1. Participants

- People who have worked on your project:
  
  Prof. Jean Walrand, UC Berkeley (PI)
  Prof. Pravin Varaiya, UC Berkeley (Co-PI)
  John Musacchio, UC Berkeley (Graduate Student)
  Rahul Jain, UC Berkeley (Graduate Student)
  Yusuf Buntun, IU Germany (Visiting Graduate Student)

2. Activities and Findings

Major research and education activities of the project.

The focus of this research is the impact of protocol designs on the economics aspects of the network. We examine the benefits that can accrue to users and providers when services are differentiated. We study the protocols that would enable such offerings and the resulting incentives for network providers. The reality is that today’s services are not differentiated and that differentiation requires some investments. The providers are unclear about the potential benefits of implementing new services. Moreover, such improved services require collaboration and some form of standardization or at least agreements. Nevertheless, the potential benefits are large enough to explore the issues, specially in the light of a future internet.

The top level consideration is the potential for improved user utilities that might be derived from service differentiation.

The second level issues concern the incentives required for network and content providers to upgrade their services.

The third level issues are the design of protocols to create the incentives.

Describe the major findings resulting from these activities.

Increase in User Utility

New applications would be possible with service differentiation. Such applications include games, remote control, quality video conferences, and improved video streaming. The monetary value of these new applications depends on the users’ willingness to pay...
and on the market size. The evaluation of these factors is difficult since the services do not exist.

**Incentives**

To upgrade the network and the services, the providers need to see higher revenues. Such higher revenues require a billing mechanism and a revenue sharing scheme. We have examined formulations of the revenues and showed that they result in poor incentives that lead to providers not upgrading their services. We then obtained a formulation that avoids these problems and creates incentives for the network participants to improve the services to increase their revenues and the utility of users.

We also formulated the interactions between providers and users as a bilateral combinatorial auction. In such an auction, users want to buy a combination of items that seller put for sale. We proposed a mechanism for allocating and pricing the items based on the bids of the buyers. The mechanism is efficient and incentive-compatible for all but one seller.

**Protocols**

We have explored a scalable protocol for billing and revenue sharing. The scalability comes from storing the necessary information in the packets, so that the routers do not need to maintain any information. Moreover, the billing takes place at edge devices that belong to the local network providers. That is, the scheme is distributed and does not require any centralized server or exchanges of information.

Summing up, the work shows that scalable protocols can be designed that promote network upgrades.

**Describe the opportunities for training and development provided by your project.**

The project was a catalyst for the Ph.D. thesis of John Musacchio and that of Rahul Jain and their subsequent research. It also provided a focus for the research of Yusuf Butun.

John Musacchio explored the pricing of WiFi services and new models of multimedia services. He showed that a fixed price is a subgame perfect equilibrium for many wireless web services. He also analyzed the incremental upgrading of a network and showed conditions under which providers would all eventually upgrade their services instead of free-riding on the improvement of others.

Rahul Jain studied the combinatorial bilateral auctions and proposed an efficient and almost incentive-compatible mechanism. He then studied the auction of divisible goods.

Yusuf Buntun worked on a software platform for bilateral combinatorial auctions. This platform enables the design and running of auctions to study the strategy of actual players in such auctions.
Describe outreach activities your project has undertaken.

The project has led to a collaboration with Fujitsu Laboratories in a study of bandwidth auction mechanisms among network access providers. In particular, we have started a continuing collaboration with Dr. Richard Rabbat of Fujitsu.

This project also started a collaboration with Dr. Galina Schwartz, an economist specialized in the study of transaction costs.

3. Publications and Products

- Conference Papers
  
  An Efficient Auction Mechanism for Multiple Divisible Goods, with R. Jain, IEEE CDC 2006

  "Pricing Differentiated Internet Services," with Linhai He, INFOCOM 2005 [pdf]

  An Experimental Analysis of a Combinatorial Market Mechanism, C. Kaskiris, Y. Butun, R. Jain, December 2005, under submission


- Journal publications

  Pricing and Revenue Sharing Strategies for Internet Service Providers, with Linhai He. JSAC 2006.

- Books or other non-periodical, one-time publications

- What Web site or other Internet site have you created?
  http://auctions.eecs.berkeley.edu/

- What other specific products (databases, physical collections, educational aids, software, instruments, or the like) have you developed?
  Software: A time-slotted simulator written in Matlab that can simulate different multi-channel wireless MAC protocols. We used this simulator to compare existing protocols with our proposed McMAC protocol.

4. Contributions

Unique contributions, major accomplishments, innovations and successes of your project relative to:

- the principal discipline(s) of the project:
- The understanding of impact of revenue sharing mechanisms on the upgrades of networks.
- The analysis of the behavior of users facing differentiated services.
- The design of scalable protocol for billing and revenue sharing.
- Models of the behavior of multiple providers and their incentives to upgrade the network.
- A mechanism for bilateral combinatorial auctions.

- other disciplines of science or engineering;

- the development of human resources;
  
  John Musacchio and Rahul Jain finished their Ph.D. thesis while working on this project. Yusuf Buntun completed a M.S. Thesis for his home institution in Germany on a software platform for bilateral auctions.

- the physical, institutional, or information resources that form the infrastructure for research and education;
  
  We set up a research group on the economics of networks that has led to collaboration with industry.

- or other aspects of public welfare beyond science and engineering, such as commercial technology, the economy, cost-efficient environmental protection, solution of social problems;

5. Special Requirements
This section will show if (but only if) you are filing a required project report, in which case you need to click it to respond to obligatory questions bearing on contractual or legal requirements.

Not applicable.