, 4 cores) [45]. Integrated GPU is powerful (1024 GFLOPS) but have CUDA support only. Applications can be downloaded to this device from Nintendo eShop service. All this make this video game console a best choice to be supported by BOINC.

These devices the same as Sony PlayStation and Microsoft Xbox can run applications in foreground only because of the main purpose of video game consoles.

As a conclusion, we can say that Nintendo video games consoles are less powerful than the similar Microsoft Xbox and Sony PlayStation models but all three generations could be used by BOINC.

3.4 Conclusion

Sony PlayStation, Microsoft Xbox and Nintendo Wii/Switch are very good platforms and they could potentially increase the total power of the BOINC distributed calculation network. After this research, we can conclude that the most perspective platform is Sony PlayStation. Less power can produce Microsoft Xbox devices: they are less effective and are not so popular and distributed as Sony PlayStation. Least effective platform if Nintendo Wii/Switch. This video game consoles were never designed to be the powerful one and are not so popular as Sony PlayStation also.

So BOINC application might be supported by Sony PlayStation first, then by Microsoft Xbox and at last by Nintendo Wii/Switch.

4 Conclusion

Currently BOINC is present on Android mobile devices only but doesn't support GPU calculations that will increase the speed of calculations but also will lead to device overheat. That is why GPU support on mobile devices is very attractive but dangerous too because can damage the device itself. It can be supported by Odroid devices only. iOS platform has many limitations (e.g. no possibility to run application in background). Market share of Windows Phone devices is too low. That is why both iOS and Windows Phone devices are not suitable for BOINC.

Video game consoles are not so wide spread as mobile devices but their total amount is significant. Sony is the main player on this market, their device has more than 50% of total market share. PlayStation devices are the most powerful too so these two factors (market share and effectiveness) make this platform the best candidate to support BOINC. Both Microsoft and Nintendo have the same market share (25%) but Nintendo video game

consoles have less effectiveness than Microsoft Xbox devices. This makes Microsoft more attractive for BOINC than Nintendo but last one can be used for distributed calculations also.

Finally, we can say that the potential platforms for distributed BOINC calculations are (sorted from most effective to less effective): Sony PlayStation (PlayStation 4 Pro, PlayStation 4, PlayStation 3), Microsoft Xbox (Xbox One S, Xbox One, Xbox 360), Nintendo Wii/Switch (Switch, Wii U, Wii).

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