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Education

Harvard University, Cambridge, Massachusetts.
Doctor of Philosophy in Computer Science. Graduated November 2000.
Thesis title: *Geographic Routing for Wireless Networks*.
Master of Science in Computer Science received June 1995.
Advisor: H. T. Kung.

Yale University, New Haven, Connecticut.
Bachelor of Science in Computer Science. Graduated May 1992.
Thesis title: *Massively Parallel Algorithms for Adaptive Function Approximation in One and Two Dimensions*.

Research Interests

Wireless and mobile networks; Internet performance analysis and architecture; network operating system software performance.

Research Experience

Reordering-Robust TCP: 2001–present. With a student intern advisee, co-designed extensions to the TCP reliable transport protocol to improve its robustness on network paths that reorder packets. SACK TCP, the previous state-of-the-art TCP, performs poorly on such paths because it mistakes reordering for loss, and incorrectly sends more slowly. Reordering-Robust TCP uses measurements of the degree of reordering on a network path to adapt TCP's retransmission algorithm dynamically, such that the sender proactively avoids such spurious window reductions. The result is significantly increased throughput on networks that reorder. This work relaxes the constraint that the Internet deliver packets in order, and thus enables work on desirable network systems that violate this constraint, such as multi-path routing.

GPSR: 1998–present. Created and evaluated Greedy Perimeter Stateless Routing, a scalable routing algorithm for wireless networks that uses the *positions* of routers and a packet's destination to make forwarding decisions. In link-state, distance-vector, and ad-hoc routing algorithms, each router relies on state concerning the full path between that router and each network destination. In contrast, by using geography for forwarding decisions, GPSR requires state describing only a router's *immediate neighbor* routers. As a result, GPSR uses far less memory at each router than do LS, DV, and ad-hoc routing algorithms, and finds routes more robustly after topology changes, while generating significantly reduced routing protocol message traffic. This work continues with the application of GPSR to *data-centric storage on sensor networks*, and the design of a novel *geographic traffic engineering system*, for separating flows on a wireless network to improve a workload's spatial reuse, and thus the flows' achieved throughputs.

APRL and HUMR: 1997–1999. Designed and built a multi-hop wireless mobile network on commodity Metricom Ricochet radios. Created HUMR, an application-level UNIX driver for peer-to-peer IPv4 and IPv6 communication using Ricochet radios, that are ordinarily used only for PPP connections with Metricom's commercial wireless service. HUMR uses hints provided by the radios' firmware to detect acquisition and loss of neighbors. This software is to be integrated into the FreeBSD UNIX distribution. Created APRL, Any-Path Routing without Loops, a distance-vector routing system that *provably* does not acquire looping routes. Demonstrated the combined system running on mobile networks of dozens of hosts for the Air Force.

SABRA: 1995–1996. Built SABRA, an ATM ABR with EPRCA rate-based flow control system for Intel hosts with a CMU/Harvard/Intel-designed ATM network interface and the Harvard/Nortel CreditNet ATM switch. The research community widely expected ABR to require a dedicated ASIC on host interfaces. Motivated by the importance of software's flexibility in the evolution of flow control protocols, I built an optimized ABR system where the host CPU performs ABR in software. A SABRA host can sustain the full OC-3 ATM link rate; no ASIC is needed.

Mobile IP: 1993–1994. Collaborated in the design and building of the Harvard Mobile IP system, one of the first working Mobile IP implementations, when Mobile IP was still being defined. The Harvard system supports secure "short-cut" routing, through which wired hosts communicate directly with a roaming mobile host, rather than through the mobile host's home agent.

CreditNet: 1992–1995. As a member of a team comprised of H.T. Kung's lab at Harvard and a group at Nortel, co-designed the CreditNet switch, a multi-gigabit ATM switch with hardware support for per-circuit credit-based flow control. Built the first host-side N23 credit-based flow control system. This system assumes minimal host adapter hardware, and performs all credit cell processing on the host CPU. A modest 133 MHz Alpha CPU running this code can saturate an OC-3 ATM link.

Work Experience

ICSI Center for Internet Research, Berkeley, California: October, 2000–present. Research Scientist. Developed algorithms for improving TCP's robustness to packet reordering; developed techniques for geographic provisioning of wireless networks; contributed to design of a distributed hash table for sensor networks, built on GPSR.

AT&T Center for Internet Research at ICSI, Berkeley, California: June, 1999–April, 2000. Research Intern. Developed GPSR, a scalable geographic routing system for wireless networks.

USC/Information Sciences Institute, Arlington, Virginia: September, 1996–December, 1998. Research Assistant. While a graduate student at Harvard, but supported in part by ISI, built HUMR and APRL, a system for multi-hop IPv4 and IPv6 over Metricom Ricochet radios. Ported the operating system for the Netstar Gigarouter to FreeBSD UNIX in support of the DARTnet/CAIRN network testbed.

Digital Equipment Corporation, Littleton, Massachusetts: June, 1996–August, 1996. Research Intern. Evaluated, designed, and simulated open-loop and best-effort traffic scheduling algorithms for input-buffered switch architectures.

USC/Information Sciences Institute, Arlington, Virginia: June, 1995–August, 1995. Research Assistant. Built a software ATM Forum ABR/EPRCA system for the NetBSD UNIX kernel running on the Intel Pentium processor with an experimental Intel ATM interface. Analyzed performance of resulting system.

Ungermann Bass Networks, Andover, Massachusetts: October, 1994. Consultant in ATM Switch Design and Performance. Evaluated the TCP and UDP performance implications of a proposed ATM switch core design for a future UB Networks product. Recommended changes to the design to improve switch behavior for these classes of traffic.

