Paul Schmitt

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Education

University of California, Santa Barbara **2017**
Ph.D., Computer Science
Thesis: *Network Measurement and Systems for Resource-Constrained Environments*
Advisor: Elizabeth Belding

University of St. Thomas **2011**
M.S., Software Engineering

University of St. Thomas **2009**
B.A., Computer Science

Conferences & Journals

[1] **Inferring Streaming Video Quality from Encrypted Traffic: Practical Models and Deployment Experience**
Francesco Bronzino, **Paul Schmitt**, Sara Ayoubi, Guilherme Martins, Renata Teixeira, Nick Feamster
ACM SIGMETRICS 2020, June 2020, Boston, MA

[2] **Comparing the Effects of DNS, DoT, and DoH on Web Performance**
Austin Hounsel, Kevin Borgolte, **Paul Schmitt**, Jordan Holland, Nick Feamster
The Web Conference (WWW 2020), April 2020, Taipei, Taiwan

[3] **How DNS over HTTPS is Reshaping Privacy, Performance, and Policy in the Internet Ecosystem**
Kevin Borgolte, Tithi Chattopadhyay, Nick Feamster, Mihir Kshirsagar, Jordan Holland, Austin Hounsel, **Paul Schmitt**
Research Conference on Communications, Information and Internet Policy (TPRC). September 2019, Washington DC

[4] **Oblivious DNS: Practical Privacy for DNS Queries**
Paul Schmitt, Anne Edmundson, Allison Mankin, Nick Feamster
Privacy Enhancing Technologies Symposium (PETS).
July 2019, Stockholm, Sweden

[5] **MPTCP Performance over Heterogenous Subpaths**
Vivek Adarsh, **Paul Schmitt**, Elizabeth Belding
International Conference on Computer Communications and Networks (IC3N).
July 2019, Valencia, Spain

[6] **Third-Party Cellular Congestion Detection and Augmentation**
Paul Schmitt, Daniel Iland, Mariya Zheleva, Elizabeth Belding
IEEE Transactions on Mobile Computing. January 2019

[7] **Efficient Spectrum Summarization Using Compressed Spectrum Scans**
Mariya Zheleva, Timothy Larock, **Paul Schmitt**, Petko Bogdanov
IEEE DySPAN 2018. October 2018, Seoul, South Korea

[8] **Enhancing Transparency: Internet Video Quality Inference from Network Traffic**
Paul Schmitt, Francesco Bronzino, Renata Teixeira, Tithi Chattopadhyay, Nick Feamster
Research Conference on Communications, Information and Internet Policy (TPRC). September 2018, Washington DC

[9] **A Cellular Network Radio Access Performance Measurement System: Results from a Ugandan Refugee Settlements Field Trial**
Carleen Maitland, Richard Caneba, **Paul Schmitt**, Tom Koutsky
Research Conference on Communications, Information and Internet Policy (TPRC). September 2018, Washington DC

[10] **AirVIEW: Unsupervised Transmitter Detection for Next Generation Spectrum Sensing**
Mariya Zheleva, Petko Bogdanov, Timothy Larock, **Paul Schmitt**
IEEE Infocom 2018. April 2018, Honolulu, HI

[11] **PhoneHome: Robust Extension of Cellular Coverage**
Paul Schmitt, Daniel Iland, Elizabeth Belding, and Mariya Zheleva.
International Conference on Computer Communication and Networks (IC3N 2016). August 2016, Waikoloa, HI

[12] **SmartCell: Small-Scale Mobile Congestion Awareness**
Paul Schmitt, Daniel Iland, and Elizabeth Belding.
IEEE Communications Magazine. July 2016

[13] **Community-Level Access Divides: A Refugee Camp Case Study**
Paul Schmitt, Daniel Iland, Elizabeth Belding, Brian Tomaszewski, Ying Xu, and Carleen Maitland.
International Conference on Information and Communication Technologies and Development (ICTD). June 2016, Ann Arbor, MI

[14] **HybridCell: Cellular Connectivity on the Fringes with Demand-Driven Local Cells**
Paul Schmitt, Daniel Iland, Mariya Zheleva, and Elizabeth Belding.
IEEE INFOCOM 2016. April 2016, San Francisco, CA

[15] **A Study of MVNO Data Paths and Performance**
Paul Schmitt, Morgan Vigil, and Elizabeth Belding.
Passive and Active Measurements Conference (PAM 2016).
March 2016, Heraklion, Crete, Greece

[16] **Internet Media Upload Caching for Poorly-Connected Regions**
Paul Schmitt, Ramya Raghavendra, and Elizabeth Belding.
Sixth annual Symposium on Computing for Development (ACM DEV 2015).
December 2015, London, United Kingdom

