

Martin Suchara

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RESEARCH INTERESTS

Quantum computing with focus on efficiency and fault tolerance, quantum error-correcting codes, quantum communication protocols and their security applications, large-scale numerical simulations. Broader research interests at the intersection of science and computation.

EDUCATION

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| Princeton University , Princeton, NJ Ph.D., Computer Science , June 2011 (GPA: 3.9/4.0) M.A., Computer Science , April 2008 (GPA: 3.9/4.0) | <i>2006-2011</i> |
| California Institute of Technology , Pasadena, CA B.S. with Honor, Computer Science , June 2006 (GPA: 3.9/4.0) | <i>2003-2006</i> |

CITIZENSHIP: U.S. Citizen

WORK EXPERIENCE

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| AT&T Labs Research – Principal Inventive Scientist | <i>2015–present</i> |
| IBM T. J. Watson Research Center – Postdoctoral Scholar in the Theory of Quantum Computing and Information Group | <i>2013–2015</i> |
| University of California Berkeley – Postdoctoral Scholar at the Berkeley Quantum Information & Computation Center | <i>2011-2013</i> |
| Princeton University – Graduate Research Assistant | <i>2006-2011</i> |
| Caltech – Undergraduate Research Assistant | <i>2004-2006</i> |

MAJOR RESEARCH PROJECTS

Work on IARPA Multi-Qubit Coherent Operations (MQCO) Program as a Postdoctoral Scholar at IBM T. J. Watson Research Center

- Developed a maximum likelihood decoder that finds the optimal recovery operation in the surface quantum error-correcting code and demonstrated greater than 100-fold improvement of the logical error probability for error rates lower than 10%.
- Investigated strategies for correction of leakage faults that excite qubits outside of the computational subspace, designed new leakage reducing quantum circuits, accompanying error decoders and evaluated their performance by numerical simulations on the IBM Blue Gene supercomputer.
- Constructed a topological subsystem quantum error-correcting code that only requires two-qubit nearest-neighbor measurements for error correction and designed the corresponding error decoder.

- Wrote a simulator that determines the noise threshold of topological error-correcting codes and used it to compare the properties of several codes.

Work on IARPA Quantum Computer Science (QCS) Program as a Postdoctoral Scholar at UC Berkeley

- Led a group of students and postdocs who quantified the resources (such as running time and number of qubits) needed to run a variety of quantum algorithms and error-correcting codes on several physical quantum computation technologies.
- Investigated the practical implications of incorporating quantum error-correcting codes into large-scale quantum computing architectures, identified tradeoffs and sources of inefficiencies.
- Designed a heuristic that improves the speed of decoding errors in topological quantum error-correcting codes and implemented a proof-of-concept demonstration.
- Repeatedly presented project results to the IARPA Program Manager at PI meetings.

Work at AT&T Labs as a Principal Inventive Scientist and earlier as a Contractor, part of work funded under DARPA CORONET Project

- Provided guidance to management about the uses of quantum computing and communication technologies and their security applications.
- Supervised summer interns working on quantum communication and security projects.
- Designed a new patented architecture that unifies network failure resilience and traffic engineering, performed convex optimizations of a national IP telecommunication network.
- Collaborated with several departments to perform extensive numerical simulations with real topology, traffic, and failure data from the AT&T backbone network.

PUBLICATIONS

Quantum Computing, Physics of Information, Physics:

1. **M. Suchara**, A. Cross and J. Gambetta, “Leakage Suppression in the Toric Code”. In Quantum Information and Computation, Vol. 15, No. 11 & 12, pp. 0997-1016, 2015. Also available as arXiv 1410.8562 and as a conference paper in the Proceedings of IEEE ISIT, June 2015.
2. S. Bravyi, **M. Suchara** and A. Vargo, “Efficient Algorithms for Maximum Likelihood Decoding in the Surface Code”. In Physical Review A 90, 032326, 2014. Also available as arXiv 1405.4883.
3. **M. Suchara**, A. Faruque, C. Lai, G. Paz, F. Chong and J. Kubitowicz, “Comparing the Overhead of Topological and Concatenated Quantum Error Correction”. Preprint available as arXiv 1312.2316.
4. **M. Suchara**, A. Faruque, C. Lai, G. Paz, F. Chong and J. Kubitowicz, “QuRE: The Quantum Resource Estimator Toolbox”. In Proceedings of IEEE International Conference on Computer Design, 2013.
5. C. Lai, G. Paz, **M. Suchara** and T. Brun, “Performance and Error Analysis of Knill’s Postselection Scheme in a Two-Dimensional Architecture”. In Quantum Information and Computation, Vol. 14, No. 9 & 10, pp. 807-822, 2014.
6. **M. Suchara**, A. Faruque, C. Lai, G. Paz, F. Chong and J. Kubitowicz, “Estimating the Resources for Quantum Computation with the QuRE Toolbox”. UC Berkeley Technical Report UCB/EECS-2013-119, 2013.
7. S. Bravyi, G. Duclos-Cianci, D. Poulin and **M. Suchara**, “Subsystem Surface Codes with Three-Qubit Check Operators”. In Quantum Information and Computation, Vol. 13, No. 11 & 12, pp. 0963, 2013.

