If you bill it, they will pay: Energy consumption in the cloud will be irrelevant until directly billed for

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***Abstract*—Don't leave the lights on! One reason we take energy consumption seriously is because we are directly billed for it. If one leaves the heat on high over night the effect is noticeable on the next bill. Yet as granular as cloud computing billing can be in terms of resources and quality of service, we have limited motivation to investigate energy consumption in the cloud because cloud customers cannot necessarily realize savings. Proxies for quality of service such as lower performance CPU allocations can be used but at no point does a user see a bill listing energy consumption. Furthermore the difficulty in billing energy consumption of virtualized services is non-trivial and indirect. When many VMs share the same host, attribution of energy consumption becomes difficult. When many hosts are in the same datacenter attribution of cooling costs become difficult as well. Thus due to the direct and indirect costs of running a cloud, and the sharing of resourcing pricing cloud energy consumption is difficult and typically not done. We argue that until energy consumption of hosted computers, VMs, and cloud services is pushed down from the cloud provider to the cloud consumer, datacenters will continue to consume massive amounts of energy to provide software services. When cloud end-users have to pay for energy consumption they will consider optimizing energy consumption. Once energy consumption in the cloud is a bill line item, energy consumption will become a first class performance non-functional requirement of software.**

I. Introduction

We propose a lightning talk to be delivered within 5 to 10 minutes at RE4SUSY 2018. The lightning talk will cover the topic of lack of demand for software sustainability features until cloud services start billing for energy consumption.

During a discussion with some unnamed industry partners we asked about energy consumption, they responded that they were concerned, but until they could put a price on energy consumption of their software systems, they were going to ignore it. Why bother to optimize or even plan for energy consumption when you had immediate pressing concerns from requirements and non-functional requirement alike including features, stability, reliability, and cost of cloud services. Typically cost of cloud services already includes energy consumption and it is not a line item—thus optimizing for energy consumption does not have a clearly observable effect on the cost. Without insight into, feedback about, or the cost pressure of energy consumption, it will not be optimized for or even requested for from customers.

Energy consumption of software systems and services is a grave concern as data-centers now account for a significant portion of the worldwide energy consumption (2-3% [1]). Even office computers are blamed for city-sized levels of energy consumption [2], [3]. Yet mobile energy consumption is not significant environmental sustainability issue [4]. The chemicals used in batteries are a concern but the joules used on mobile devices pale in the comparison to the joules of an idle server in a datacenter being cooled by air conditioning. Thus server-side software energy consumption is one of the biggest sustainability concerns of software.

Cloud providers face tough decisions regarding energy consumption as elasticity and availability are buffered by the high cost of idle machines in the datacenter. High utilization is a goal, achieved by slicing servers up into VMs and containers. Yet high utilization has many other costs, heat, maintenance, energy, poorer per VM performance, are just a few. Heat requires further cooling thus consuming even more energy.

While it is easy to slice up the resources of a server and add it to a cloud, it is hard to attribute energy consumption to each particular VM, container, or service on a cloud server, although there is much research in the area [5], [6]. Performance counters are the simplest method of performance monitoring yet they do not work for counting energy consumed by cloud services. Cloud services therefore will need to leverage performance counters to suggest or estimate the actual energy consumption in the cloud. Furthermore knowledge of the global data-center will be required to understand the externalities of the energy consumption of computation.

We argue that nothing will motivate cloud end-users to optimize for such an invisible externality until it becomes a reality on their cloud services bill! Until the motivation for sustainability can be expressed monetarily on a bill for services, there will be few requirements communicated from customers to address software energy consumption of their cloud services. Given the current trend in cloud billing where giants such as Amazon rate CPU time and even engage in CPU credit systems with fine granularity there is likely pressure to bundle the cost of the externalities of a data-center into the cloud costs as well. The closer the customer can get to paying for exactly what they using the easier both parties can plan and expand. Thus we argue there is pressure on the part of cloud providers such as Amazon, Microsoft, and Google, to ensure that they can push all of their costs to the end-user proportionally. The value in not direct billing is that the customer assumes it is accounted for, but what the customer cannot see or measure, they will not optimize for. A customer who uses non-optimal instance VMs has no incentive to avoid this behaviour—for example low memory VMs coupled high numbers of CPU cores waste memory as they deny the unused memory to other VM instances who cannot be scheduled to that machine until the cores are freed up.

We argue that the incentives for sustainability should be, and eventually will be, pushed down to the cloud-service end-user. Until that point, few will prematurely optimize for energy, and sustainability when they can directly optimize for other costs.

II. Dire Need

Energy consumption can come at a high cost, Song et al. [7] show that 40% of the energy cost of a server is in cooling that server, which means for a small server running at 300W for 5 years, not only would nearly $1000 USD be spent powering the server—given the US average rate of 0.0733 per kWh [8] $(.3kW \cdot 24h \cdot 365d \cdot 5y \cdot \$0.0733)$ —but $600 USD would be spent cooling that same server. The externalities of data center cooling are such a concern that Microsoft has experimented/marketed with underwater datacenters [9] that use the ocean as a giant heat-sink.

