Sustainability Considerations

Jukka Manner, jukka.manner@aalto.fi

Department of Communications and Networking

Aalto University, Finland

The grand challenges with environmental degradation and climate change call for major sustainability improvements in our societies. The Paris Climate Agreement requires that the energy supply and demand shall be reformed by the middle of this century in the way that global carbon neutrality can be achieved [1]. The quest ahead is huge considering that most of our energy is still fossil fuel based and even renewable energy creates emissions during its lifecyle. Therefore, all sectors of the society need to seek for sustainable and efficiency solutions to decarbonize their operations.

Information and Communication Technology (ICT), where the Internet and IP stack are the fundamental core, is considered as a critical enabler for digitalization and important to enable managing not only new and smart energy systems, but also to capture energy efficiency improvements in the end-use sectors such as industry, transport, services, and households. For example, ICT enables enhanced manufacturing processes, optimized logistics, solutions supporting environmental protection, and solutions facilitating climate change adaptation [2].

The downside of the ICT infrastructure and the Internet is its own resource and energy consumption. For example, producing hardware will need base materials, but also much critical materials such as rare earth metals, and naturally also energy both for producing and operating the infrastructure. Measuring indirect and direct energy use is difficult because ICT is embedded throughout the society in its all sectors. Such an assessment is also challenged by the way ICT firms run their operations, e.g., some may have in-house hardware and software, but some may outsource operations to external cloud services operated elsewhere or have a mix of both. Distinguishing the diverse sources of emissions may also be challenging [3].

It has been estimated that the whole ICT sector represented 2% of the world-wide greenhouse gas (GHG) emissions in 2008 [4]. A few years later in 2011 the estimate had grown to 3% but envisioning 6% by 2020 [5]. An analysis by Andrae [6] concluded that by the end of this decade, ICT could consume up to 20% of all electricity in the world. The Shift Project has made its own analyses which indicate a staggering increase in the overall energy use of the ICT [7]. Similar projections have also been presented by many other research groups. For example, Koot et al. [8] estimate that global data center energy usage could grow over 4 times from 2016 to 2030, Liu et al. [9] estimate the global data center energy consumption to grow 5 times from 2010 to 2030, and Wang et al. [10] analysed the trends in China and estimate that ICT energy consumption could growth over 8 times from 2001 to 2030.

National studies support the above observation, The Global Action Plan stated already in 2007 that ICT could consume 10% of the United Kingdom's electrical energy [11]. The Ministry of Transport and Communications of Finland estimated in its climate and environmental strategy for the ICT sector in 2021 [2] that ICT accounts for 4-10% of the global electrical energy consumption and around 3-5% of the global GHG emissions.

Clearly the present situation and the trend of energy use in the ICT sector and the Internet is not optimal. On one hand ICT helps other sectors (handprint) in energy efficiency and reducing emissions, but on the other hand its increasing own self-consumption of energy and resources (footprint) may lead to shifting consumption from one sector to another. This has also been raised by Freitag et al [3] who argue that the ICT industry is increasing its own consumption.

In [12], the author estimates the ICT sector's footprint (own consumption) and handprint benefits to other sectors. In 2020, the footprint is estimated to be higher than the handprint but could shift strongly to the other direction by 2030. Many uncertainties are discussed in this scenario.

When discussing the energy and resource consumption of the ICT sector and the Internet, hardware and software both contribute to the energy use. Often these are dealt with in a lumped way or focusing only on hardware. The role of software may have therefore been undermined, which would be of importance in the industry [14].

The ICT hardware has evolved tremendously over the last decades, for example the chipsets and electronics in present high-end smart phones have the same computing power than the super computers from the 1990's. Supercomputers can consume even megawatts of electrical power while smart phones are powered by small batteries and USB chargers. Network equipment increases performance at a fast pace while the power consumption is more stable, leading to lower energy per transferred bit. Yet, with the increased usage, the overall power consumption of networking is growing. For example, every generation of mobile technology is more energy-efficient per transferred bit and new product versions also become more energy-efficient. This has led to a dropping curve on the kWh/GB in Finland [15]. Yet, as Finns consume more and more data, the overall energy consumption is growing.

This positive hardware development should reflect in declining or stabilizing energy use and emissions, but a rebound effect, when efficiency gains are outpaced by the increase in usage, is taking place despite the positive evolution of electronics and processors. The number of people and devices using Internet services and the amount of data transmitted are growing but much less than the energy performance of the hardware.

