



What do hospitals, airlines, supply chains, and the Internet all have in common? According to David Yao, they are all complex networks that must bring together multiple services and assets to accomplish any task. They must also share these same resources among different classes of customers, who pay different amounts for service.

Organizations want to manage their resources efficiently to maximize profits. But if they are too efficient—Yao likens it to filling a highway with cars so traffic slows to a crawl—they sacrifice quality of service. Balancing efficiency and service across complex networked resources is an exercise in extreme juggling. Yao wants to help by giving organizations the tools to do it in real time.

He points to airlines as an example. They must divide a limited number of seats among first, business, and several types of economy classes. Each class sells for a different price.

Airlines maximize revenue when they fill every seat. They can do this by discounting and by overbooking flights, since they know there will always be some no-shows. They also reserve some tickets to sell at higher last-minute prices.

That leads to problems. “The price they pay for overbooking is that they may have to ask people to get off the airplane. They also don’t want to hold too many last-minute tickets, or they will have unfilled seats,” Yao said.

Airlines estimate how many seats to sell and reserve by looking at past data. “That does not capture the real-time dynamics of the network,” Yao stated. “On a particular day, a plane might be delayed and those passengers will need new connecting flights. Now their planes must carry their own customers plus passengers from the delayed flight.”

Yao’s models capture that type of real-time information and use it to optimize the entire system rather than a specific resource, like a single flight, a bank of servers, or a hospital bed. On airlines, his models assign all seats a shadow price, the revenue they could potentially earn if they sold a reserved ticket, and compare it with the probability of delays and other events as they evolve. It shows them the most profitable way to reroute passengers and flights.

“We look at the probability of events, but also at how we can hedge our bets if that probability is wrong,” said Yao. “We want to create models that are predictive but robust, so if you’re off, you won’t walk away from money on table.”

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Optimizing Networked Resources

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