

**04201 Abstracts Collection**  
**Content Distribution Infrastructures**  
— **Dagstuhl Seminar** —

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**Abstract.** From 11.05.04 to 14.05.04, the Dagstuhl Seminar 04201 “Content Distribution Infrastructures” was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

**Keywords.** Content distribution networks, peer-to-peer, overlay networks

## 04201 Summary – Content Distribution Infrastructures

We provide a summary of the Dagstuhl workshop on content distribution infrastructures. The presentations and group discussions of the workshop are summarized in context, and visionary and outrageous opinions of the workshop participants are described.

*Keywords:* Content distribution networks, peer-to-peer, overlay networks

*Joint work of:* Griwodz, Carsten; Plagemann, Thomas; Steinmetz, Ralf

*Full Paper:* <http://drops.dagstuhl.de/opus/volltexte/2006/502>

## Multimedia Gateway Architecture for Adaptive Content Distribution - Work in Progress -

*Jens Brandt (TU Braunschweig, D)*

Digital video plays an increasingly important role on the Internet. Advances in video and audio coding make multimedia streaming across a wide range of different networks possible.

But the transmission of digital audiovisual data still needs high bandwidths which results in high resource requirements at the consuming client. Especially mobile devices often cannot comply with such requirements. Low bandwidths, limited processing power and low display resolutions frequently reduce the pleasure of multimedia streaming with mobile devices. To overcome this problem, the multimedia streams have to be adapted to the capabilities and requirements of mobile devices. One promising approach to meet the requirements of such devices is to transcode each stream either into another or into the same coding format with other coding parameters while it is transmitted to the client.

In this talk we present our ongoing and future work towards a multimedia delivery system based on the Internet standard protocols RTSP and RTP. Our proposed system consists of several multimedia gateways which provide an adaptation service for mobile clients. The adaptation is done by using different transcoding methods at the gateway. Each method is implemented as a transcoding module which can be loaded by the gateway at runtime. This provides great flexibility, because the set of supported transcoding techniques is not limited by the system.

Our project is currently in an early state but we already have implemented a RTSP/RTP proxy which is capable of loading transcoding modules at runtime. Inside this proxy the data of a stream is sent through a datapath consisting of several `StreamHandlers` which can manipulate the stream. This architecture is also used for the transcoding modules. Such a module contains at least one `StreamHandler` which is plugged into the datapath of the proxy. The future directions of our system are to include mechanisms for gateway location, capability exchange, gateway handoff and caching.

A gateway location mechanism is needed for a client to find an appropriate gateway without user interaction. Capability exchange mechanisms will be used to automatically send information about the capabilities and requirements of the client to the gateway. In order to support the mobility of connecting devices we also need a gateway handoff mechanism to migrate an active multimedia session from one gateway to another. We have also planned to include caching mechanisms at the gateway in order to reduce the network load.

*Keywords:* Multimedia transcoding, multimedia gateway, RTSP, RTP, multimedia proxy

## **A Management System for a High Quality TV Content Distribution Network**

*Adrian Cahill (University College Cork, IRL)*

Content Distribution Networks (CDNs) are used extensively on the Internet to relieve hot spots and reduce client latency when delivering web documents in the WWW. Recently their role has been extended to the delivery of streaming multimedia content. Our work details a management system for the distribution

of high-quality TV content over a CDN. The role of the management system is to ensure that a number of resources such as network bandwidth and disk capacity are optimised. Due to the dynamic nature of TV viewing patterns the replica layout will have to be analysed continuously to ensure that the system remains in a constant efficient state. In order to achieve this, costs are assigned to the resources that we believe to be important in the long-term operation of a multimedia CDN. We have designed a cost function that can be used to quantify the resources used under a given replica layout. Using this cost function, an algorithm has been designed to identify the optimal replica set for a given set of client requests. I will discuss how this cost function is designed, the resources that are to be minimized and finally, the object replication process.

*Keywords:* Management System, CDN, TV distribution

*Joint work of:* Cahill, Adrian; Sreenan, Cormac

## Peer-to-Peer-Architectures for Content Distribution

*Pascal Felber (Eurecom - Sophia Antipolis, F)*

Peer-to-peer networks have often been touted as the ultimate solution to scalability. Although cooperative techniques have been initially used almost exclusively for content lookup and sharing, one of the most promising application of the peer-to-peer paradigm is to capitalize the bandwidth of client peers to quickly distribute large content and withstand flash-crowds (i.e., a sudden increase in popularity of some online content). Cooperative content distribution is based on the premise that the capacity of a network is as high as the sum of the resources of its nodes: the more peers in the network, the higher its aggregate bandwidth, and the better it can scale and serve new peers.

Such networks can thus spontaneously adapt to the demand by taking advantage of available resources. We evaluate the use of peer-to-peer networks for content distribution under various system assumptions and we develop analytic models that provide insights into how long it takes to deliver a file to  $N$  clients. Our results indicate that the service capacity of these systems growth exponentially in time and in the number of chunks a file consists of.

*Keywords:* Peer-to-Peer, Content Distribution

## Enhancements to Collaborative Media Streaming with IETF Protocols

*Verena Kahmann (TU Braunschweig, D)*

In this talk, we present our ongoing research of enhancements to the Collaborative Media Streaming architecture with IETF signaling protocols we presented in earlier publications.

Our goal is to provide for synchronization of clients in a streaming group with the flexibility to watch parts of the movie individually. We use a pure signaling approach independent of media transport applying the standard Internet protocols SIP for client invitation and joining and RTSP/RTP for streaming. The need for user-friendly discovery and support of mobile users led to an enhancement to SIP suitable for supporting the Association Service in several ways.

