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Peer-to-Peer Systems

Peer-to-Peer-Systeme

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The term *peer-to-peer* started gaining popularity since summer 2000. This identified a group of applications which allow the clients involved to interact directly as opposed to the well established client/server approach. These applications include *Napster*, *SETI@home*, *Freenet*, and *Gnutella*. The peer-to-peer communication paradigm involves direct communication and sharing of resources amongst peers, or simply: *peer-to-peer*.

Peer-to-peer applications attracted millions of users in a very short period of time. Napster became one of the fasted growing applications in the history of the Internet. The impact of the peer-to-peer paradigm on society, business models and novel Internet technology has been tremendous.

Today, about 60% to 80% of the traffic on the Internet stems from applications within the peer-to-peer paradigm. The most popular applications are file sharing and content distribution. With the introduction of Skype, Internet telephony has also experienced a significant growth and is often blamed for the falling revenues in the telecommunication industry. VoIP providers were never a serious threat for traditional telecommunication providers, at least until Skype started being used widely. Apart from Skype, peer-to-peer applications have failed to achieve commercial success.

Peer-to-peer is a disruptive technology as it does not have a central entity without which companies are unable to generate revenues. This is contrary to traditional business models. It has been proven that peer-to-peer based content distribution is able to cut distribution costs, e. g., by using native BitTorrent, up to 90% of bandwidth costs can be saved compared to client/server delivery. Therefore, many current peer-to-peer based video-on-demand applications, e. g., Babelgum, Joost, or Zattoo, are being developed.

From the moment the first peer-to-peer applications appeared, the research community has become heavily active in this area. Peer-to-peer became a field of research on its own, which combines research in networking, systems, and theory. Every year since 2001, e. g., at the ACM SigComm, one of the most recognized conferences in networking, several papers in the area of peer-to-peer have appeared. Conferences dedicated to peer-to-peer have been established, such as the IEEE P2P-Conference or the International Workshop on Peer-to-Peer Systems. Besides this, all top journals on networking and systems also regularly publish papers on peer-to-peer.

Peer-to-peer continues to remain very attractive for researchers as (1) central entities should be avoided, (2) traditional straight forward communication patterns between the nodes of the network cannot be applied as self-organization takes place, and (3) peer-to-peer requires autonomy of nodes. Therefore, strategic or opportunistic peer behaviour always has to be taken into account. Peer-to-peer demands new ideas from the researcher, new ways of thinking and the combination of emerging new mechanisms and existing technologies. Very often the goal is to enhance performance and increase efficiency. This unconventional way of thinking in peer-to-peer seems to be very appealing to students and young researchers.

The research community has created a substantial knowledge pool which remains a rapidly evolving field. In this special issue we are proud to present papers which cover (to a certain extent) the most important areas in peer-to-peer research.

The DFG research unit (DFG Forschergruppe F 733) "*Improvement of the Quality of Peer-to-Peer Systems by Systematically Researching Quality Features and Their In-*

terdependencies" (*QuaP2P*) was established recently at the Technische Universität Darmstadt. Its researchers investigate the quality attributes of peer-to-peer systems in a systematic manner by explicit considerations of the interdependencies between quality attributes and their mechanisms. They provide a comprehensive overview of the current status, trends and challenges in peer-to-peer research in the first paper of this special issue.

Both, *Andreas Binzenhöfer* and *Phuoc Tran-Gia* from the Universität Würzburg, experts in the field of peer-to-peer overlay networks, discuss the properties and improvements in Kademilia, the overlay network used, e. g., in the file sharing applications Overnet and the open source adaptation eMule.

The performance of overlay networks and the amount of overhead traffic created depend on an awareness of the underlying network's properties among other factors. For instance, neighbour nodes within an overlay should not be located too remotely within the underlay. *Matthias Scheidegger* and *Torsten Braun* from Universität Bern present an improved method to identify groups of closely located nodes in mOverlay, a locality-aware overlay network.

Another emerging research topic is the combination of research in the area of peer-to-peer overlay networks and mobile ad-hoc networks. However, as peer-to-peer systems assume reliable connections and the possibility of direct peer-to-peer communications, the transfer of peer-to-peer overlays on top of mobile ad-hoc networks remains an open challenge. *Olaf Landsiedel* and *Klaus Wehrle* from the RWTH Aachen present MHT, a mobility aware distributed hash table which exploits local knowledge in order to circumvent the problems mentioned.

Live streaming and video-on-demand applications using the peer-to-peer paradigm remain increasingly popular. The next article presents challenges arising from peer-to-peer streaming. *Jens Wildhagen*, *Thorsten Strufe*, and *Günter Schäfer* from the Technische Universität Ilmenau discuss the challenges and solutions for network efficiency and stable topologies for peer-to-peer streaming in the presence of churn.

Finally, for the research of peer-to-peer systems appropriate tools are helpful and often required. In the analysis of peer-to-peer systems scalability is a key question to be tackeled. Observations in test-beds and small scale experiments are limited due to their size. Detailed examination beyond this size requires the use of appropriate simulations. In the Multimedia Communications Lab in Darmstadt *Aleksandra Kovačević* and *Sebastian Kaune* have developed a simulation framework with the capability to simulate peer-to-peer systems in all relevant layers – from the application layer, over the overlay layer, to the network layer. As their simulator is widely used within the previously mentioned DFG research unit "QuaP2P" and within the EU Node of Excellence "CONTENT" the presentation of this framework to the research community provides the invaluable conclusion for this special issue.

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