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A peep into information and technology

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Abstract
Information and Communication Technologies (ICTs) playing a pivotal role in the development process. ICTs have a significant footprint in global resource consumption, Greenhouse Gas (GHG) emissions and waste, particularly considering the high growth rates. However, intelligent use of ICT can support other domains in mitigation monitoring of resources and environmental impacts and adaptation to unavoidable changes, for instance due to climate change. This paper provides an overview on activities to reduce the direct ICT footprint and on positive indirect effects in other domains. Finally, it briefly outlines the potential of ICT to support education, public awareness and policy-making.

Keywords: Global warming, ICTs, lifecycle, Natural resources, sustainable development.

INTRODUCTION

"*Globalization*" is a buzzword for a long time since early 21st century especially used by marketing personals or politicians. Lately, the occurrence of the recent past "economic crisis" made it clear to everyone that most problems we are facing in the 21st century are global in nature. This is true for the connected economy (which strongly relies on information and communication technology) as well as for environmental and natural-resource issues. In the book "Toward Inherently Secure and Resilient Societies" Allenby [1] stated that "*A principal result has been the evolution of an anthropogenic Earth in which the dynamics of major natural systems are increasingly affected by human activity*."

Global warming, the degradation of biodiversity, dependence on non-sustainable (carbon-based) energy sources, a lack of management of valuable natural resources and at the other end of the production- lifecycle, lack of proper waste-treatment etc., are the major threats to the entire globe in the present conditions. Due to the huge influence of human activity on the planets ecosystems, political and scientific activities that are try to deal with these problems have to take place on a global scale and with an interdisciplinary approach. Information and Communication Technology (ICT) came under surveillance also due to strong growth rates. This paper mainly discusses the *direct impacts* of ICT and the steps the ICT industry and science have to take to reduce the future impact of ICT.

ICT and Its Impact

ICT systems have three obvious impacts: *resource consumption*, *energy consumption* and *production wastage*. The performance of ICT devices per Watt has been steadily increasing over the last decade; between 1999 and 2007 the overall performance increased by a factor of approximately 75 and the performance per Watt increased 16 fold. At the same time the growth rates of ICT are so high, that overall energy consumption is still increasing significantly. Since energy density has increased as well, in current data centres only about 50% of the energy is consumed for actual data processing, the other 50% is used for cooling and other support functions. As per the analysis of Cremer *et al*. [2], the situation in Germany, which is quite typical for industrial countries, where ICT devices and infrastructure counted for approximately 8% of total electricity consumption (excluding industrial production) in 2001. This report estimates a growth of 45% until 2010. Mankoff *et al*. [3] predicted for all OECD countries an energy consumption of 8% (of total consumption) for the year 2010. From the greenhouse gas emissions viewpoint, the ICT sector is currently responsible for approximately 2% of the overall carbon emissions in Europe, but with strong growth rates in "business as usual" scenarios.

Resource consumption is one of the major factors in the process of energy consumption. One reason for the high energy consumption of devices is apparently the fact that product selection of customers is driven by performance and features and not (yet) by resource consumption. Consequentially, the parameter "energy consumption" is only optimized in product development when it directly affects the usability of devices. For example: personal computers/ desktop computers usually consume 5-10 times as much energy as notebooks do without providing 5-10 times the performance. The optimization in notebooks is done because it affects the battery life, which makes it an important feature [4]. On the software side, the current situation is also far from being ideal. The average usage of servers in data-centre's is down from about 70% (mainframes in the 80s) to 10% and less. Energy consumption, however, is not the only important issue. Other important yet indirect footprints of ICT are its "side-" and rebound effects. Dramatic increases in efficiency have reduced the footprint of the individual ICT device (e.g. a mobile phone/smart phone/notebook), but at the same time have also reduced the price so significantly that the increase in the adoption rate has by far outbalanced the efficiency gain. ICT is also the basis of modern logistics in a globalised

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economy that allows to produce on demand` and to send products around the globe during the production cycle [5].

