

Christopher A. Wood

Permanent Address

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RESEARCH INTERESTS

Computer and network security and privacy, network architectures and protocols, cryptographic algorithms and engineering, and software engineering.

EDUCATION

Doctor of Philosophy, Computer Science

University of California Irvine, Irvine, CA

2013 - 2017

Thesis: Security and Privacy Challenges in Content-Centric Networks

Advisor: Dr. Gene Tsudik

Master of Science, Computer Science

Rochester Institute of Technology, Rochester, NY

2012 - 2013

Thesis: Large Substitution Boxes with Efficient Combinational Implementations

Advisor: Dr. Stanisław Radziszowski

Bachelor of Science, Computer Science and Software Engineering

Rochester Institute of Technology, Rochester, NY

2008 - 2012

Concentrations: Computational Mathematics and Computer Engineering

Minor: Mathematics

PUBLICATIONS

Conference Proceedings

- C-1. I. Oliviera-Nunes, G. Tsudik, and C. A. Wood, "Namespace Tunnels in Content-Centric Networks," *42nd Annual IEEE Conference on Local Computer Networks (LCN 2017)*, October 9 - 12, 2017, Singapore.
- C-2. C. Ghali, G. Tsudik, and C. A. Wood, "Mitigating On-Path Adversaries in Content-Centric Networks," *42nd Annual IEEE Conference on Local Computer Networks (LCN 2017)*, October 9 - 12, 2017, Singapore.
- C-3. C. Ghali, G. Tsudik, and C. A. Wood, "When Encryption is Not Enough: Privacy Attacks in Content-Centric Networking," to appear in the *4th ACM Conference on Information-Centric Networking (ICN 2017)*, September 26 - 28, 2017, Berlin, Germany.
- C-4. C. Ghali, G. Tsudik, E. Uzun, and C. A. Wood, "Closing the Floodgate with Stateless Content-Centric Networking," to appear in the *26th International Conference on Computer Communication and Networks (ICCCN 2017)*, July 31 - August 3, 2017, Vancouver, Canada. **(Best paper award)**
- C-5. C. A. Wood, "Protecting the Long Tail: Transparent Packet Security in Content-Centric Networks," *IFIP Networking 2017*, June 12-16, 2017, Stockholm, Sweden.
- C-6. M. Mosko, E. Uzun, and C. A. Wood, "Mobile Sessions in Content-Centric Networks," *IFIP Networking 2017*, June 12-16, 2017, Stockholm, Sweden.
- C-7. M. Mosko, C. A. Wood, "Secure Off-Path Replication in Content-Centric Networks," *IEEE ICC 2017 Next Generation Networking and Internet Symposium (NGNI 2017)*, May 21-25, 2017, Paris, France.

