Innovation in Network Pricing


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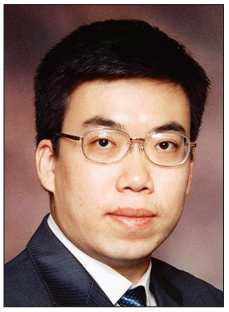
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Networking researchers have long predicted the need for new pricing mechanisms for networks since the early days of the commercial Internet. In 1997, David Clark wrote: "In the future it will be desirable to provide additional explicit mechanisms to allow users to specify different service needs, with the presumption that they will be differentially priced." In 1999, Pravin Variaya, Principal Investigator of the Berkeley INDEX project, made a similar observation: "Although flat-rate continues to be the predominant form in which Internet access is sold, that form of pricing is unviable."

These predictions are now coming true. Network capacity is not expanding fast enough to handle demand growth, especially on cellular wireless networks. Smart data pricing (SDP) argues that solving this problem requires understanding not just users' demands for different types of data traffic, but also their economic interactions with content providers and network operators. For wireless, broadband, cloud, the Internet, and the Internet of Things, SDP asks questions that range from how much to charge and how to charge to what to charge for and who would pay. Substantial research and industry momentum has been building up over the past several years and continues to grow.

This Feature Topic presents a subset of this research effort. The first article, "A Game-Theoretic Perspective on Advance Reservations," studies the strategic behavior of users in systems supporting advanced reservations and the impact of the network provider's decisions on the behavior of its users. The authors focus on studying the impact of several important aspects of the model, including pricing, information sharing, and learning, on the economic equilibria and the dynamic behavior of the system. For each aspect, they provide an analytical model along with numerical examples to illustrate the model's insights. Unlike much previous literature in this field, this work incorporates the fact that the strategic behavior of customers in making advanced reservation is driven not only by their prices, but also by their beliefs on other customers' decisions.

In the second article, "The Role of Data Cap in Two-Part Pricing under Market Competition," the authors consider the impact of data caps on a usage-based pricing scheme (i.e., cap then metered) in congestion-prone service markets. "Cap then metered" means that a user pays up to a predetermined volume of traffic, beyond which the user is charged in proportion to usage. Their results indicate that the data cap provides a mechanism for Internet service providers (ISPs) to transition from flat-rate to pay-as-you-go types of pricing schemes. With growing data demand and network capacity, the optimal pricing structure will move toward usage-based schemes with diminishing data caps; however, under intense market competition, the optimal pricing structure will move toward flat-rate schemes with higher data caps.

The IoT is a giant network of connected "things," which collect useful information to provide actionable intelligence to cloud-based applications. The third article, "Smart Data Pricing Models for the Internet of Things: A Bundling Strategy Approach," discusses the use of pricing to incentivize the sharing of IoT sensing data. The authors introduce a pricing scheme for IoT service providers to determine prices for collected sensor data that they purchase from sensor owners and the subscription fees these providers can charge to IoT service users. They also consider bundling strategies among multiple IoT service providers.

The fourth article, "An Economic Model for a New Broadband Ecosystem Based on Fast and Slow Lanes," considers the economic impact of fast lanes in the Internet, which has been a central aspect of the net neutrality debate. The authors propose an ecosystem in which ISPs can prioritize traffic of video content service providers (CSPs) by using "fast lanes" in a dynamic fashion, and intelligently incentivizing bulk-transfer CSPs to use "slow lanes." The work develops an economic model that balances fast- and slow-lane pricing by the ISP with the resulting return for CSPs and service quality improvement for end users. It also provides simulation results with real traffic traces.

Following up on the theme of net neutrality, the fifth article, "Under a Cloud of Uncertainty: Legal Questions Affecting Internet Storage and Transmission of Copyright-Protected Video Content," presents an overview of the complex legal issues surrounding the cable, digital TV, and modern streaming services. It discusses the relevant copyright laws in the United States, and then considers how recent court case decisions might affect the legality of time-shifting and place-shifting of streaming video content delivery. These legal and historical perspectives are informative for the future of pricing practices in the streaming media industry.

The final article, "Trace-Driven Analysis for Location-Dependent Pricing in Mobile Cellular Networks," focuses on the efficacy of dynamic smart data pricing mechanisms to manage network congestion in mobile networks. Using a large-scale cellular network dataset, the article provides a trace-driven analysis of the motivation and benefits of time and location-dependent pricing.

Biographies

MATTHEW ANDREWS [F'15] is a Distinguished Member of Technical Staff at Nokia Bell Labs. His research interests include algorithm design and analysis, with applications to resource allocation and revenue management in wireless networks. He received a B.A. in mathematics from the University of Oxford in 1993 and a Ph.D. in the theory of computing from MIT in 1997. In 2010 he was a recipient of the best paper award at the IEEE FOCS conference.

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