Kendall Square Research, Waltham, Massachusetts: May, 1993–August, 1994. Consultant in Network and Filesystem Design and Performance. Performed detailed performance analysis of the network and disk hardware and software (device driver levels up through application levels) of the KSR1. Analysis focused on NFS server performance.

Bell Communications Research, Morristown, New Jersey: June, 1991–January, 1993. Senior Staff Technologist and Consultant in Parallel Computation. Implemented and analyzed the performance of parallel resolution constraint adaptive methods for functional approximation.

Argonne National Laboratory, Argonne, Illinois: June, 1990–August, 1990. Summer Research Intern. Designed and implemented graph transformations to improve granularity of and reduce contention in automatic differentiation on parallel processors.

Teaching

Teaching Fellow (1993): Operating Systems (Harvard CS 161/261, graduate and undergraduate).
Co-instructor (1996): Operating System Network Performance (Harvard CS 248, graduate).
Instructor (1993, '94, '96): Computer-Assisted Research (Harvard DN 118, undergraduate).
Invited Guest Lecturer (1993–1999): Harvard's Operating Systems and Networks courses.
Co-advisor (1998): Undergraduate Computer Science thesis, graded *summa cum laude* by Harvard's Computer Science Department.
Advisor (2001): Three Ph.D.-student research summer interns at ICSI.
Resident Tutor in Computer Science (1995–1999): Dunster House. Advised and assisted Harvard undergraduate Computer Science students in thesis topic selection, problem sets, *&c.*

Awards and Prizes

Henry Dunster Tutor Prize (1997) for excellence in advising, chosen by Harvard undergraduates.

Best Student Paper Award (1994) for Secure Short-Cut Routing for Mobile IP in *Usenix '94*.

Publications

Greenstein, B., Zhuang, S., and Karp, B., STREWN: Spatial Traffic Engineering for Wireless Networks, submitted for publication.

Shenker, S., Ratnasamy, S., Karp, B., Govindan, R., and Estrin, D., Data-Centric Storage in Sensornets, in the *Proceedings of the First ACM SIGCOMM Workshop on Hot Topics in Networks (HotNets 2002)*, Princeton, NJ, October, 2002.

Ratnasamy, S., Karp, B., Yin, L., Yu, F., Estrin, D., Govindan, R., and Shenker, S., GHT: A Geographic Hash Table for Data-Centric Storage, in the *Proceedings of the First ACM International Workshop on Wireless Sensor Networks and Applications (WSNA 2002)*, September 2002.

Zhang, M., Karp, B., Floyd, S., and Peterson, L., Improving TCP's Performance under Reordering with DSACK, ICSI Technical Report TR-02-006, July 2002. Submitted for publication.

Karp, B., Challenges in Geographic Routing: Sparse Networks, Obstacles, and Traffic Provisioning, in the *Proceedings of the DIMACS Workshop on Pervasive Networking*, May 2001.

Karp, B., Geographic Routing for Wireless Networks, Doctoral Disseration in Computer Science, Harvard University Division of Engineering and Applied Sciences, October 2000.

Karp, B. and Kung, H. T., Greedy Perimeter Stateless Routing for Wireless Networks, in *Proceedings of the Sixth Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom 2000)*, August 2000.

Gaynor, M., Karp, B., and Kung, H. T., A PC-Based ATM Link Delay Simulator, in *Proceedings of the 1998 Summer Computer Simulation Conference (SCSC '98)*, July 1998.

Karp, B., Mankin, A., Kung, H.T., Demirtjis, A., and Edwards, B., An Implementation Study of ABR/EPRCA, *ATM Forum Contribution 96-587*, April 1996.

Blackwell, T., Chan, K., Chang, K., Charuhas, T., Karp, B., Kung, H.T., Lin, D., Morris, R., Seltzer, M., Smith, M., Young, C., Bahgat, O., Chaar, M., Chapman, A., Depelteau, G., Grimble, K., Huang, S., Hung, P., Kemp, M., Mahna, I., McLaughlin, J., Ng, M.T., Vincent, J., Watchorn, J., An Experimental Flow-Controlled Multicast ATM Switch, in *Proceedings of the First Annual Conference on Telecommunications in Massachusetts*, October 1994.

Blackwell, T., Chan, K., Chang, K., Charuhas, T., Gwertzman, J., Karp, B., Kung, H.T., Li, W.D., Lin, D., Morris, R., Polansky, R., Tang, D., Young, C., Zao, J., Secure Short-Cut Routing for Mobile IP, in *Conference Proceedings of the Usenix Summer 1994 Technical Conference*, Boston, Massachusetts, June 6-10, 1994, pp. 305-316.

Karp, B. and Moulin, P., Implementation of Multiresolution Regression Splines on the MasPar: Function and Image Estimation in Parallel, *Bell Communications Research Internal Technical Memorandum*, February 1993.

Karp, B. and Bischof, C., Increasing the Granularity of Parallelism and Reducing Contention in Automatic Differentiation, *Argonne National Laboratory Technical Memorandum ANL/MCS-TM-142*, November 1990.

Personal

Languages: French and German (moderate proficiency).
Non-technical interests: Choral Music (Tenor I in the Harvard and Yale Glee Clubs); Jazz Piano (playing and listening); 19th- and 20th-Century Fiction; Fine Food (cooking and eating); Theatre; Skiing; Improvisational Comedy (former musical director of Yale's Viola Question group).

References

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