- C-8. C. Ghali, G. Tsudik, C. A. Wood, “(The Futility of) Data Privacy in Content-Centric Networking,” *2016 Workshop on Privacy in the Electronic Society (WPES 2016)*, October 24, 2016, Vienna, Austria.
- C-9. C. Ghali, G. Tsudik, C. A. Wood, “Network Names in Content-Centric Networking,” *3rd ACM Conference on Information-Centric Networking (ICN 2016)*, Sept. 26 - 28, 2016, Kyoto, Japan.
- C-10. C. Tschudin, E. Uzun, C. A. Wood, “Trust in Information-Centric Networking: From Theory to Practice,” *Proceedings of the 25th International Conference on Computer Communication and Networks (ICCCN 2016)*, August 1 - 4, 2016, Waikoloa, Hawaii, USA.
- C-11. C. Ghali, G. Tsudik, C. A. Wood, “BEAD: Best Effort Autonomous Deletion in Content-Centric Networking,” *FIP Networking 2016*, May 17 - 19, 2016, Vienna, Austria.
- C-12. C. Ghali, G. Tsudik, C. A. Wood, E. Yeh, “Practical Accounting in Content-Centric Networking,” *NOMS 2016, IEEE/IFIP Network Operations and Management Symposium*, April 25 - 29, 2016, Istanbul, Turkey.
- C-13. G. Tsudik, E. Uzun, and C. A. Wood, “AC3N: An API and Service for Anonymous Communication in Content-Centric Networking,” *Proceedings of CCNC 2016*, Las Vegas, NV, USA. January 2016.
- C-14. C. A. Wood, S. P. Radziszowski, and M. Lukowiak, “Constructing Large S-boxes with Area Minimized Implementations,” *Proceedings of MILCOM’2015*, Tampa, FL, USA. October 2015.
- C-15. M. Mosko and C. A. Wood, “Secure Fragmentation for Content-Centric Networking,” *IEEE MASS 2015 Workshop on Content-Centric Networking (CCN 2015)*, Dallas, TX, USA. October 2015.
- C-16. C. Ghali, M. A. Schlosberg, G. Tsudik, and C. A. Wood, “Interest-Based Access Control for Information Centric Networks,” *Proceedings of ICN 2015, the 2nd ACM Conference on Information Centric Networking*, San Francisco, CA, USA. September 2015.
- C-17. C. Ghali, A. Narayanan, D. Oran, G. Tsudik, and C. A. Wood, “Secure Fragmentation for Content-Centric Networks,” *NCA 2015, the 14th IEEE International Symposium on Network Computing and Applications*, Cambridge, MA, USA. September 2015. **(Best paper award)**
- C-18. J. Kurihara, C. A. Wood, and E. Uzun, “An Encryption-Based Access Control Framework for Content-Centric Networking,” *IFIP Networking 2015*, Toulouse, France. May 2015.
- C-19. S. Skalicky, S. Lopez, M. Lukowiak, and C. A. Wood, “Mission Control: A Performance Metric and Analysis of Control Logic for Pipelined Architectures on FPGAs,” in *Proceedings of the 2014 International Conference on Reconfigurable Computing and FPGAs - ReConFig 2014*, Cancun, Mexico. December 2014.
- C-20. C. A. Wood and E. Uzun, “Flexible End-to-End Content Security in CCN,” *IEEE Consumer Communications and Networking Conference (CCNC 2014) Special Session: Information Centric Networking*, Las Vegas, Nevada. January 2014.
- C-21. S. Skalicky, C. A. Wood, M. Lukowiak, and M. Ryan, “High Level Synthesis: Where Are We? A Case Study on Matrix Multiplication,” *Proceedings of the 2013 International Conference on Reconfigurable Computing and FPGAs - ReConFig 2013*, Cancun, Mexico. December 2013.
- C-22. M. Lukowiak, A. Meneely, S. Radziszowski, J. Vallino, and C. Wood, “Developing an Applied, Security-Oriented Computing Curriculum,” *Proceedings of the ASEE 2012*, San Antonio, Texas. June 2012.
- C-23. C. A. Wood, “Chaos-Based Symmetric Key Cryptosystems,” *Proceedings of the 2011 International Conference on Security & Management*, Las Vegas, Nevada. July 2011.
- C-24. C. A. Wood and R. K. Raj, “Keyloggers in Cybersecurity Education,” *Proceedings of the 2010 International Conference on Security & Management*, Las Vegas, Nevada. July 2010.

Journal Articles

- J-1. G. Acs, M. Conti, P. Gasti, C. Ghali, G. Tsudik, and C. A. Wood, "Privacy-Aware Caching in Information-Centric Networking," *IEEE Transactions on Dependable and Secure Computing*.
- J-2. E. Ngai, B. Ohlman, G. Tsudik, E. Uzun, M. Wahlisch, C. A. Wood, "Can We Make a Cake and Eat It Too? A Discussion of ICN Security and Privacy," *ACM SIGCOMM Computer Communication Review*, Volume 47 Issue 1, January 2017, Pages 49-54.
- J-3. P. Bajorski, A. Kaminsky, M. Kurdziel, M. Lukowiak, S. Radziszowski, and C. Wood, "Stochastic Analysis and Modeling of a Tree-Based Group Key Distribution Method in Tactical Wireless Networks," *Journal of Telecommunications System & Management, Engineering Journals, OMICS Publishing Group*.
- J-4. C. A. Wood and J. Jacob, "Characterization of Small Trees Based on their L(2,1)-Span," *AKCE International Journal of Graphs and Combinatorics*, Volume 12, Issue 1, July 2015, Pages 2631.
- J-5. M. Lukowiak, S. Radziszowski, J. Vallino, C. Wood, "Cybersecurity Education: Bridging the Gap between Hardware and Software Domains," *ACM Transactions on Computing Education*, 14(1) (2014).

