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A Literature Review on Improving energy efficiency on Android using Cloud based services

Renuka M. Dhanwate[1]
Department of Computer Science
Amravati University
Amravati, India

Vaishali B. Bhagat[2]
Department of Computer Science
Amravati University
Amravati, India

Abstract: ***Mobile devices of today offload their compute intensive application to Cloud, but also consume huge energy while communicating using mobile network services like 3G/4G. Cloudlets can be used to provide such services with wireless LANs. Worldwide Android becomes the fastest-growing mobile OS. Millions of new Android devices are activated worldwide every single day. Even so, it is the fact that Android smart phones have limited resources, such as battery charge capacity, network bandwidth utilization, storage capacity, and processor performance. These restrictions may be relieved by computation offloading: sending heavy computation to resourceful servers and receiving the results from these servers. Several issues related to offloading have been investigated. The energy consumption of under-utilized resources, particularly in a cloud environment, accounts for a substantial amount of the actual energy use. Inherently, a resource allocation strategy that takes into account resource utilization would lead to better energy efficiency; this, in clouds.***

Keywords: energy efficiency, cloud computing, mobile cloud computing, Android, WLAN

I. INTRODUCTION

In recent years, smart phone technologies have become powerful and smart phones are now like small computers for mobile users. Due to more powerful computation, better processing and sharper mobile screens in smart phones, there are various mobile applications in the market which use the advantages of smart phone technologies to make applications more interesting. However, there are many mobile applications such as games, navigation, voice recognition, and image retrieval which can cause batteries to drain quickly because of the heavy computation required by these multi-media applications.

Therefore, battery drain has become a big issue in smart phones. A study [1] showed that mobile users in 15 countries worry the most about short battery life of their smart phones. Another study [2] also had a similar result with 38% of 215 iPhone users having short battery life as their biggest concern.

The aim of this paper is to investigate if the cloud can be used to execute mobile phone application functions faster by offloading the task to the cloud, in comparison to execute the function on the mobile phone. The collaboration advantages, and disadvantages, with mobile phones and cloud computing will also be investigated as well as if different phones models with different network connections are more or less suitable for offloading.

II. METHODOLOGY

In order to assess the state of cloud computing energy research and awareness, we portray a current landscape based on online computing database searching, such as IEEE, ACM, Google. We examined papers, reviews and their references, to result in our studies samples, papers and reports published during 2010' – 2013'.

We chose a classification framework to categorize our study articles, as shown in Table 1, based on the literature review, the interest of energy and green cloud computing research and the existing ACM Computing Classification System [1].

As we can see from the table 1, after a full text review of all selected publications, we grouped them in two main domains: research papers and reports. Then in these sub domains: Review, Improvements in existing Technology, New Design, regarding first domain, and Environmental Impact, Cloud Service Provider Perspective regarding the second domain.

TABLE 1

Main classification scheme of publications in two domains and five sub domains.

Domain	Subdomain
1.Research Paper	1) Review 2) Improvements in existing technology 3) New designs
2.Report	1) Environmental Impact 2) Cloud Service Provider Perspective

III. LITERATURE REVIEW

There is quite a lot of material on the topic of mobile phones and cloud computing. Much of investigates the possibility to offload mobile phone functions into the cloud to extend battery life, by reducing the computational load of the mobile phone. Miettinen & Nurminen explains that energy efficiency is a fundamental consideration for mobile phones and argues that cloud computing has the potential to save energy through offloading (Miettinen & Nurminen, 2010). The energy cost of the computation must however be greater than the communication transfer cost to the cloud. Another interesting remark is that energy consumption is greater if the data sent is divided into smaller bits than by sending the same data in one large chunk. Miettinen & Nurminen presents a remarkably basic but straightforward formula, Ecloud < Elocal, which states that the energy consumption to send the task to the cloud must be smaller than the local consumption on the mobile phone, for offloading to be beneficial. They have also investigated the difference between 3G and WLAN connections where they state that the 3G connection uses more mobile phone energy the further away from the base station it is and that it takes longer time for the 3G connection to transfer data, in comparison to the WLAN connection, due to the lower bandwidth. To receive data is also less power consuming than to send it.

In this section we give the results of our study, based on the methodology explained in section 2: we will classify all 40 selected publications of our search in two main categories: Papers and Reviews and give the results of our study.

TABLE 2

Representation of the total number of publications per year regarding energy in cloud computing.

Year	Total nr. of publications	Papers / Reports	Percentage Papers / Reports(%)
2010	6	4 / 2	67 / 33
2011	10	6 / 4	60 / 40
2012	17	15 / 2	89 / 11
2013	7	6 / 1	86 / 14
Total	40	31 / 9	-

As we can see from table 2, 72.5% of all selected publications are research papers and 22.5% of them are reports. Till 2011' there has been a constant growth in number of publications in both research papers and reports, meanwhile in 2012' we can

notice a descent on the number of reports but 2.5 times greater number of paper publications. We can justify this as an awareness impact of reports towards researchers of the field.