[17] **Internet Bandwidth Upgrade: Implications on Performance and Usage in Rural Zambia**
Mariya Zheleva, **Paul Schmitt**, Morgan Vigil, and Elizabeth Belding.
Information Technologies and International Development Journal (ITID).
Summer 2015

[18] **The Increased Bandwidth Fallacy: Performance and Usage in Rural Zambia**
Mariya Zheleva, **Paul Schmitt**, Morgan Vigil, and Elizabeth Belding.
Fourth Annual Symposium on Computing for Development (ACM DEV).
December 2013, Cape Town, South Africa

Workshops & Short Papers

[1] **Low On Air: Inherent Wireless Channel Capacity Limitations**
Paul Schmitt and Elizabeth Belding.
Third Workshop on Computing within Limits (ACM LIMITS 2017).
June 2017, Santa Barbara, CA

[2] **Helping the Lone Operator in the Vast Frontier**
Thomas Pötsch, **Paul Schmitt**, Jay Chen, and Barath Raghavan.
ACM Workshop on Hot Topics in Networks (HotNets 2016).
November 2016, Atlanta, GA

[3] **Navigating Connectivity in Reduced Infrastructure Environments**
Paul Schmitt and Elizabeth Belding.
Second Workshop on Computing within Limits (ACM LIMITS 2016).
June 2016, Irvine, CA

[4] **AirPress: Towards Scalable Spectrum Inventory**
Timothy LaRock, **Paul Schmitt**, Petko Bogdanov, Elizabeth Belding, and Mariya Zheleva. *Networked Systems Design and Implementation (NSDI)*. March 2016, Santa Clara, CA

[5] **NosyNeighbor: Augmenting Post-Disaster Cellular Service with Local Cellular Networks**
Daniel Iland, Mariya Zheleva, **Paul Schmitt**, and Elizabeth Belding.
Sixteenth Workshop on Mobile Computing Systems and Applications (ACM HotMobile 2015). February 2015, Santa Fe, NM

[6] **Bringing visibility to rural users in Ivory Coast**
Mariya Zheleva, **Paul Schmitt**, Morgan Vigil, and Elizabeth Belding.
International Conference on Information and Communication Technologies and Development (ICTD). December 2013, Cape Town, South Africa

[7] **Community Detection in Cellular Network Traces**
Mariya Zheleva, **Paul Schmitt**, Morgan Vigil, and Elizabeth Belding.
International Conference on Information and Communication Technologies and Development (ICTD). December 2013, Cape Town, South Africa

[8] **Communication Flow Patterns in the D4D Dataset**
Paul Schmitt, Morgan Vigil, Mariya Zheleva, and Elizabeth Belding.
NetMob Session on Data for Development (D4D). May 2013, Boston, MA

Books

[1] **Cellular and Internet Connectivity for Displaced Populations**
Paul Schmitt, Daniel Iland, Elizabeth Belding, Mariya Zheleva
chapter in *Digital Lifeline? ICTs for Refugees and Displaced Persons*
MIT Press, 2018

Preprints, Works in Progress

[1] **Pretty Good Phone Privacy**
Paul Schmitt, Barath Raghavan
in submission

[2] **Packets as Pictures: A General Spatial Representation of Network Traffic**
Jordan Holland, **Paul Schmitt**, Prateek Mittal, Nick Feamster
in submission

[3] **D-DNS: Towards Re-Decentralizing the DNS**
Austin Hounsel, Kevin Borgolte, **Paul Schmitt**, Nick Feamster *in submission*

Technical Reports

[1] **Beyond the Trees: Resilient Multipath for Last-mile WISP Networks**
Bilal Saleem, **Paul Schmitt**, Jay Chen, Barath Raghavan
arXiv:2002.12473. February 2020

[2] **OCDN: Oblivious Content Delivery Networks**
Anne Edmundson, **Paul Schmitt**, Nick Feamster, Jennifer Rexford
arXiv:1806.00276. December 2018

[3] **Rangzen: Anonymously Getting the Word Out in a Blackout**
Adam Lerner, Giulia Fanti, Yahel Ben-David, Jesus Garcia, **Paul Schmitt**, Barath Raghavan
arXiv:1612.03371. December 2016

[4] **Youth Mobile Phone and Internet Use, January 2015, Za'atari Camp, Mafraq, Jordan**
Carleen Maitland, Brian Tomaszewski, Elizabeth Belding, Karen Fisher, Ying Xu, Danny Iland, **Paul Schmitt**, and Amira Majid.
Penn State Univ., State College, PA, Tech. Rep., October 19 2015

Selected Press

[1] **"The Truth About Faster Internet: It's Not Worth It"**
The Wall Street Journal, August 20, 2019

Research Experience

Princeton University, Princeton, NJ

Associate Research Scholar **May 2019 - present**

Postdoctoral Research Associate **August 2017 - May 2019**

Collaborators: Nick Feamster, Renata Teixeira, Zakir Durumeric, Barath Raghavan

Research Projects:

Privacy

- **Pretty Good Phone Privacy (PGPP)**. Redesigning the cellular core network to provide identity and location anonymity for users.

