Xiaowei Yang

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Education

Massachusetts Institute of Technology

expected 2004 Ph.D. in Electrical Engineering and Computer Science
Dissertation: *NIRA: a New Internet Routing Architecture*
Advisor: David Clark
Minor in Approximation Algorithms

Massachusetts Institute of Technology

1998 M.S. in Electrical Engineering and Computer Science
Thesis: *A Model for Window Based Flow Control in Packet-Switched Networks*
Advisor: David Clark

Tsinghua University, Beijing, China

1996 B.S. in Electronic Engineering

Research Interests

My research interests are in computer networks and distributed systems. They include network architecture design, routing, network modeling and simulation, network measurement, network security, and Internet economics. I am particularly interested in designing complex systems and developing realistic simulations and analytical models to guide the design and to gain understanding.

Research Experience

Research Assistant – *MIT Computer Science and Artificial Intelligence Laboratory, formerly Laboratory for Computer Science, Advanced Network Architecture Group*

2001+ **Internet Routing Architecture:** My dissertation is on the design and evaluation of a new Internet Routing Architecture (NIRA) that gives an end user the ability to choose routes at the domain level (at the level of the Autonomous Systems). Today, users can pick their own ISPs, but once their packets have entered the network, users have no control over the overall routes their packets take. My hypothesis is that it would be a better alternative to give a user more control at this level, because user choice fosters competition, which imposes an economic discipline on the market, and fosters innovation and the introduction of new services.

I designed NIRA to use a provider-rooted hierarchical addressing scheme for scalable route discovery and efficient route representation. I developed a policy-based, link-state like Topology Information Propagation Protocol to disseminate both address allocation information and topology information related to a user's providers to the end user. A user uses another infrastructure

service, the Name-to-Route Resolution service to discover the addresses and topology information of another user. Combining these two pieces of information together, a user is able to select an initial route to contact another user. NIRA uses a combination of proactive notifications and reactive router feedbacks to notify end users of route failures.

I implemented NIRA in the widely used network simulator *ns-2*. I evaluated NIRA using both simulations on realistic domain-level topologies derived from BGP routing tables and analytical modeling. Preliminary work on NIRA was presented in August 2003 at the ACM SIGCOMM Future Directions on Network Architecture workshop.

2003 **Compact Routing on Internet-like Graphs:** The key idea to scalable routing is to use ingenious addressing schemes to compress the routing states a node needs to keep. In the field of theoretical computing, such routing schemes are called "Compact Routing." The common drawback of such routing schemes is that packets are often routed on non-shortest paths. The ratio between the actual path length and the shortest path length is called stretch, which is a key performance metric for evaluating compact routing schemes. In the process of designing a scalable Internet routing architecture for my dissertation, I studied the performance of one of the best known compact routing schemes (the Thorup-Zwick (TZ) routing scheme) on Internet-like topologies in collaboration with Dimitri Krioukov and Kevin Fall, Our findings show that the average stretch of TZ scheme is around 1.1 and is much lower than the theoretical upper bound 3. Our work will appear in IEEE INFOCOM conference 2004.

2001 **Traffic Profile Design in Diff-Serv Framework:** I designed a traffic profile for metering heavy-tailed on/off traffic streams. A heavy-tailed on/off traffic stream models a user's web browsing session, which has a high peak-to-average data rate ratio. The traditional token bucket profile aims at smoothing bursty traffic. When policed by such a profile, even though the long term average data rate of a traffic stream does not exceed the token rate, consecutive bursts from the traffic stream may interfere with each other. I designed a traffic profile that separates the long term average rate control from the burst control. Compared to the token bucket profile, this profile not only effectively limits the long term average rate of a traffic stream, but also provides QoS with a higher statistical guarantee. Moreover, it allows a service provider to specify different burst control policies for metering different classes of traffic. This work was presented at IEEE Global Internet conference in 2002.

1999-2001 **Service Discovery in Ubiquitous Computing Environment:** I designed a framework for semantic service discovery that can be used in ubiquitous computing environment. In this framework, service representation and discovery are based on an ontology shared between service providers and clients only. A service is represented by a tree data structure and matching functions that capture the semantics of the tree nodes. A directory agent matches a query against service representations by invoking matching functions. Thus, a generic implementation of a directory agent can answer semantic queries for arbitrary service representations. This work was presented at the MIT Student Oxygen Workshop in 2001.

1998-1999 **The Effects of Bottleneck Link Speed on Web Browsing:** Broadband residential connections are expected to reach most American homes within a decade. But how fast is fast enough? By comparing the downloading time for synthetic web pages under different bottleneck link speeds, I showed that when link speed exceeds 1Mbps, user perceived delay is often dominated by round trip times. Thus, further increasing the bottleneck link speed will have limited effects on improving user perceived performance. In this aspect, the two techniques ADSL and cable modem can be considered equivalent.

