Traffic on the Internet: Components and Source Profiles, Variability on Network Platforms, Impact on Service Quality

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Motivation and Scope

Presently, increasing access speeds and the integration of a variety of new services are ongoing trends in the development of telecommunication over the Internet. Accordingly, network capacities are steadily extending to cope with higher traffic volumes, while the traffic mix is becoming more complex.

In this framework, the tutorial is focused on measurement, modeling and analysis of traffic on Internet service provider platforms. In addition, the demanded quality of service (QoS) from the users and applications perspective is considered, as determined by parameter ranges for tolerable loss, delay and service availability. Each service type generates a characteristic traffic profile (broadband ↔ narrowband; with high ↔ low variability; short ↔ long range correlation) and has its own QoS requirements (real time ↔ without strict time constraints; error free delivery ↔ limited error tolerance etc.). Both, the traffic profiles and the QoS demands have to be taken into account for the dimensioning of network resources (capacity of transmission links and switches, buffers and network servers).

Since the year 2000, peer-to-peer (P2P) networking introduced a major shift in the application and traffic mix of the Internet and established as the main driver of increasing traffic volume. The P2P principle proved to be much more efficient than client-server communication especially for fast distribution of large amounts of data, since bottlenecks at servers with sporadic popularity are avoided by distributing requested data and the available access capacity over a global community of recipients. P2P file sharing networks presently contribute 50% - 80% of the traffic on Internet platforms in Europe and the USA. While file sharing has reached a saturated state or may decrease in future because of unresolved problems with copyright infringement, many legal services are expected to be launched via peer-to-peer overlay networks, following the success of Seti@Home for distributed computing and Skype as the currently most popular voice over IP platform. Video streaming, online gaming, radio and TV over P2P are some further candidates.

Thus a part of the tutorial is devoted to the measurement of traffic components, especially with regard to peer-to-peer. Possible overheads and inefficient transmission paths due to independent topology views and routing on the P2P application and the IP network layer are addressed. As another measure to improve the throughput, P2P applications often initiate a number of parallel transmissions from several sources to the destination. This also improves the smoothing effect of statistical multiplexing on the traffic profile, since the aggregation of a large number of small and independent flows reduces the overall variability.

While users and applications have an end-to-end view of their data transfer and corresponding QoS parameters, the service providers are operating network platforms for integrated services including access areas and peering gateways to neighboring platforms connecting the Internet. The access and backbone network architectures are addressed and methods for traffic engineering, load balancing for an optimized resource usage are summarized.

The tutorial is structured in two parts:

Part I on traffic characteristics, modelling and analysis with regard to quality of service and

Part II on the impact of peer-to-peer networking and transmission protocols on the traffic management for Internet platforms

In particular, the following aspects are included:

Part I: Internet Traffic Characteristics, Modelling & Evaluation

- **Traffic descriptors**
  Rate distribution function & autocorrelation
  Time scales: Short & long term dependencies
- **Source traffic types and profiles**
  Real time applications: VoIP, MPEG video; influence of coding schemes on profiles
  Transport without strict timing: WWW browsing and peer to peer data & file transfer
- **Aggregated traffic: Relevance of statistical multiplexing**
  Gaussian analysis as a simple worst case scenario
  Long-range dependency, self-similarity and multi-fractal models
- **Modelling & performance evaluation with regard to service quality (QoS)**
  Analysis of the traffic workloads
  (Semi-)Markov state models: queues, delay and loss at switching systems
  Buffer efficiency depending on autocorrelation in different time scales
- **Network layer aspects**
  Structure of IP service provider networks in the backbone and for broadband access
  Routing, switching and multiplexing of traffic
  Network planning & management; traffic engineering & load balancing
- **Simulation of Internet traffic**
  Tool support with regard to multi-layer transport protocols
  Challenges: Relevance of rare events and long range correlations

Main Applications and traffic components

- **Composition of Internet traffic**
  Measurement results of the Internet application mix from Europe
  Daily profiles and long term growth
  Transport and application layer analysis
- **Peer-to-peer versus client server concept**
  Applications with increased throughput and efficiency due to P2P networking
  Additional features enabled by a distributed P2P environment
  Hybrid P2P $\leftrightarrow$ Server Architectures
- **P2P protocols**
  Course of search and transmission phases
  Effect of source selection and parallel transmission on data paths and traffic profiles
  P2P traffic and caching
- **Quality of Service & Traffic Management**
  Quality of service aspects for P2P and other applications in a multi service IP platform

Biography

Gerhard Hasslinger worked for about 10 years as a researcher and lecturer at the computer science department at Darmstadt University of Technology, Germany, and for another 10 years at Deutsche Telekom, as a consultant in the planning of large enterprise networks at the headquarters of T-Systems in Frankfurt and at the Center of Technology in Darmstadt, where he is involved in the design and operation of the Internet platform and the integration and support of Internet services.
His research interests are focused on performance, reliability and quality of service aspects in computer and communication networks, traffic engineering, modelling and analysis of servers and queueing systems, codes for data compression and error protection. In those fields, he is involved in several European and German research projects. His publication list includes more than 50 reviewed contributions on conferences and in journals. He is (co-)author of two books on telecommunication networks.