8. **M. Suchara**, S. Bravyi and B. Terhal, “Construction and Noise Threshold of Topological Subsystem Codes”. In Journal of Physics A: Mathematical and Theoretical, Vol. 44, Issue 15, pp. 155301, 2011. **Paper included in the Highlights of 2011 Collection.**
9. M. Grocky, **M. Suchara**, Z. Kluiber, V. Janovec and Z. Zikmund, “Structure of Ferroelastic Domain Walls and Antiphase Boundaries in Crystals of β -K₂SO₄”. XV-Czech-Polish seminar: “Structural and Ferroelectric Phase Transitions”, 2002.

Optimizations of Multipath Routing:

10. **M. Suchara**, D. Xu, R. Doverspike, D. Johnson and J. Rexford, “Network Architecture for Joint Failure Recovery and Traffic Engineering”. In Proceedings of ACM SIGMETRICS, 2011. **Paper won the Best Student Paper Award.**
11. W. Fisher, **M. Suchara** and J. Rexford, “Greening Backbone Networks: Reducing Energy Consumption by Shutting Off Cables in Bundled Links”. In ACM SIGCOMM Workshop on Green Networking, 2010.
12. J. He, **M. Suchara**, M. Bresler, J. Rexford and M. Chiang, “Rethinking Traffic Management: From Multiple Decompositions to a Practical Protocol”. In Proceedings of CoNEXT, 2007.
13. U. Javed, **M. Suchara**, J. He and J. Rexford, “Multipath Protocol for Delay-Sensitive Traffic”. Invited paper in COMSNETS, 2009.

Routing Safety, Security and Reliability:

14. **M. Suchara**, A. Fabrikant and J. Rexford, “BGP Safety with Spurious Updates”. In Proceedings of IEEE INFOCOM, 2011. Longer version also available as Technical Report TR-881-10, Dept. of Computer Science, Princeton University, July 2010.
15. I. Avramopoulos and **M. Suchara**, “Protecting DNS from Routing Attacks: A Comparison of Two Alternative Anycast Implementations”. In IEEE Security & Privacy, Issue on Securing the Domain Name System, September/October 2009.
16. I. Avramopoulos, **M. Suchara** and J. Rexford, “How Small Groups Can Secure Interdomain Routing”. Technical Report TR-808-07, Dept. of Computer Science, Princeton University, December 2007.
17. **M. Suchara**, I. Avramopoulos and J. Rexford, “Securing BGP Incrementally”. In CoNEXT Student Workshop, 2007.

Congestion Control:

18. **M. Suchara**, L. Andrew, R. Witt, K. Jacobsson, B. Wydrowski and S. Low, “Implementation of Provably Stable MaxNet”. In Proceedings of BROADNETS, 2008.
19. B. Wydrowski, S. Hegde, **M. Suchara**, R. Witt and S. Low, “Grid networks and TCP services, protocols, and technologies”. In Grid Networks: Enabling Grids with Advanced Communication Technology, F. Travostino, J. Mambretti, G. Karmous-Edwards (Eds.), John Wiley & Sons, Ltd., 2006, ISBN: 0-470-01748-1.
20. **M. Suchara**, R. Witt and B. Wydrowski, “TCP MaxNet – An Implementation and Experiments on the WAN in Lab”. In Proceedings of IEEE International Conference on Networks, 2005.