In this project, I designed and implemented a link emulator in FreeBSD kernel for my experiments. Unlike *dummynet*, this emulator inserts dummy packets between real data packets to schedule packet departures. Thus, real data packets are evenly paced out at the emulated link speed instead of at the real physical link speed.

The results of this work were published in my advisor Dave Clark's article "High-Speed Data Races Home," Scientific American, September, 1999.

1998-1999 **Non-intrusive Bottleneck Link Inference:** With Dina Katabi and Issam Bazzi, I co-developed a non-intrusive technique to discover shared bottleneck bandwidth among multiple flows ob-

served at a receiver. The technique is based upon the observation that packet inter-arrival times of flows that share a bottleneck have a lower entropy than those who do not share a bottleneck. We used machine learning techniques to cluster flows and to infer shared bottleneck bandwidth. This work was presented at IEEE ICCCN 2001.

1998 **Multicast Tree Topology Inference:** With Li-wei Lehman, I co-developed an algorithm for inferring the topology of multicast trees. The basic idea of the algorithm is that if a packet is dropped, the loss will be seen by all nodes on the multicast subtree rooted at the node where the loss occurs. Using this loss correlation, nodes are clustered into subtrees recursively. Thus, by collecting data traces at the end nodes, our algorithm is able to reconstruct the topology of multicast trees.

1997-1998 **Network Modeling:** For my M.S. thesis, I developed an analytical model for window-based flow control networks and designed an algorithm for finding the fixed point solution for the model. My model is able to compute the steady state throughput of each flow and the queue length at each intermediate router. This work was presented at IEEE INFOCOM 1999.

Summer Intern – *Networking Software Research Department, Bell Labs, Holmdel, NJ.*
Mentor: Thomas Woo

1999 **Router Load Balancing Algorithms:** I designed and simulated several load balancing algorithms for high speed routers based on real data traces.

Teaching Experience

2001 Teaching Assistant for Computer Networks (MIT course 6.829)

I prepared and taught lectures and tutorials, held weekly office hours, graded problem sets, exams, and students' projects. Moreover, I helped develop course materials, including problem sets, exams, and code base. Some of these materials were integrated into MIT's OpenCourseWare project.

Refereed Publications

Dmitri Krioukov, Kevin Fall, and Xiaowei Yang. "Compact Routing on Internet-like Graphs." *To appear in the proceedings of IEEE INFOCOM*, HongKong, China, March 2004.

Xiaowei Yang. "NIRA: A New Internet Routing Architecture." *In the proceedings of ACM SIGCOMM Future Directions in Network Architecture Workshop*, Karlsruhe, Germany, August 2003.

Xiaowei Yang. "Designing Traffic Profiles for Bursty Internet Traffic." *In the proceedings of IEEE Global Internet*, Taipei, Taiwan, November 2002.

Steven Bauer, George Lee, Indraneel Chakraborty, Xavier Brucker, Xiaowei Yang, Ben Leong, and John Wroclawski. "The Personal Router." Student poster, *ACM MobiCom*, September 2002, Atlanta, Georgia, USA.

Xiaowei Yang. "A Framework for Semantic Service Discovery." *In the proceedings of MIT Student Oxygen Workshop*, Gloucester, MA, USA, August 2001.

Dina Katabi, Issam Bazzi, and Xiaowei Yang. "A Passive Approach for Detecting Shared Bottlenecks." *In the proceedings of IEEE International Conference on Computer Communications and Networks*, Arizona, USA, November 2001.

Xiaowei Yang. "A Model for Window Based Flow Control in Packet-Switched Networks." *In the proceedings of IEEE INFOCOM*, New York, USA, March 1999.

Pending Publications

Xiaowei Yang. "An Inter-domain Topology Information Propagation Protocol." To be submitted, February, 2004

Selected Honors

Member, Sigma Xi engineering honor society

1996 MIT EECS Fellowship

1996 Honorable Mention in the 12th Mathematical Contest in Modeling (MCM)

1994 Outstanding Student of Universities in Beijing
Awarded to 10 students from all universities in Beijing.

1993-1996 First class scholarships, Tsinghua University, Beijing, China

1991 Second Prize in National Physics Olympiad, China

Service

Reviewer for CCR, SIGCOMM, INFOCOM

2000, 2003 Network Reading Group (NetRead) Organizer – MIT Laboratory for Computer Science

I organized weekly student seminars discussing recent research papers in networking and related fields.

Visa Status

US Permanent Resident

References

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