Internet Drafts and RFCs

- D-1. B. Trammell, C. Perkins, M. Kuehlewind, T. Pauly, C. A. Wood, "Post Sockets, An Abstract Programming Interface for the Transport Layer," Internet Draft, October, 2017.
- D-2. M. Kuehlewind, T. Pauly, C. A. Wood, "Separating Crypto Negotiation and Communication," Internet Draft, October, 2017.
- D-3. T. Pauly and C. A. Wood, "A Survey of Transport Security Protocols," Internet Draft, July, 2017.
- D-4. M. Mosko, I. Solis, and C. A. Wood, "CCNx Semantics," Internet Draft, October, 2017.
- D-5. M. Mosko, I. Solis, and C. A. Wood, "CCNx Messages in TLV Format," Internet Draft, October, 2017.
- D-6. B. Wissingh, C. A. Wood, A. Afanasyev, L. Zhang, D. Oran, C. Tschudin, "Information-Centric Networking (ICN): CCN and NDN Terminology," Internet Draft, September, 2017.
- D-7. M. Mosko and C. A. Wood, "The CCNx URI Scheme," Internet Draft, October, 2016.
- D-8. M. Mosko, E. Uzun, and C. A. Wood, "CCNx Key Exchange Protocol Version 1.0," Internet Draft, July, 2017.
- D-9. M. Mosko and C. A. Wood, "Encrypted Sessions In CCNx (ESIC)," Internet Draft, September, 2017.
- D-10. C. Tschudin and C. A. Wood, "File-Like ICN Collection (FLIC)," Internet Draft, June, 2017.
- D-11. C. A. Wood, "Content-Locked Encryption and Authentication of Nameless Objects," Internet Draft, September, 2017.

Posters

- P-1. C. A. Wood and G. Scott, "A Network-Agnostic Data Framework and API for CCN," ICN 2015, the 2nd ACM Conference on Information Centric Networking, September 30 - October 2, 2015, San Francisco, CA, USA.
- P-2. M. Mosko, G. Scott, I. Solis, and C. A. Wood, "Secure Prefix Registration in CCN," ICN 2015, the 2nd ACM Conference on Information Centric Networking, September 30 - October 2, 2015, San Francisco, CA, USA.

Technical Reports

- TR-1. M. Mosko, I. Solis, and C. A. Wood, "Content-Centric Networking - Architectural Overview and Protocol Description," June 22, 2017. Available online at <https://arxiv.org/abs/1706.07165>.
- TR-2. E. Ngai, B. Ohlman, G. Tsudik, E. Uzun, and C. A. Wood, "Information-centric Networking and Security (Dagstuhl Seminar 16251)," Dagstuhl Reports. Vol. 6. No. 6. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik (2016). Available online at http://drops.dagstuhl.de/opus/volltexte/2016/6727/pdf/dagrep_v006_i006_p049_s16251.pdf.
- TR-3. C. Ghali, G. Tsudik, E. Uzun, C. A. Wood, "Living in a PIT-less World: A Case Against Stateful Forwarding in Content-Centric Networking," December 24, 2015. Available online at <https://arxiv.org/abs/1512.07755>.
- TR-4. C. Ghali, G. Tsudik, C. A. Wood, E. Yeh, "Practical Accounting in Content-Centric Networking (extended version)," October 7, 2015. Available online at <https://arxiv.org/abs/1510.01852>.
- TR-5. C. Ghali, M. A. Schlosberg, G. Tsudik, C. A. Wood, "Interest-Based Access Control for Content Centric Networks (extended version)," May 23, 2015. Available online at <https://arxiv.org/abs/1505.06258>.
- TR-6. G. Scott and C. A. Wood, "Network-Agnostic Systems in a Networked World," August 1, 2014. Available online at https://www.christopher-wood.com/docs/reports/icn_layers15.pdf.
- TR-7. C. Ghali, A. Narayanan, D. Oran, G. Tsudik, C. A. Wood, "Secure Fragmentation for Content-Centric Networks (extended version)," May 12, 2014. Available online at <https://arxiv.org/abs/1405.2861>.
- TR-8. G. Tsudik, E. Uzun, and C. A. Wood, "AC3N - An API and Service for Anonymous Communication in Content-Centric Networking," May 1, 2014. Available online at <https://www.christopher-wood.com/docs/reports/ac3n14.pdf>.
- TR-9. G. Scott and C. A. Wood, "Application-Layer Gateway for IP and Content Centric Network Interoperability," January 1, 2014. Available online at <https://www.christopher-wood.com/docs/reports/ccnsink14.pdf>.