Reducing the growth of resource consumption is major task before the globe. IT companies to be take initiation in this regard. To leverage the impact of ICT and particularly to stop the exponential growth of resource consumption, a series of activities need to be done, in alignment with which “Green IT” has been recently highly promoted, particularly by IT companies. These activities typically refer to energy-efficient hardware technology, reduction of hazardous chemicals used and data centre architecture. However, more steps have to be taken, notably in product design. McDonough and Braung art do not focus particularly on ICT equipment in their work; yet it is clear that true “Green IT” starts in the planning phase of new products. The whole life cycle including production and usage resource consumption and end-of-life has to be taken into consideration. Even in the software-side also major initiations taken in this regard. Cloud computing, virtualization and software as a service promise to make software services easier to manage and much more efficient. Instead of operating small-scale and inefficient server infrastructures in-house, outsourcing of data centres to more efficient (larger) ICT companies is recommended, example: “renting” virtual machines and storage services (e.g. Amazon, Google) or whole-software packages from Office products (e.g. Google Docs, Zoho) or Customer Relationship Management softwares (e.g. Salesforce). If appropriately implemented, the energy consumption should at best stop rising despite significant growth of IT services in the next decades [6].

Easing of ICT

ICT supporting mitigation efforts in a broad variety of domains is more important aspect. ICT also supported significant changes in the way management works: Thomas Friedman describes this as a change from *command and control* towards *collaborate and connect*. And *connect* also means that 3 billion people reaching for western lifestyle mediated through ICT channels. Thus, ICT already plays a significant role in our today’s world-order and hence has to take its responsibilities in the future. But ICT can also help on various levels: ICT can provide new insights, e.g. by applying new algorithms in better understanding climate models, can help to reduce energy use and provide real-time data, hence reduce time and distance between measured effects and actions to be taken. Web-based access to this data will provide real-time information to different user-groups and help influence their decisions. Laitner also suggests value-added materialization, meaning that in a modern “knowledge-based” economy more money is made per “material unit”, e.g. comparing the pharmaceutical or ICT industry with mining. This point is however under dispute.

Industrial production is still the largest energy consumer (approximately 23% in 2002, globally) and ICT can help to increase efficiency by smart-motor systems [7], end-to-end optimizations or demand-side management. Another often cited aspect of dematerialization is the “paperless-office”. Climate Group [7]: in particular usage of online media versus print documents, e-commerce and e-government initiatives (electronic files) and tele-working. The potential is significant, but until now printing has been deeply engrained in the conventional business-work done by “digital immigrants”. This might change, however, with a new generation of office workers that are “digital natives”. In academia, but also in business, traditional conferences can and should be replaced with virtual “green” conferences to a significant extent. Again, a young generation of professionals might find virtual interaction much more appealing than the current workforce (as it is seen e.g. in Open Source communities). Finally, ICT can help develop sustainable "green supply chains". Environmental Resource Management such as fishery and forestry is long overdue. Countries like Indonesia lose huge amounts of essential resources for illegal activities.

Many research groups work on integrating lifecycle activities with IT monitoring. E-government and international organizations should participate in such systems to allow monitoring international trade and environmental agreements [8]. The goal should be an end-to-end accounting; a “green supply chain”, through which the whole footprint of a product is measured and tracked and paid by the consumer. Even under optimistic assumptions, climate change and the degradation of the ecosystems are so far advanced, that adaptation of the society to the inevitable effects will be required. Also mitigation efforts need data and models as previously mentioned.

What Next?

ICT will play an important role in monitoring and adaptation efforts. Already today a wide range of environmental information systems are in place or are being rolled out, e.g. the Global Monitoring for the Environment and Security- GMES system of European Union [9]. It is important however, that these different information systems are not isolated and provide synergies through data- and process integration. Next-generation de-centralised distributed communication networks will be required that allow communication also in case of unreliable parts of the infrastructure or attacks and in remote areas. Thus R&D should target not only performance but also resilience. Our unsustainable behavior is resulting from the interactions of very complex systems of systems. Public awareness, appropriate political decisions and education are only possible when also laymen are able to understand the consequences of certain actions, e.g. effects of climate change on specific regions [10].

CONCLUSION

Impact of IT should on the sustainable development have to be checked out frequently. The direct negative impact of ICT is sometimes overestimated, yet has to be treated seriously, particularly due to the high growth rates in ICT. A lot of potentials are already identified and covered in the “Green IT movement”. Virtualization, Software as a Service and Cloud Computing also offer more efficient services for the future. On the hardware side, cradle-to-cradle design has to be incorporated in the design of new products. Usage of rare elements, hazardous chemicals and waste-treatment require special consideration. ICT has significant leverage to reduce e.g. the carbon footprint in other industries and by far over-compensate the own footprint. Studies suggest that impacts of ICT on other fields can lead to emission reductions five times the size of ICTs own footprint. Finally, ICT is required for adaptation, modelling and public awareness and as supporter for political decision-making. Albeit the potential impact of ICT, it seems that the communication among disciplines needs to be improved to give computer scientists a better idea where their services can be of help and vice versa.

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