Energy Consumption of Telecommunication Networks

Christoph Lange[(1)], Dirk Kosiankowski[(1)], Christoph Gerlach[(2)], Fritz-Joachim Westphal[(1)], Andreas Gladisch[(1)]

[(1)] Deutsche Telekom AG, Laboratories, Goslarer Ufer 35, 10589 Berlin, Germany
[(2)] Deutsche Telekom Netzproduktion GmbH, Goslarer Ufer 35, 10589 Berlin, Germany
{christoph.lange; dirk.kosiankowski; cgerlach; fritz-joachim.westphal; andreas.gladisch}@telekom.de

Abstract *The energy consumption of a telecommunication network increases, but at a reduced slope compared to the assumed traffic volume increase. The major energy consumption portion shifts from access to backbone networks with rising traffic volume.*

Introduction

The rapidly rising variety of broadband communication services induces an increasing demand for high access rates of telecommunication networks. This in turn leads to an increase in the overall Internet traffic volume of approximately 50% to 60% per year[5] requiring network operators to extend their network's capacity. Necessary related network extensions in general lead to an increasing number of active network elements.

In the context of the public discussion concerning the climate change the question arises, how the energy consumption of the network will develop: Does the energy consumption of telecommunication networks grow at the same rate as the traffic volume? In addition, for network operators this is of vital economical interest, since energy-related costs contribute considerably to their operational expenditures.

Access networks typically consist of a high number of distributed active network elements and therefore currently they consume by far the highest share of the total energy needed by a telecommunication network.[7] However, according to theoretical investigations[6,8], in the future the backbone network energy consumption share is expected to rise.

In this paper a study of the energy consumption of a broadband telecommunication network is performed based on traffic forecasts and real network architectures and requirements like e. g. a hierarchical network structure and resilience mechanisms.

Network and traffic model

The considered broadband telecommunication network (Fig. 1) is structured into the partitions access, aggregation and backbone network. The aggregation network partition consists of a layer 2 part (L2) and an underlying optical transport network (OTN). Similarly, the backbone network is composed of a layer 3 IP/MPLS backbone (L3) and an optical transport network for the backbone.

Topologies and architectures of the model have been chosen in order to ensure flexibility, quality of service (QoS), scalability and to guarantee a reliable and cost-efficient operation of the network. For example resilience concepts were included. In order to obtain a baseline for the energy consumption, network elements with state-of-the-art technology are taken into account and no technology-related advances in energy efficiency are considered.

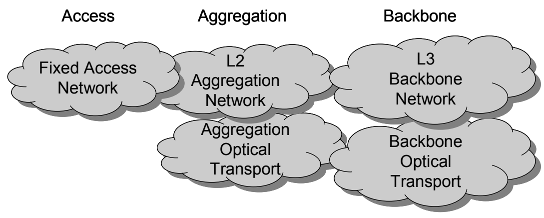

Fig. 1: Telecommunication network model

The access network partition is composed of a mixture of fibre to the exchange (FTTEx) and fibre to the cabinet (FTTCab) approaches, where either the ADSL2+ DSLAM (digital subscriber line access multiplexer) is located in the central office or the VDSL2 DSLAM resides in the street cabinet, respectively.[1,7] The L2 aggregation function is composed of a tree-type logical topology of carrier-grade Ethernet switches which are physically interconnected via metro/regio OTN rings. The modelled L3 backbone network consists of partly meshed IP/MPLS routers interconnected via an OTN platform.

For dimensioning the network and the calculation of its energy consumption a scenario for the DSL and Ethernet services has been chosen which is related to the expected development of the number of residential and business customers. The traffic volume in the Nth year ($N \geq 1$) is modelled according to

$$V_N = V_0 \prod_{n=1}^{N} \alpha_n$$

with V_0 as the traffic volume in the reference year (2009 throughout this paper) and α_n as the annual traffic growth rate in the nth year. Based on an Internet traffic forecast[9] for 2009–2012 and an extrapolation for 2012–2017 a traffic model has been generated taking QoS requirements for the considered services into account (Fig. 2)