SELECTED TALKS

- **Efficient Fault-Tolerant Quantum Computing**
Fishbowl Seminar at Texas A&M University (02/2017), QES Seminar, Princeton University (11/2016), IQC at the University of Waterloo (10/2016), CE Colloquium at TU Delft, Netherlands (09/2015)
- **Qubit Leakage Suppression in the Toric Code**
APS March Meeting, San Antonio, TX (03/2015)
- **Baseline Resource Estimates for IARPA's Quantum Computer Science Program**
IEEE ICCD, Asheville, NC (10/2013), Microsoft Research, Redmond, WA (08/2012), IARPA QCS PI Meeting, Princeton, NJ (07/2012), IARPA QCS Workshop, Minneapolis, MN (05/2012), IARPA QCS Technical Exchange Meeting, El Segundo, CA (01/2012)
- **Fast Parallel Decoder for Topological Error-Correcting Codes**
IBM T. J. Watson Research Center (05/2012)
- **Constructions and Noise Threshold of Topological Subsystem Quantum Error-Correcting Codes**
IQC at the University of Waterloo (02/2011), NEC Laboratories of America, Princeton, NJ (02/2011), UC Berkeley (12/2010), IQI at Caltech (12/2010), IBM T. J. Watson Research Center (08/2010)
- **BGP Safety with Spurious Updates: The Conditions of BGP Convergence**
IEEE INFOCOM, Shanghai, China (04/2011), Harvard University (01/2011), Stanford University (01/2011), Yale University (10/2010), Columbia University (05/2010)
- **Simple Failure Resilient Load Balancing**
ACM SIGMETRICS, San Jose, CA (06/2011), AT&T Labs Research, Florham Park, NJ (09/2008)
- **Greening Backbone Networks: Reducing Energy Consumption**
ACM SIGCOMM Workshop on Green Networking, New Delhi, India (09/2010)
- **Rethinking Internet Traffic Management: From Multiple Decompositions to a Practical Protocol**
Cambridge University (09/2008), Stanford University (04/2008), UC Berkeley (04/2008)
- **How Small Groups can Secure Interdomain Routing**
Princeton University (01/2008), CoNEXT Student Workshop, New York, NY (12/2007)
- **TCP MaxNet: Implementation and Experiments on the WAN in Lab**
BROADNETS 2008, London, UK (09/2008), IEEE ICON, Kuala Lumpur, Malaysia (11/2005), Stanford University (08/2005)

TEACHING ASSISTANTSHIPS

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| COS226 – Algorithms and Data Structures, Princeton | <i>Spring 2009</i> |
| COS424 – Interacting with Data – Machine Learning, Princeton | <i>Spring 2008</i> |
| COS126 – General Computer Science, Princeton | <i>Fall 2007</i> |
| CS21 – Decidability and Tractability, Caltech | <i>Winter 2006</i> <i>Winter 2005</i> |
| CS38 – Introduction to Algorithms, Caltech | <i>Spring 2005</i> |

HONORS AND AWARDS

- Best Student Paper Award at ACM Sigmetrics, 2011.
- Gordon Wu Fellowship, awarded to 15 students in the School of Engineering at Princeton, 2006-2010.
- Upper Class Merit Award for academic achievement and research, Caltech, 2005-2006.
- Patricia B. Conklin Scholarship for academic achievement, Caltech, 2004-2005 and 2005-2006.
- Marcella and Joel Bonsall Technical Writing Prize, 2005.
- Arthur Rock SURF Fellowship, undergraduate research award, 2005.
- Fulbright Travel Grant to U.S.A., 2003.
- Bronze Medal, 15th International Young Physicists' Tournament, 2002.
- Various travel grants (Travel Grant for Scholarly Travel, IEEE Infocom Travel Grant, ACM Sigcomm Travel Grant, etc.)

PATENTS

- 8,422,379 – “Method of Simple and Efficient Failure Resilient Load Balancing”

PROFESSIONAL ACTIVITIES

- Program Committee Member
 - International Conference on Systems and Networks Communications (ICSNC 2011)
- External Reviewer
 - Physical Review Letters
 - Physical Review A
 - Communications of the ACM
 - IEEE Transactions on Very Large Scale Integration Systems
 - IEEE Transactions on Parallel and Distributed Systems
 - IEEE/ACM Transactions on Networking
 - ACM SIGCOMM CCR
 - Optimization and Engineering, Springer
 - Software: Practice and Experience, Wiley
 - Computer Communications, Elsevier
 - Computer Networks, Elsevier
 - Journal of Computer Networks and Communications, Hindawi
 - IEEE/ACM ISCA 2013
 - ACM SIGCOMM 2011
 - NSDI 2011, 2010, 2009
 - IEEE ICFIN 2009
 - International Conference on High Performance Scientific Computing

TECHNICAL SKILLS

- Quantum computing: design and analysis of quantum error-correcting codes, fault-tolerant quantum computing with topological and concatenated codes, quantum communication protocols
- Simulation and optimization: Matlab, Octave, AMPL, MOSEK
- Programming and scripting: C, C++, Python, Linux shell scripting
- Network protocol analysis and redesign: TCP, BGP, MPLS, etc.

REFERENCES

**Professor John Kubiawicz
(Postdoc Advisor)**

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