AN INTERVIEW WITH...

Jennifer Rexford

Jennifer Rexford is a Professor in the Computer Science department at Princeton University. Her research has the broad goal of making computer networks easier to design and manage, with particular emphasis on routing protocols. From 1996–2004, she was a member of the Network Management and Performance department at AT&T Labs–Research. While at AT&T, she designed techniques and tools for network measurement, traffic engineering, and router configuration that were deployed in AT&T's backbone network. Jennifer is co-author of the book "Web Protocols and Practice: Networking Protocols, Caching, and Traffic Measurement," published by Addison-Wesley in May 2001. She served as the chair of ACM SIGCOMM from 2003 to 2007. She received her BSE degree in electrical engineering from Princeton University in 1991, and her MSE and PhD degrees in electrical engineering and computer science from the University of Michigan in 1993 and 1996, respectively. In 2004, Jennifer was the winner of ACM's Grace Murray Hopper Award for outstanding young computer professional and appeared on the MIT TR-100 list of top innovators under the age of 35.

Please describe one or two of the most exciting projects you have worked on during your career. What were the biggest challenges?

When I was a researcher at AT&T, a group of us designed a new way to manage routing in Internet Service Provider backbone networks. Traditionally, network operators configure each router individually, and these routers run distributed protocols to compute paths through the network. We believed that network management would be simpler and more flexible if network operators could exercise *direct* control over how routers forward traffic based on a *network-wide* view of the topology and traffic. The Routing Control Platform (RCP) we designed and built could compute the routes for all of AT&T's backbone on a single commodity computer, and could control legacy routers without modification. To me, this project was exciting because we had a provocative idea, a working system, and ultimately a real deployment in an operational network.

What changes and innovations do you see happening in network management in the future?

Rather than simply "bolting on" network management on top of existing networks, researchers and practitioners alike are starting to design networks that are fundamentally easier to manage. Like our early work on the RCP, the main idea in so-called Software Defined Networking (SDN) is to run a controller that can install low-level packet-handling rules in the underlying switches using a standard protocol. This controller can run various

network-management applications, such as dynamic access control, seamless user mobility, traffic engineering, server load balancing, energy-efficient networking, and so on. I believe SDN is a great opportunity to get network management right, by rethinking the relationship between the network devices and the software that manages them.

Where do you see the future of networking and the Internet?

Networking is an exciting field because the applications and the underlying technologies change all the time. We are always reinventing ourselves! Who would have predicted even five or ten years ago the dominance of smart phones, allowing mobile users to access existing applications as well as new location-based services? The emergence of cloud computing is fundamentally changing the relationship between users and the applications they run, and networked sensors are enabling a wealth of new applications. The pace of innovation is truly inspiring.

The underlying network is a crucial component in all of these innovations. Yet, the network is notoriously "in the way"—limiting performance, compromising reliability, constraining applications, and complicating the deployment and management of services. We should strive to make the network of the future as invisible as the air we breathe, so it never stands in the way of new ideas and valuable services. To do this, we need to raise the level of abstraction above individual network devices and protocols (and their attendant acronyms!), so we can reason about the network as a whole.

What people inspired you professionally?

I've long been inspired by Sally Floyd at the International Computer Science Institute. Her research is always purposeful, focusing on the important challenges facing the Internet. She digs deeply into hard questions until she understands the problem and the space of solutions completely, and she devotes serious energy into "making things happen," such as pushing her ideas into protocol standards and network equipment. Also, she gives back to the community, through professional service in numerous standards and research organizations and by creating tools (such as the widely used ns-2 and ns-3 simulators) that enable other researchers to succeed. She retired in 2009 but her influence on the field will be felt for years to come.

What are your recommendations for students who want careers in computer science and networking?

Networking is an inherently interdisciplinary field. Applying techniques from other disciplines to networking problems is a great way to move the field forward. We've seen tremendous

breakthroughs in networking come from such diverse areas as queuing theory, game theory, control theory, distributed systems, network optimization, programming languages, machine learning, algorithms, data structures, and so on. I think that becoming conversant in a related field, or collaborating closely with experts in those fields, is a wonderful way to put networking on a stronger foundation, so we can learn how to build networks that are worthy of society's trust. Beyond the theoretical disciplines, networking is exciting because we create real artifacts that real people use. Mastering how to design and build systems—by gaining experience in operating systems, computer architecture, and so on—is another fantastic way to amplify your knowledge of networking to help change the world.