

DUSHYANTH NARAYANAN

Computer Science Department
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213-3891

Office: (412) 268-1425
Mobile: (412) 606-7892
Fax: (412) 268-5576
bumba@cs.cmu.edu
URL: <http://www.cs.cmu.edu/~bumba/research/>
Citizenship: Indian, Visa status: F1 student

RESEARCH AREAS

Operating systems; networking; mobile and wearable computing

EDUCATION

Carnegie Mellon University, Pittsburgh, PA

Ph.D. in Computer Science, July 2002 (expected)

Thesis: "Operating System Support for Mobile Interactive Applications"

Advisor: M. Satyanarayanan

Indian Institute of Technology, Madras, India

B.Tech. in Computer Science and Engineering, May 1995

HONORS

1995-96 AT&T Asia-Pacific Scholarship (one of 36 students from 12 Asia-Pacific countries)

1989-95 National Talent Search Scholarship (one of 750 students nationwide)

RESEARCH

Operating System Support for Mobile Interactive Applications

Thesis research, Carnegie Mellon University, Fall 1999 - Present.

Mobile interactive applications such as augmented reality rendering and speech recognition must provide bounded interactive response times for a good user experience, and limit their energy consumption to prolong battery lifetimes. To do this, they must dynamically adapt resource demand to resource supply, which varies continually due to changes in load, processor frequency, wireless connectivity, server availability, and battery charge levels. Previous research has shown that application adaptation can reduce the bandwidth and energy usage of data access. In my thesis research, I introduce *multi-fidelity computation*: a general model for adaptation that covers a wide range of adaptive behaviors. I also present a resource model that can uniformly represent system resources — CPU, network, memory, disk, file cache state, and remote server resources — in terms of supply and demand.

I have designed an API and built system support for multi-fidelity computation in Linux. The multi-fidelity API is small and designed to minimize the modification required to port legacy code. The system support provides a novel service: automatic learning and prediction of application resource demand. This shifts much of the burden of adaptation from the application programmer to the system: the programmer describes the application at a high level, and does not need to know the exact relationship between application behavior, resource demand, and performance. The API and system support have been tested with a number of interactive applications, including 3-D rendering, speech recognition, web browsing, and language translation. In my thesis research I show that applications are able to satisfy latency constraints through adaptation. E.g., we reduce the mean response time for a virtual walkthrough application by 3x, and the variance by 42x. Other researchers have used the same infrastructure can to achieve users' battery lifetime goals through adaptation.

Wireless network emulation for mobile users

Graduate research assistant, Carnegie Mellon University, Fall 1998 - Fall 1999.

Studying and interpreting the behavior of a mobile computing system under conditions of motion is difficult. We implemented a *wireless obstacle course* to facilitate such evaluations. The infrastructure consists of a physically compact, limited-access region over which the quality of wireless network performance can be controlled. As a test system moves through the obstacle course, it perceives wireless network quality that varies spatially according to a pattern set up by the experimenter. Our prototype implementation uses Active Badges to sense the location of the mobile computer; a network trace modulation layer then emulates the wireless network characteristics for that location.

Migration planning in self-configuring storage systems

Summer intern, HP Labs Palo Alto, Summer 1998.

As part of the Storage Systems group, I implemented a migration planner for Forum. Forum automatically computes a configuration for a large-scale storage system based on workload properties and performance requirements. It must periodically recompute the configuration to track workload or system changes; the migration planner then generates a plan to move data objects efficiently to the new configuration.

Application-aware adaptation in Odyssey

Graduate research assistant, Carnegie Mellon University, Fall 1995-Fall 1998.

Odyssey is a system support layer for adapting data fidelity to network bandwidth availability. As part of the Odyssey group, I implemented various system components and an adaptive video player.

PUBLICATIONS

Refereed conferences/workshops

- Jason Flinn, **Dushyanth Narayanan**, and M. Satyanarayanan. "Self-Tuned Remote Execution for Pervasive Computing". *Proc. 8th Workshop on Hot Topics in Operating Systems (HotOS-VIII)*, May 2001, Schloss Elmau, Germany.
- David Petrou and **Dushyanth Narayanan**. "Position summary: Hinting for goodness' sake". *Proc. 8th Workshop on Hot Topics in Operating Systems (HotOS-VIII)*, May 2001, Schloss Elmau, Germany.

- **Dushyanth Narayanan**, Jason Flinn, and M. Satyanarayanan. “Using History to Improve Mobile Application Adaptation”. *Proc. 3rd IEEE Workshop on Mobile Computing Systems and Applications (WMCSA 2000)*, Dec 2000, San Diego, CA.
- Brian D. Noble, M. Satyanarayanan, **Dushyanth Narayanan**, J. Eric Tilton, Jason Flinn, and Kevin R. Walker. “Agile Application-Aware Adaptation for Mobility”. *Proc. 16th ACM Symposium on Operating Principles (SOSP '97)*, Oct 1997, Saint-Malo, France.

Journal Articles

- M. Satyanarayanan and **Dushyanth Narayanan**. “Multi-Fidelity Algorithms For Interactive Mobile Applications”. *Wireless Networks*, Vol. 7, pp. 601–607, 2001, Kluwer Academic Publishers. (Also in *Proc. 3rd International Workshop on Discrete Algorithms and Methods in Mobile Computing and Communications (DIAL-M '99)*, Aug 1999, Seattle, WA.

Patents

- Elizabeth Lynn Borowsky, Richard Andrew Golding, and **Dushyanth Narayanan**. “Computer Data Storage System with Migration Plan Generator”. US Patent #6381619, 2002.
- Elizabeth Lynn Borowsky, Richard Andrew Golding, and **Dushyanth Narayanan**. “Computer Data Storage System with Parallelization Migration Plan Generator”. *US Patent application*, Aug 1999.

TEACHING

- Project Mentor, Carnegie Mellon University, Fall 2000 and Fall 2001, *Mobile Computing* (graduate). Guided three semester-long research projects: CPU monitoring/prediction, service discovery, and 3-D rendering through remote execution.
- Teaching Assistant, Carnegie Mellon University, Spring 1998, *15-412: Operating Systems* (senior).
- Teaching Assistant, Carnegie Mellon University, Fall 1996 *15-451: Algorithms* (senior).
- Teaching Assistant, IIT-Madras, Fall 1995 *Introduction to Computer Science* (freshman).

PROFESSIONAL AND COMMUNITY SERVICE

- Reviewed submissions to MobiCom, SOSP, FAST and several IEEE publications.
- Student Coordinator for Fall 2000 Immigration Course for new Computer Science graduate students.
- Program committee member for the 1999 CMU Symposium on Computer Systems (SOCS-2).
- Member of Dec/5 — a School of Computer Science graduate student social organization (1996-97).

REFERENCES

Professor M. Satyanarayanan
School of Computer Science
Carnegie Mellon University
5000 Forbes Ave
Pittsburgh, PA 15213
(412) 268-3743
satya@cs.cmu.edu

Professor Christos Faloutsos
School of Computer Science
Carnegie Mellon University
5000 Forbes Ave
Pittsburgh, PA 15213
(412) 268-1457
christos@cs.cmu.edu

John Wilkes
Hewlett-Packard Laboratories
Mailstop 1U-13
1501 Page Mill Road
Palo Alto, CA 94304
(650) 857-3568
wilkes@hpl.hp.com