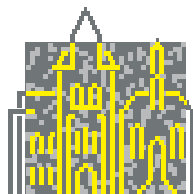


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## Internet Economics

Dagstuhl Seminar 03321 – August 03 to August 07, 2003  
Dagstuhl-Seminar-Report No. 389



SCHLOSS DAGSTUHL

INTERNATIONALES  
BEGEGNUNGS-  
UND FORSCHUNGSZENTRUM  
FÜR INFORMATIK

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ISSN 0940-1121

Herausgegeben von IBFI gem. GmbH, Schloss Dagstuhl, 66687 Wadern, Germany.

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## Summary

### 1 Introduction

The Dagstuhl Seminar on “Internet Economics” brought together two groups of international experts on networking and economists for the Internet. While the underlying emphasis on today’s technology for an end-to-end provisioning of Quality-of-Service (QoS) — covering the Internet as a network as well as the end-system — determines the networking aspects of Internet Economics, the business policy management, the economics of service differentiation, and incentive structures required for a charging support of transport and content defines the key economic aspects. Both areas target the joint discussion and identification of solutions, investigations of their feasibility, and a consolidation of technical and economic mechanisms to enable a fast, guaranteed, and efficient provisioning of differentiated services in the Internet.

### 2 Public Outreach

Internet Economics outline a key aspect of a commercialized Internet, which address a.o. the pricing problem for Internet services and various management as well as resource allocation problems under economic perspectives. The combination of technical mechanisms, Internet protocols, and economic models determines the best possible methodological approach for optimizing the commercial operation of Internet services in heterogeneously wired and wireless networking technology environments. This Dagstuhl Seminar on “Internet Economics” emphasized the economic modeling of technology problems in the Internet and considered the network, its technical mechanisms, and some areas of the Internet’s application domains. While the combination of technical protocol and distributed system aspects cover security, efficiency, and load control, the economic view points included modeling of content pricing and mobile ad-hoc network pricing.

### 3 Scientific Highlights

The seminar was organized in four sessions, addressing the following topics:

- Pricing,
- ISPs and Internet Economics,
- Architecture and Peer-to-peer, and
- Auditing and Load Control.

#### 3.1 Pricing

The first topic covered the problem of selling e-con-tent, e.g., video by auction mechanisms. While the work investigated suitable mechanisms and effects of this pricing mechanism, the applicability in a wide range of e-con-tent remained debated. In addition, the modeling of correct incentives for a collaboration of users and devices in mobile ad-hoc

networks was presented. An underlying model and definitions for ad-hoc under economic perspectives were given.

Discussions covered technical details, which indicated the problem of which parameters to include into a viable and realistic model. Therefore, two working groups have been set up to identify and determine the key problems and tasks in the pricing domain with respect to auctions as well as wire-less ad-hoc local area network. Key results show that auctions require further investigations in terms of user acceptance and technical practicability in distributed systems. In addition, the ad-hoc group determined an initial level of low-level parameters to be incorporated into an applicable model for incentive investigations.

### 3.2 ISPs and Internet Economics

Internet Service Provider (ISP) operate successful only in an interconnected manner, therefore, ISPs with those mandatory interconnections see costs due to up to 1000 peering partners to be managed. This problem has been investigated by mathematical optimization mechanisms and an architecture has been defined. The broader area of technical issues in networks, a seamless operation for the user, the economic success of such a network including its applications and services offered, has been combined with law enforcement perspectives in a new project and study program on information economic, computer science, law, and economics with interdisciplinary issues.

Finally, a proposal termed Contract and Balancing Process (CBP) was presented, which addresses the problem on how an owner of a communication network shall sell bandwidth to users; e.g., for business with Entertainment-on-demand. Having explicit congestion notifications and their marks in an Internet enables the operator to provide the right incentives and prices to charge his customers a fair price corresponding to their initial statements.

### 3.3 Architecture and Peer-to-peer

Suitable architectures for commercially applicable networks require service components in an all-IP networking environment in support of charging. However, problems arise from technical faults within the network. Therefore, the key issue is: can these types of services be charged? Depending on the accounting infrastructure and the details being accounted for various different charges may be applied. In case of peer-to-peer (P2P) systems this problem increases, since a group of people is working together without any controlling entity with any type of permanent privileges. Even more, some areas may show a conflict of interest. P2P systems shows currently market failures, which are based on the fact that current P2P applications make a contribution to a public good, rather than a marketable good.

The approach presented introduces market management mechanism in P2P systems and currently develops a prototype. Finally, the technical networking details in the network effect the service quality extremely, which in turn shall be charged. Therefore, scheduling matters for non-cooperative multi-class QoS provisioning and business models

for assured services are essential. The three types of functional, performance, and organizational challenges have been presented and proposals for end-to-end QoS in legacy operating systems in the local area access have been shown. In consequence, two working groups have been established in the seminar to discuss trust as well as intelligent end systems and externalities. In case of charging there was a consensus that any type of trust is required, while the problem on conflicting information has to be considered.

Though, either established through means of an infrastructure, e.g., a full set of PKIs and security mechanisms, or by means of reputation mechanisms remains an open debate. With respect to intelligence of endsystems and their mechanisms, P2P economics need to cover nonexclusive goods, e.g., content with digital copies at no cost. Based on the categorization of private and public goods as well as natural monopoly or common resource goods a P2P network may work in a rivalries or nonrivalrous fashion, which may be excludable or nonexcludable goods' offers.

### 3.4 Auditing and Load Control

Once data of service usage has been accounted for in a subsequent step the validity of these data has to be verified, which requires auditing mechanisms in place. While the Service Level Agreement (SLA) auditing has been focused on in this work, related mechanisms have been investigated in terms if security auditing, e.g., denial-of-service attack or intrusion detection. Though, the key problem in SLA auditing is the violation detection. The approach presented offers a framework and initial mechanisms to specify and describe those actions to be undertaken, many of them automatically, to verify the compliance degree of a service delivered with its original specification.

Binary packet marking has been suggested earlier as an economic signal to enforce cooperation from end systems in times of overloaded network resources. Load control gateways at edge gateways allow building a network system that uses the load signal embedded in a packet stream for connection admission control. The design and implementation of a prototype system has been presented. Thorough performance investigations in various scenarios and with different mechanisms showed that edge based load control can be performed effectively and can efficiently provide reliable service guarantees.

## 4 Perspectives

In the mid-term range Internet Economics will be effected by law and policy guidelines, which will vary depending on the region of the world. This regionalized view point simplifies the understanding of the problem areas, though, defines an obstacle for worldwide and open markets operating under the same set of rules. However, the need for interdisciplinary research work, especially the effects of incentives and legal aspects for service delivery, proof, and provisioning will determine the key problems to look into soon.

## Participants

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