Based on table 1 classification scheme, we give the results on the total number of publications per sub domain and their percentage on the domain they are part of, shown in table 3.

TABLE 3

Representation of the total number of publications per sub domain and percentage given by: "number of each sub domain divided by total number of publications per domain"

Domain	Sub domain	Nr. of publications	Percentage per domain
Papers	Review	5	16%
	Improvements in existing technology	10	32%
	New designs	16	52%
Reports	Environmental Impact	6	67%
	Cloud Service Provider Perspective	3	33%

This section is an overview of each of the sub domains, showed on table 1, regarding their specific topic on how they contribute to the energy issue. We could not have all full text publications of the four conferences to fully review them, so this analysis is focused on the some publications we presented .

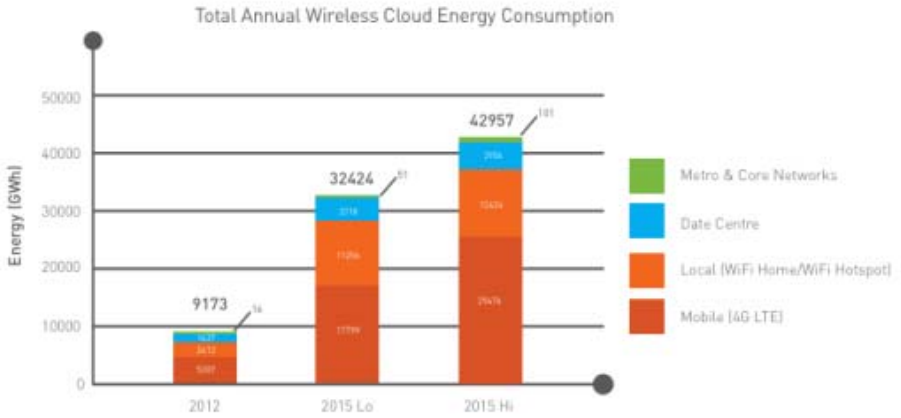

Fig. 1 Total Annual wireless Cloud Energy Consumption

For every sub domain we will mention the main strategies, policies, focuses on their research, as well as references and possible analysis.

1. Research Papers: This domain includes latest academic researches on the field of energy and power consumption in cloud computing, focusing on new techniques, concepts, designs, or improvements on this area. We categorize them as follows:

1.1 Review: this sub domain consist of studies that tend to give a state of the art on energy issue on cloud computing and classifies the existing techniques or hardware and software current solutions on the field, like articles in [7],[12].

1.2 Improvements in existing Technology: they tend to focus on the implementation of optimization techniques such as virtualization and consolidation [2], [4], on evaluating cloud computing data centers aspects that directly or indirectly have impact on energy issues like: current network traffic [9], speed and stability [8], power consumption peak and valleys [10], power budgeting [10], energy awareness.

1.3 New Design: which includes studies presenting novel approaches [12] resource management systems [6], simulating software [11], [12], algorithms and mechanisms for new energy-aware framework [11], [8], new methodologies for energy efficiency improvements [11], [6], new kind of usable energy [3], new architecture [4], new developed software [5], [3],

2. Reports: This domain includes latest reports on the field of energy and power consumption in cloud computing, focusing on the environmental impact cloud computing has for the moment, its trends for the future, statistics awareness on the area, as well as cloud service providers perspective for the advantages and disadvantages of cloud computing regarding energy consumption.

2.1 Environmental Impact: this includes publications that highlight the current state of energy issue on cloud computing, how this current trend can result too problematic regarding environment and worthless consumed energy, as well as new design considerations for green data centers. Main organizations or companies contributing on this sub domain are: Greenpeace [2], U.S. Energy Information Administration [3], Analytic Press [7], Dimension Data [11].

2.2. Cloud Service Provider Perspective: we will mention IBM, Dell and Google Reports. IBM gives its Energy Management Strategy in their Data Centers and IT Efficiency [5]; Dell gives its ideas on usage of techniques such as consolidation and hyperscale hardware, virtualization, integrated solutions for lower power consumption via better hardware designs [4]. Meanwhile Google gives an all new perspective on how cloud computing can in fact be seen as part of the solution towards amore energy efficient future. According to [12], migrating to the cloud can produce estimated energy savings of 68–87% for typical companies.

IV. CONCLUSION

In this paper we gave an overview of the current level of research on cloud computing energy aspects. We presented a literature review classifying a selected group of publications, some papers and reports published in the four recent years. We provided results and analyzed them. We identified that 72.5% of all selected publications are research papers and 22.5% of them are reports. Till 2011' there has been a constant growth in number of publications in both research papers and reports, meanwhile in 2012' we can notice a descent on the number of reports and 2.5 times greater number of paper publications. We also perform a topic-related analysis to show the main current research techniques: hardware or software solutions for better energy-efficiency cloud systems.

To conclude, this paper can also help academics or practitioners interested in the cloud computing area to consider research on the energy efficiency issue, as we can see its importance and growth of research level on this specific area recently.

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