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ENERGY EFFECTIVENESS OF MOBILE TRADE IN CLOUD COMPUTING

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ABSTRACT

Energy effectiveness is a primary concern for mobile campaign. Cloud computing has the likely to save mobile trade energy but the reserves from offloading the process require going beyond the energy cost of the further communication. In this paper we focus to provide an breakdown of the critical factors touching the energy spending of mobile trade in cloud computing, which demonstrates energy savings. We show that the trade-offs are highly sensitive to the exact characteristics of the workload, data communication patterns and technologies.

Keywords: Energy effectiveness, trade-offs, Cloud Computing

INTRODUCTION

Through this paper we noticed the energy efficiency of mobile trade in cloud computing. We are witnessed cloud computing as a capable technology which can offer many paybacks for mobile devices. In this paper we focus on computation offloading, which can be used to save energy for the battery powered devices. We describe the present state of mobile device characteristics that are critical for cloud computing and highlight cases where cloud computing can be used to save energy. It turns out that the computational characteristics of many current mobile applications favor local processing. This can be a result of a natural selection process, which has favored light-weight applications that are able to run with the limited resources of a mobile device. Therefore computationally demanding mobile applications are rare even though the need for such applications may well exist. Nevertheless, cloud computing does allow running some existing applications with less energy. Thinking about the future, cloud computing can

be an essential enabler for the development of new computationally intensive applications for mobile devices

Cloud computing has received large interest recently. The primary motivations for the mainstream cloud computing are related to the elasticity of computing resources. Cloud computing offers virtually infinite resources that are available on demand and charged according to usage. This offers considerable economic advantages both for cloud providers and cloud users as described in [1].

For mobile devices the motivations of using cloud computing differ from the motivation of cloud computing with well-connected PC devices. A shared problem between mobile and mainstream cloud computing is the data transfer bottleneck. For mainstream cloud computing the most important concern is the time and the cost of transferring massive amounts of data to the cloud while for mobile cloud computing the key issue is the energy consumption of the communication. This is probably one of the reasons why there are few examples of true mobile cloud computing. Device backup would be a useful service for a small device that can easily get lost but it requires transferring large amounts of data. However, synchronization of contact and calendar data, where the amount of transferred data is more modest, is a service that is widely available.

Energy efficiency has always been critical for mobile devices and the importance seems to be increasing. Use cases are developing towards always on-line connectivity,high speed wireless communication, high definition multimedia, and rich user interaction. Development of battery technology has not been able to match the power requirements of the increasing resource demand. The amount of energy that can be stored in a battery is limited and is growing only 5% annually [8]. Bigger batteries resulting into larger devices are not an attractive option.Also thermal considerations limit the power budged ofthe small devices without active cooling to about three watts [5].

Energy efficiency improvements can also always be traded for other benefits like device size, cost and R&D efficiency. Indeed, large part of the hardware technology benefits have been traded for programmability in mobile phone designs [11].

Computation offloading has been the topic of a number of studies. However, only a subset of those studies focus on the effect offloading has on the energy consumption of the mobile device. In most cases the focus is on response time and other resource consumption. Large part of the research uses modelling and simulation, like [7], which is an early investigation of offloading work from mobile to a fixed host concluding that under certain conditions 20% energy savings would be possible. Compiler technology has been studied in, e.g., [12],where a program is partitioned to client and server parts. The client parts are run on a mobile device and the server part is offloaded. The main metrics evaluated are execution speed and energy consumption. Even though the measurements show that significant energy savings are possible, the outcome is shown to be sensitive to program inputs.

ENERGY TRADE-OFF ANALYSES

In the context of cloud computing, the critical aspect for mobile clients is the trade-off between energy consumed by computation and the energy consumed by communication. We need to consider the energy cost of performing the computation locally (Elocal) versus the cost of transferring the computation input and output data (Ecloud). For offloading to be beneficial we require that

$$Ecloud < Elocal \quad (1)$$

IfD is the amount of data to be transferred in bytes and C is the computational requirement for the workload in CPU cycles then

$$Ecloud = D/ Deff \quad (2)$$

$$Elocal = C/Ceff \quad (3)$$

where Deff and Ceff are device specific data transfer and computing efficiencies. The Deff parameter is a measure for the amount of data that can be transferred with given energy (in bytes per joule) whereas the Ceff parameter is a measure for the amount of computation that can be performed with given energy (in cycles per joule). With these we can derive the relationship between computing and communication for offloading to be beneficial

$$C/D > Ceff/Deff \quad (4)$$

The computing energy efficiency (Ceff) is affected by the device implementation. For example, a CPU designed for high peak performance requires much more

Device/frequency	Power/W	Cycles/energy (C_{eff})
N810/400 MHz	0.8	480 MC/J
N810/330 MHz	0.7	480 MC/J
N810/266 MHz	0.5	540 MC/J
N810/165 MHz	0.3	510 MC/J
N900/600 MHz	0.9	650 MC/J
N900/550 MHz	0.8	690 MC/J
N900/500 MHz	0.7	730 MC/J
N900/250 MHz	0.4	700 MC/J

Table 1: Energy characteristics of local computing for Nokia N810 and N900 (MC=megacycle).

Table 1 lists the computational energy characteristics of two mobile devices, the Nokia N810 and Nokia N900,measured with the gzip deflate compression program compressing ASCII data. In this paper we have used the Nokia Energy Profiler [2], which measures the power consumption of the complete device. The cycle values were calculated from program execution time and CPU

clock speed. From the table we can see that DVFS does affect the energy efficiency of computing (Ceff) but not radically. Device implementation has much bigger impact.The power and bit-rate characteristics of wireless modems vary also significantly. The most significant factor for the energy consumption of a wireless modem is the activity time of the interface. The latencies associated with the activation and deactivation of the wireless interface vary by technology and are longer in cellular communication than in WLAN.

DISCUSSION

The setup for mobile cloud computing is substantially different from the traditional client-server computing arrangement. Energy is a fundamental factor for battery powered devices and an important criterion when considering moving computing to the cloud. The basic balance between local and remote computing is defined by the trade-off between communication energy and computing energy. However, there are many factors to consider when thinking about mobile cloud computing scenarios.

The computing to data ratio defining the break-even for moving to cloud is highly dependent on the exact energy efficiencies of wireless communication and local computing. The measurements in this paper provide a rough guideline for current mobile devices but technology development can shift the trade-off point significantly. Naturally device specific implementation decisions affect the balance but to a less radical extent. Also, the computation offloading needs careful design in order to avoid introducing long latencies into user visible operations computation offloading can in some cases be used to improve performance in addition to saving energy. For wireless communication, not only the amount of data but also the communication pattern has a large impact on the energy consumption. E.g., interactive workloads utilizing thin client technologies represent probably the most challenging target because of the fine granularity of the required communication. The best energy efficiency for communication would be achieved with bulk data transfers. Also if immediate response is not required the data transfers can be delayed and executed later when a bearer with better energy efficiency is available.

CONCLUSIONS

Energy effectiveness is a primary concern for mobile campaign. Cloud computing has the likely to save mobile trade energy but the reserves from offloading the process require going beyond the energy cost of the further communication. In this paper We focus to provide an breakdown of the critical factors touching the energy spending of mobile trade in cloud computing, which demonstrates energy savings. We prove that the trade-offs are highly sensitive to the exact characteristics of the workload, data communication patterns and technologies

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