

# Chapter LIV

## Network Planning and Dimensioning for Broadband Access to the Internet Regarding Quality of Service Demands

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### ABSTRACT

*An ongoing challenge in telecommunication is the integration of a variety of services on broadband access platforms at increasing transmission speed. Traditional Internet services like file transfer, email and web browsing, are carried on the same multi service IP platforms with voice, video and television over IP, online gaming, peer-to-peer and grid networking etc. While broadband access is established as a standard equipment for homes, the networking capacities in the access and the backbone are steadily extended to keep pace with higher traffic volumes. Together with the spectrum of services, the traffic mix on the aggregation levels becomes increasingly versatile with different demands for end-to-end transport in terms of throughput, loss and delay sensitivity. The chapter focuses on planning and traffic engineering for link bandwidth and buffers as main resources in communication platforms based on measurement and statistical properties of traffic growth and variability. We summarize quality of service demands of main Internet applications and mechanisms to control and stabilize the performance of ISP network platforms on different time scales. Load thresholds for link dimensioning are derived with regard to quality of service (QoS) demands and the variability in source and aggregated profiles. Finally, link level and network wide traffic engineering is addressed together with load balancing techniques.*

## **INTRODUCTION: GROWTH AND COMPOSITION OF INTERNET TRAFFIC**

Information on developing Internet traffic and services does not seem to be available as a global picture. A few periodical reports are provided by standardization bodies and fora, e.g. [5] or in official statistics of countries [1] [16] and some spontaneous sources can be found in market research reports as well as publications from equipment vendors [4] and research institutes [3][15]. The Minnesota Internet Traffic Statistics (MINTS) provides an overview on the home page [20] including links to many relevant sources and measurement data from traffic exchanges in the USA. Odlyzko et al. [15] found Internet traffic to roughly double per year since 1990. Figure 1 shows traffic growth factors based on several previously mentioned sources [1][3][16][20] and Deutsche Telekom's IP platform [17] in the time frame 2001–2007. The steepest curves still follow the trend of doubling per year, whereas moderate cases have annual growth factors in the range 1.5–2. A current white paper of the router manufacturer Cisco [4] gives estimates on the total traffic growth as well as a breakdown into applications. The main conclusions are a forecast of mean annual growth factors of about 1.45 until 2011 mainly driven by several types of video data transfers from peer-to-peer downloads to IP-TV via multicast and video streaming on demand. Within each ISP platform, the product marketing strategy and deployment steps for new transmission and switching technology on the optical and the IP layer have an influence on different growth phases.

Not all factors are clearly predictable and can be planned in advance. When we differentiate the growth due to an increasing subscriber base and the growth caused by in the data rate per subscriber, then the latter is observed to be almost constant on Deutsche Telekom's IP platform from 2002 – 2007. Although this may be unexpected

on first glance, the figures can be interpreted when looking at the fraction of file sharers, who generate the major portion of the Internet traffic since the millennium. File sharing was a driver of the demand for broadband access especially in the early deployment phase of digital subscriber lines (DSL).

In 2002 probably most of the subscribers were running P2P file sharing programs which dominated the traffic demand and smoothed the traffic curve to an almost constant rate over day and night as visible in Figure 2. Meanwhile the population of DSL subscribers in Germany is well beyond 10 million and most of them are using the Internet for multiple purpose. While broadband access entered the mass market, P2P file sharing traffic continued to increase, but the fraction of extensive file sharers was reducing and the traffic profiles per user shifted to applications with lower demand than file sharing. Thus the mean traffic volume per subscriber did not follow the increase in access speed from less than 1 Mb/s in 2002 up to 16 Mb/s or more nowadays.

In the future, the increase in the broadband access population will be relatively smaller than in the last years, whereas the access bandwidth and the traffic generated per user has a large potential for growth when video streaming and television over IP will become feasible and popular. Therefore measurement of the components in the Internet application mix is important for prognosis and planning processes for network expansion.

Odlyzko et al. [15] already pointed out that the traffic mix is changing with a shift from Web browsing applications to peer-to-peer file sharing as the driver of traffic growth since the millennium. Figure 2 shows measurement over four days on a link in Deutsche Telekom's Internet platform in 2003 at the time when file sharing was most dominant. The measurement was obtained on transport layer based on standard or usual TCP/UDP port assignment.

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