- **Oblivious DNS**. Implementing DNS query privacy with existing infrastructure. *Impact:* ODNS techniques integrated into IETF proposals "Oblivious DNS Over HTTPS" and "Adaptive DNS: Improving Privacy of Name Resolution."

- **Oblivious CDN**. Privacy-preserving content storage.

Measurement

- **High-speed network measurement**. System designed to provide researcher and practitioners a flexible platform for making sense of network traffic at high data rates ($\geq$ 100 Gbps) using commodity hardware.

- **Network Microscope**. Low-cost system placed at the home network gateway that passively estimates Internet traffic performance.

- **Video QoE Estimation**. Passive estimation of encrypted OTT video service QoE from network traffic.

University of California, Santa Barbara, Santa Barbara, CA

Research Assistant, MOMENT Lab **September 2012 - July 2017**

Research Projects: Advisor: Elizabeth Belding

Network Measurement

- **Cellular congestion detection**. Developed system and algorithm for passive detection and characterization of cellular base station radio congestion. Conducted measurement campaign comparing congestion in the United States, rural Guatemala, and a large refugee camp in Jordan. Findings of extreme congestion at the base station level in refugee camp allowed local organizations to approach carriers to find solutions.
- **Mobile data network performance analysis**. Studied performance and behaviors for traffic on mobile network operator (MNO) and mobile virtual network operator (MVNO) networks. Found that poor performance of MVNOs may be attributable to inefficient network topologies, lack of peering arrangements, and inflated paths relative to the underlying carrier.
- **Rural Internet / Cellular Usage Analysis**. Investigated usage patterns and performance analysis in rural African environments. Focused on Internet traffic before and after a network upgrade, finding that TCP performance degraded despite increased bandwidth. Explored cellular communication flow patterns, uncovering correlations between the underlying population densities of source and destination antennas, call durations and physical distance.

Connectivity in Resource-Poor Areas

- **HybridCell**. Developed HybridCell, which enables coexistence between commercial and local cellular coverage to augment poorly performing existing infrastructure. HybridCell monitors nearby commercial cellular networks and dynamically adjusts local network usage based on the "health" of the commercial network.

Dynamic Spectrum Access (DSA)

- **AirPress**. Developed a system that allows for one-pass spectrum characterization. AirPress employs wavelet decomposition to achieve rapid transmitter detection in low and high noise environments.

Field work:

- Cellular and data communications infrastructure analysis in Za'atari refugee camp, Jordan. **January 2015**
- Cellular network infrastructure and performance analysis in San Cristóbal, Alta Verapaz, Guatemala **January 2015**

- Expanding local partnership and deployment of local cellular network in Macha, Zambia — **December 2013**

International Computer Science Institute (ICSI), Berkeley, CA

Research Intern — **June 2016 - September 2016**

- Advisors: Barath Raghavan, ICSI, Jay Chen, NYU
- Project: **WISPR**. Developed a network protocol, WISPR (Wireless Internet Service Providers with Redundancy), that enables multipath over low-cost, heterogeneous wireless links.

IBM Research, Yorktown Heights, NY

Research Intern — **June 2013 - September 2013**

- Advisor: Ramya Raghavendra, IBM Research
- Project: **VillageCache**. Developed a system that transparently scrapes uploads and redelivers locally-created media in users' web sessions without accessing the Internet bottleneck link for poorly-connected networks.

Grants and Awards

- 2016-2017 UCSB President's Dissertation Year Fellowship
- 2014-2015 Dean's Fellowship, UCSB

Teaching Experience

Princeton University — **2017 - present**
Mentoring of 3 Ph.D. students in research activities

University of California, Santa Barbara — **2013**
Teaching assistant for Object Oriented Design and Implementation

University of California, Santa Barbara — **2013**
Teaching assistant for Network Computing

University of California, Santa Barbara — **2012**
Teaching assistant for Object Oriented Design and Implementation

University of St. Thomas — **2012**
Adjct instructor for Computer Networking

University of St. Thomas — **2011**
Adjunct instructor for Operating Systems

Academic Activities

- Reviewer for IEEE INFOCOM
- Reviewer for ACM MobiCom
- Reviewer for IEEE Transactions on Mobile Computing
- Reviewer for IEEE International Conference on Data Mining
- Representative on UCSB CS Graduate Student Cabinet
- PC member of the Graduate Student Workshop in Computing 2014, UCSB
- PC member of the Graduate Student Workshop in Computing 2013, UCSB