Energy consumption of the telecommunication network

Based on the network model (Fig. 1) with state-of-the-

978-3-8007-3173-2

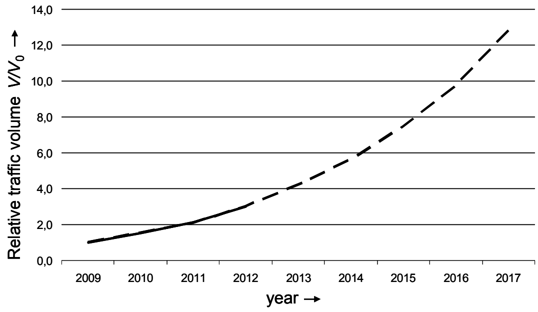

Fig. 2: Traffic volume growth

art network elements and the traffic volume forecast (Fig. 2) the energy consumption of the telecommunication network in the *N*th year is given by

$$E_N = \sum_M P_m \cdot T_m$$

summing the product of power consumption P_m of the *m*th network element and its operation time T_m of the overall *M* active network elements. In a typical network with national footprint *M* is usually very large and varies over the considered timeframe (2009–2017), since e. g. the network capacity has to be enhanced over the years. The relative energy consumption result is shown in Fig. 3.

In the reference year the access network exhibits the highest share of the total energy consumption: This is due to the fact, that there is a huge number of active elements distributed in the field at the network edge in

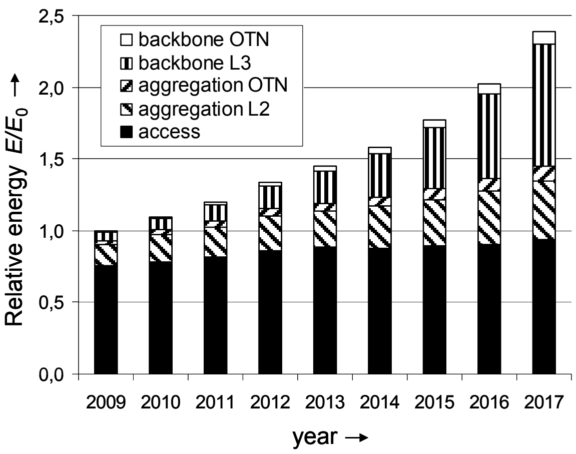

Fig. 3: Energy consumption of the telecommunication network

the FTTEx and FTTCab access networks. Furthermore the energy consumption of DSLAMs is nearly independent from the delivered access bit rate per port (e. g. the ADSL2+ energy consumption is nearly constant whether 1 Mbit/s or 10 Mbit/s is used). This leads to an only slightly increasing energy consumption of the access network section in the model. However, with increasing traffic volume (Fig. 2) the energy consumption of the aggregation and backbone network partition with the more concentrated traffic increases considerably and leads to nearly equal energy consumption of the access and the backbone network partition in the year 2017. Moreover, it becomes obvious that the L2 aggregation network as well as the L3 backbone network consumes significantly more energy than the associated OTNs.

The access network's energy consumption scales with the number of connected subscribers whereas the aggregation and backbone network partition's energy consumption scales with the increasing traffic volume.

Conclusion

Based on a traffic volume forecast the trend of the energy consumption over the next years of a telecommunication network with state-of-the-art technology was determined: In the first years the access network's energy consumption dominates due to the high number of active elements in the field. With increasing traffic volume the aggregation and backbone network share in the overall energy consumption increases. The energy consumption of access networks is mainly determined by the number of subscribers, whereas the energy consumption of the aggregation and backbone network sections with more concentrated traffic scales with the increasing traffic volume.

The energy consumption in the considered timeframe increases by about 150 % whereas the traffic volume rises by about 1200 %: Coming back to the initial question of this contribution, it can be stated, that the energy consumption of telecommunication networks is not expected to increase at the same rate as the traffic volume.

Since the access network is the major energy consumer, activities to reduce the energy consumption should focus on access networks at first – e. g. by using energy-efficient access network architectures[2,3,4] – but having in mind that with increasing traffic volume in particular the backbone network's energy consumption becomes more and more important. Adaptive network resource allocation is expected to be a promising approach for improving the energy efficiency of telecommunication networks.

References

1. G. Keiser, *FTTX Concepts and Applications*, John Wiley & Sons, Hoboken, New Jersey (2006).
2. J. Baliga et al., OFC '08, OThT6, (2008).
3. C. Lange et al., OFC '08, JWA105, (2008).
4. C. Lange et al., OFC '09, JThA79, (2009).
5. A. Odlyzko et al., MINTS (2002–2008).
6. J. Baliga et al., COIN '07, (2007).
7. A. Gladisch et al., ECOC '08, Tu.4.A.2 (2008).
8. R. Tucker et al., ECOC '08, Tu.4.A.1 (2008).
9. Cisco Visual Networking Index – Forecast and Methodology, 2007–2012. Cisco Systems, (2008).