*Keywords:* Media streaming, Session sharing, IETF Multimedia Protocols

## **iClouds: Content Distribution in One-Hop Networks**

*Jussi Kangasharju (TU Darmstadt, D)*

The iClouds project investigates content distribution and collaboration in wireless one-hop communication networks. The increasing numbers of wireless devices are making such networks a feasible way of distributing information between people. iClouds is based on a peer-to-peer paradigm of collaborative information sharing and distribution. Peers offer content and can specify which content they wish to receive from other peers. For communication, iClouds uses a one-hop communication paradigm, with constrained propagation. As example applications built using the iClouds framework, we present a bonus point system and a MP3 sharing application.

*Joint work of:* Kangasharju, Jussi; Heinemann, Andreas; Mühlhäuser, Max

## **Outrageous Opinion: Streaming for the Masses**

*Wolfgang Leister (Norwegian Computing Center - Oslo, N)*

We start with the observation that even though the multimedia consumers are individualists, they are a part of the mass market. After a glance at a map of technologies and applications within CDN we take a closer look at broadcast technology and possibilities for personalizing broadcasts. IBR (image based rendering) methods from computer graphics are one such example.

*Keywords:* Broadcast, image based rendering, IBR, CDN

## **Scalable Delivery and Disk Admission Control for Media Services**

*Dwight Makaroff (University of Saskatchewan, CDN)*

Media workloads stress the disk and network capacities of computer systems. Increases in processing power have made decoding at the client station possible in software, though for low-powered, low-bandwidth devices, care must be taken to efficiently perform data reception and conversion.

The need for the server to transmit variable bit-rate compressed media in an efficient manner from bandwidth-constrained disks across bandwidth-constrained networks has not disappeared.

This talk will discuss work done at the University of Saskatchewan and the University of Wisconsin that is concerned with efficient use of resources in video servers. One track of this research looks at the scalability of a system via the use of Reliable Multicast delivery to reduce the network bandwidth consumed by a server. An independent, yet complementary branch of the research considers detailed admission control for the disk resource. A constant change in the performance capabilities of the computer hardware on which these systems are deployed makes identifying the resource of concern a moving target. Part of the ongoing work is to develop a strategy for incremental evaluation of the resource allocations.

## Efficient Content Distribution using Peer-to-Peer Technology

*Jochen Munding (University of Cambridge, GB)*

We consider a problem which is partially motivated by the BitTorrent protocol. Suppose that a large file is initially available only at some server and we desire to disseminate it amongst  $N$  end users in the least possible time. We suppose that the file is divided in  $M$  parts of equal size and that an end user may download a part from either the server or one of the peers who has previously downloaded it. Given constraints on the rates at which the server and peers can upload to one another, we seek a strategy that minimizes the time until all peers have downloaded the entire file. Assuming that there is a centralized controller who does the scheduling of the uploads, we show how to solve this problem by solving a finite number of linear programs.

Making connections with the so-called broadcasting problem, we provide a complete solution of this problem when the capacities are all equal. We also carry out simulations to assess the performance of a natural randomized algorithm that operates under distributed control. We compare the performance of this algorithm in two different information scenarios with what can be achieved by centralized control.

*Keywords:* BitTorrent protocol, broadcasting problem, content distribution, file sharing, load balancing, performance analysis, distributed algorithmic mechanism design

*Joint work of:* Munding, Jochen; Weber, Richard

## Analysis of BitTorrent and its use for the Design of a Hybrid CDN

*Thomas Peter Plagemann (University of Oslo, N)*

Peer-to-peer (P2P) based networks have several desirable features for content distribution, such as low costs, scalability, and fault tolerance. However, they fail to provide guarantees for content delivery.

In order to combine the desired features of classical Content Distribution Networks (CDNs) and P2P based networks, we propose a hybrid CDN structure with a P2P based streaming protocol in the access network. Our proposal is based on an empirical analysis of BitTorrent. In our BitTorrent measurements we made two important observations: (1) clients with high bandwidth connections leave the system shortly after they have downloaded the file, and (2) clients that are unable to accept incoming connections, likely because they are behind a firewall, suffer from a significant reduction in download speed.

Our design attempts to address these problems by structuring the streaming protocol in a way which makes it possible to discourage freeloaders, and by incorporating a proxy based structure which can avoid performance problems due to firewalls. The proxy based structure also makes it possible to incorporate caching, which has often been identified as lacking in P2P networks. This structure will also make further reduction in bandwidth usage possible by having clusters automatically created at the lowest levels of the hierarchy.

*Joint work of:* Skjevik, Karl-André; Goebel, Vera; Plagemann, Thomas

## Priority-Based Distribution Trees for Application-Level Multicast

*Jörg Widmer (EPFL - Lausanne, CH)*

We propose a novel multicast routing algorithm that is based on application-level priorities and network characteristics: The application may specify an individual priority for each packet-receiver pair. The multicast distribution tree is then constructed such that the higher the priority, the more direct the path from the sender to the packet's destination and the lower the resulting end-to-end delay. This algorithm can be used to realize application-level multicast for delay-sensitive applications such as networked computer games. However, optimizing the multicast tree with respect to the end-to-end delay comes at the cost of an increase in link stress – the more direct a path, the less likely it is that it can be integrated efficiently into an overlay distribution tree. Our algorithm takes this tradeoff into account and constructs efficient priority-based multicast trees. We demonstrate the performance and characteristics of the algorithm through simulation.

## Content Distribution in casa

*Michael Zink (Univ. of Massachusetts - Amherst, USA)*

Content Distribution in casa.