When considering the energy use of ICT systems, one should distinguish between system/infrastructure base consumption and the increase caused by the content and services being stored, computed, transmitted, and consumed on end devices over the Internet

The IETF is focusing on the technologies and protocols used to run the Internet's infrastructure. Thus, the designs and decisions of the IETF will have a tremendous impact on the sustainability of the whole ICT ecosystem. One example of designs that has negatively affected the sustainability of the Internet is HTTPS. In [13] the authors evaluate the impact of adding TLS to protect HTTP traffic. This is only one example from 2014 but shows that designs have impact. Adding security into HTTP has been a very critical feature but at the same time it comes with a cost. Thus, even though most of the Internet's traffic and resource usage is due to the content, the design decisions related to the infrastructure and protocols do play a role, too.

Towards Sustainability Considerations in RFCs

The Request for Comments series has had a Security Considerations section for a very long time. RFC 2223 states that "All RFCs must contain a section near the end of the document that discusses the security considerations of the protocol or procedures that are the main topic of the RFC." RFC3552 goes further and gives guidelines on writing this Security Considerations section.

The ICT sector and the Internet are at the core of our daily lives. They have had a profound impact on our way of life, the digitalization of societies and a tremendous positive impact (handprint) on other sectors. Yet, at the same time the footprint of the Internet and its numerous technologies is increasing.

To show that the IETF is on top of the recent development and understands the impact of the work done, future RFCs must also consider the sustainability impact of new technical solutions, protocols, and architectures. Writing such a section is not evident at first, but with time the engineering community around the IETF can learn to look at the sustainability of the proposals and evaluate their footprint and handprint on our society.

A section on sustainability could, for example, discuss messages and bytes required to implement a protocol or extension, the impact on other nodes and even the network architecture, and give implementation and design guidelines on how to implement the documented feature or protocol in an efficient way.

References

[1] UNFCCC. Adoption of the Paris Agreement. Report. No. FCCC/CP/2015/L. 9/ Rev. 1, 21932 (UNFCCC, 2015).

[2] Ojala, T., Oksanen, P, Climate and Environmental Strategy for the ICT Sector. Ministry of Transport and Communications, ISBN 978-952-243-595-8, 2021.

[3] Freitag, Charlotte, Mike Berners-Lee, Kelly Widdicks, Bran Knowles, Gordon S. Blair, and Adrian Friday. "The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations." Patterns 2, no. 9 (2021): 100340.

[4] Mingay, S., Pamlin, D., Assessment of Global Low-Carbon and Environmental Leadership in the ICT Sector. Gartner and WWF, 3 November 2008, ID G00161337.

[5] Fujitsu, "ICT Sustainability: The Global Benchmark 2011", 2011.

[6] Andrae, A. & Edler, T., On Global Electricity Usage of Communication Technology: Trends to 2030. Challenges 6, 117–157 (2015).

[7] Ferrebeouf, H., Lean ICT: Towards Digital Sobriety. Technical report, The Shift Project, March 2019.

[8] M. Koot, F. Wijnhoven, Usage impact on data center electricity needs: A system dynamic forecasting model. Applied Energy, Volume 291, 1 June 2021.

[9] Y. Liu, X. Wei, J. Xiao, Z. Liu, Y. Xu, Y. Tian, Energy consumption and emission mitigation prediction based on data center traffic and PUE for global data centers. Global Energy Interconnection, Volume 3, Issue 3, June 2020, Pages 272-282.

[10] P. Wang, P. Zhong, M. Yu, Y. Pu, S. Zhang, P. Yu, Trends in energy consumption under the multi-stage development of ICT: Evidence in China from 2001 to 2030. Energy Reports, Volume 8, November 2022, Pages 8981-8995.

[11] Global Action Plan, An Inefficient Truth, 2007.

[12] Andrae 2021: Anders S.G. Andrae Internet’s handprint. Engineering and Applied Science Letter. Vol. 4 (2021), Issue 1, pp. 80 – 97.

[13] D. Naylor, A. Finamore, I. Leontiadis, Y. Grunenberger, M. Melia, M. Munafo, K- Papagiannaki, P. Steenkiste, The Cost of the "S" in HTTPS. CoNEXT '14: Proceedings of the 10th ACM International on Conference on emerging Networking Experiments and TechnologiesDecember 2014 Pages 133–140. https://doi.org/10.1145/2674005.2674991

[14] Jagroep, E. A., van der Werf, J. M., Brinkkemper, S., Procaccianti, G., Lago, P., Blom, L., van Vliet, R., Software energy profiling: comparing releases of a software product. Proceedings of the 38th International Conference on Software Engineering Companion (ICSE), May 2016, pp. 523–532.

[15] Finnish Federation for Communications and Teleinformatics FiCom: https://ficom.fi/ajankohtaista/uutiset/digiratkaisuilla-energiatehokkuuteen-mutta-ei-ilman-sahkoa/