Network Virtualization and Energy Efficiency

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I. Introduction

The energy consumption of IT and communication infrastructure is dramatically increasing. In the year 2000 the power consumption of servers, routers, and PCs in Germany was about 5 billion kWh per year [1]. For the year 2010 a power consumption of more than 55 billion kWh per year is expected for the IT and communication infrastructure in Germany [2]. In the face of global warming the reversal of this trend is a declared political goal. Future networks and their respective infrastructures have to be structured in a way that inherently supports an energy-efficient operation.

To achieve energy efficiency in future network infrastructures, a fundamental paradigm – the economic principle [3] – has to be applied contrariwise. Currently, the maximization principle (fixed input, maximum output) is usually applied as goal of the resource management in conventional network infrastructures. Fixed resources (available hardware and energy) are exploited to maximize the benefit (e.g. in terms of QoS, security, or throughput). However, the complementary minimization principle (fixed output, minimum input) is needed as goal of the resource management to achieve an energy-efficient operation of available hardware. Using this approach, a fixed benefit (e.g. a determined QoS) is made available by using a minimal set of resources (hardware and energy).

II. Methods to Increase Energy Efficiency

In addition to the deployment of newest energy-efficient hardware, an approach to increase energy efficiency, currently mainly employed in data centers, is server consolidation [4] through service virtualization. Virtualization is used to partition computational resources and allows for sharing of hardware. Services often need just a small fraction of the computational resources of a server [5]. Such services can be virtualized and run within a virtual machine. Depending on their resource demands, several virtual machines can run on a single hardware (server consolidation). This leads to less hardware needed and a higher utilization of the hardware. This consolidation of shared hardware enables energy efficiency, measured as the work load per consumed energy [6] and it appears feasible to envision a corresponding efficiency for future network environments.

A further improvement in energy efficiency can be achieved through the extension of server consolidation by an autonomous and energy-aware management of physical and virtual resources. On the one hand this management is based on an energy-related monitoring of these resources which provides information like e.g. the temperature, the power consumption, and the utilization of single hardware components. On the other hand also a machine-readable description of virtualized services and their energy efficiency properties is needed. Based on this information the management system moves virtualized services from lowly utilized or energy-inefficient hardware to another and can turn of or hibernate the unused hardware. Moreover, communication and application layer services have to be analyzed, regarding their energy-efficient support of network elements and their features. The main goal is to redesign the services and protocols in a way that the permanent accessibility of all virtual or physical entities is not a precondition for the availability of certain network services.

III. Conclusion

One approach to achieve an energy-efficient Future Internet is to virtualize entire networks as described in [7]. Consolidation in this context should provide savings similar to those seen today in data centers. However, the detailed implications of such an approach still have to be investigated.

References

[1] Wuppertal Institut für Klima, Umwelt, Energie GmbH, 2000.

[2] Fraunhofer ISI. Der Einuss moderner Gerätegenerationen der IuK-Technik auf den Energieverbrauch in Deutschland bis zum Jahr 2010, Studie. http://www.isi.fhg.de/e/publikation/iuk/ Fraunhofer-IuK-Kurzfassung.pdf

[3] Hans Albert. Ökonomische Ideologie und politische Theorie. Verlag Otto Schwartz & Co, Göttingen 2. Aufl. 1972. pp.13ff.

[4] Koomey et al. Server energy measurement protocol, Version 1.0, Following Energy Efficiency Server Benchmark Technical Workshop, Santa Clara, CA, 2006, http://www.energystar.gov/ia/products /downloads/Finalserverenergyprotocol-v1.pdf

[5] Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V., Energieeffizienz im Rechenzentrum Band 2, 2008, p. 10

[6] Rivoire, Shah, Ranganathan, Kozyrakis. JouleSort: A Balanced Energy-Efficiency Benchmark. ACM SIGMOD International Conference on Management of Data (SIGMOD), 2007

[7] A. Berl, A. Fischer, and H. de Meer. Using System Virtualization to Create Virtualized Networks. Workshops der Wissenschaftlichen Konferenz Kommunikation in Verteilten Systemen (WowKiVS2009), Kassel, Germany, March 2-6, 2009. vol. 17, EASST, 2009.