As data-centers are prone to deploy near where people actually live—in order to reduce latency—they often prone to rely on energy produced in the local area—for instance in Edmonton, Alberta much energy is provided by coal fired power plants which have signficant environmental and health impacts. Often this energy has significant carbon emissions and thus data-centers energy will also be taxed accordingly with carbon-taxes. We argue that much like carbon-taxes, end-user billing of software energy consumption will promote reduced energy consumption or at least sustainable energy consumption much like economic models of carbon tax predict will happen with emissions and emission producers [10].

III. Possible Effects

If end-user billing of software energy consumption of cloud services became possible then those hosting services would have another dimension of performance to optimize for. Many other researchers have argued that users might be willing to trade off one concern to improve a performance concern such as network bandwidth or energy consumption [11], [12].For instance Zhang et al. [12] propose ranking and comparing applications based on energy consumption a system they call *software application energy consumption ratings* (SAECR)/Green Star—like Energy Star [3]). Thus system operators might care about the performance rankings of server-side software if they were being billed for sustainability concerns such as energy consumption. If system operators are choosing software packages and services for their sustainability footprint then there will be significant pressure on software developers to address energy consumption as a first class non-functional requirement in their software systems.

IV. Conclusion

Thus we have argued for the need for software energy consumption billing in cloud computing services—we believe it is inevitable as price and quality of service is a constant concern and competitive for cloud services. We believe that the advent of itemized billing for energy and other sustainability concerns will prompt cloud-services end-users to care and optimize for energy consumption concerns. Conversely, as Knuth stated, "pre-mature optimization is the root of all evil" [13], cloud-service end-users will not optimize for what they cannot measure or see.

Cloud providers will have to convince users to adopt a billing scheme based on energy consumption estimation as it cannot be measured directly. Direct measurement is not a large barrier as the governments of world propose taxation and incentivization strategies to address sustainability issues and many unmeasurable externalities. It is unlikely that private service providers cannot enact what governments have successfully deployed [10].

Cloud providers should bill customers directly in order to motivate requirements of sustainability and foster further innovation in software requirements and software design relevant to software energy consumption and sustainability.

References

[1] T. Bawden, "Global warming: Data centres to consume three times as much energy in next decade, experts warn," in *Independent (Newspaper)*. Independent, 2016, https://www.independent.co.uk/environment/global-warming-data-centres-to-consume-three-times-as-much-energy-in-next-decade-experts-warn-a6830086.html.

[2] US Department of Energy, "How is electricity used in u.s. homes?" https://www.eia.gov/tools/faqs/faq.php?id=96&t=3, Feb 2018.

[3] E. Star, "Energy star: The simple choice for energy efficiency," 2016. [Online]. Available: https://www.energystar.gov

[4] A. Hindle, "Green software engineering: The curse of methodology," in *23rd IEEE International Conference on Software Analysis, Evolution, and Reengineering (SANER 2016) FOSE Track: Leaders of Tomorrow: Future Of Software Engineering*, 2016, inproceedings, pp. 529–540. [Online]. Available: http://softwareprocess.ca/pubs/hindle2016SANERFOSE-green-software-engineering.pdf

[5] M. Kurpicz, A.-C. Orgerie, and A. Sobe, "How much does a VM cost? Energy-proportional Accounting in VM-based Environments," in *PDP: Euromicro International Conference on Parallel, Distributed, and Network-Based Processing*, Heraklion, Greece, Feb. 2016, p. 8. [Online]. Available: https://hal.inria.fr/hal-01276913

[6] R. Shea, H. Wang, and J. Liu, "Power consumption of virtual machines with network transactions: Measurement and improvements," in *INFOCOM, 2014 Proceedings IEEE*. IEEE, 2014, pp. 1051–1059.

[7] Z. Song, X. Zhang, and C. Eriksson, "Data center energy and cost saving evaluation," *Energy Procedia*, vol. 75, pp. 1255 – 1260, 2015. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1876610215009467

[8] M. Rareshide, "Power in the data center and its cost across the u.s." https://info.siteselectiongroup.com/blog/power-in-the-data-center-and-its-costs-across-the-united-states (Accessed 2018-07-20), 10 2017.

[9] R. Cellan-Jones, "Microsoft sinks data centre off orkney," https://www.bbc.com/news/technology-44368813, June 2018.

[10] X. Liu, Y. Leung, Y. Xu, and L. C. W. Yung, "The effect of carbon tax on carbon emission abatement and gdp: a case study," *Journal of Geographical Systems*, vol. 19, no. 4, pp. 399–414, Oct 2017. [Online]. Available: https://doi.org/10.1007/s10109-017-0254-1

[11] R. Saborido, F. Khomh, A. Hindle, and E. Alba, "An app performance optimization advisor for mobile device app marketplaces," *Sustainable Computing*, pp. 1–18, May 2018. [Online]. Available: http://softwareprocess.ca/pubs/saborido2018SUSCOM-app-optimization.pdf

[12] Z. Chenlei, A. Hindle, , and D. M. German, "The impact of user choice on energy consumption," *IEEE Software*, pp. 69–75, 2014. [Online]. Available: http://softwareprocess.ca/pubs/zhang2014IEEESoftware-user-choice.pdf

[13] D. E. Knuth, "Structured programming with go to statements," *ACM Computing Surveys (CSUR)*, vol. 6, no. 4, pp. 261–301, 1974.