TALKS AND PRESENTATIONS

- T-1. "Separating Crypto Negotiation and Communication," presentation, IETF OPSEC Meeting, Singapore. November 13, 2017.
- T-2. "CCNx Specification Updates," presentation, IRTF ICNRG Meeting, Singapore. November 12, 2017.
- T-3. "CCNx FLIC Updates," presentation, IRTF ICNRG Meeting, Singapore. November 12, 2017.
- T-4. "Transport Security and Crypto Separation," presentation, IETF TAPS WG, Prague, Czech Republic. July 18, 2017.
- T-5. "Adoption Challenges and Prospects of Information-Centric Fog Computing," discussion panelist, Workshop on Information-Centric Fog Computing (ICFC) at IFIP Networking 2017, Stockholm, Sweden, June 12, 2017.
- T-6. "Your Apps and Evolving Network Security Standards," presentation, WWDC 2017, June 6, 2017.
- T-7. "Security and Privacy Analysis of NSF Future Internet Architectures," presentation, ICNRG Interim Meeting, Chicago, USA. March 26, 2017.
- T-8. "Content-Centric Networking: Overview, Open Problems, Closed Future?," presentation, Gene Tsudik's Network and Distributed Systems Security course, UCI, February 21, 2017.
- T-9. "A Study of Privacy and Anonymity in the DNS," presentation, DNS OARC 25, Dallas, TX, USA, October 15, 2016.
- T-10. "Access Control in Information-Centric Networks," presentation, Invited Talk at SRI, Menlo Park, CA, USA, August 17, 2016.

- T-11. “File-Like ICN Collection (FLIC),” presentation, ICNRG Meeting, Berlin, Germany, July 21, 2016.
- T-12. “CCNx Testrig,” presentation, ICNRG Interim Meeting, Berlin, Germany, July 17, 2016.
- T-13. “Secure Transport Offload with Encrypted PEPs,” presentation, ICNRG Interim Meeting, Berlin, Germany, July 17, 2016.
- T-14. “Group Key Encryption,” presentation, ICNRG Interim Meeting, Berlin, Germany, July 17, 2016.
- T-15. “CDN Architecture Pain Points and ICN Cures?,” presentation, ICNRG Interim Meeting, Berlin, Germany, July 17, 2016.
- T-16. “Let’s Check Let’s Encrypt: A Tool for Code-Driven Threat Modeling,” presentation, BSidesROC, Rochester, NY, USA. April 23, 2016.
- T-17. “Session-Based Content Distribution with CCNx-KE,” presentation, ICNRG Interim Meeting, Buenos Aires, Argentina. April 3, 2016.
- T-18. “CCNx-KE vs (D)TLS,” presentation, ICNRG Interim Meeting, Buenos Aires, Argentina. April 3, 2016.
- T-19. “Private Communication in ICN,” presentation, ICNRG Interim Meeting, Buenos Aires, Argentina. April 3, 2016.
- T-20. “TLV Encryption and Packet Encapsulation,” presentation, ICNRG Interim Meeting, Paris, France. January 15, 2016.
- T-21. “CCNx Key Exchange - Updates,” presentation, ICNRG Interim Meeting, Paris, France. January 15, 2016.
- T-22. “FLIC Manifests,” presentation, ICNRG Interim Meeting, Paris, France. January 14, 2016.
- T-23. “CCNx Key Exchange,” presentation, IETF 94 ICNRG Meeting, Yokohama, Japan. November 4, 2015.
- T-24. “Static Manifest Requirements,” presentation, IETF 94 ICNRG Meeting, Yokohama, Japan. November 4, 2015.
- T-25. “CCNx over UDP,” presentation, IETF ICNRG Interim Meeting, San Francisco, CA. October 3, 2015.
- T-26. “Manifests,” presentation, IETF ICNRG Interim Meeting, San Francisco, CA. October 3, 2015.
- T-27. “Efficient Security Bindings for Information Centric Networks,” *CCNxCon 2015, Palo Alto Research Center, Palo Alto, CA*. May 20, 2015.
- T-28. “Handling Trust Enforcement,” presentation, *CCNxCon 2015, Palo Alto Research Center, Palo Alto, CA*. May 20, 2015.
- T-29. “Digital Signatures and Implicit Certificates,” guest lecture for Dr. Stanislaw Radziszowski’s (CS@RIT), Crypto II course, May 5, 2015.
- T-30. “On the $L(2, 1)$ Labeling of Trees,” with Jobby Jacob (presenter), *Joint Mathematics Meetings*, Baltimore, MD. January 15-18, 2014.
- T-31. “Secure Content Dissemination in Content Centric Networking,” *CCNxCon 2013, Palo Alto Research Center, Palo Alto, CA*. September 5, 2013.
- T-32. “Cryptographic S-boxes,” guest lecture for Dr. Stanislaw Radziszowski’s (CS@RIT) Crypto II course, April 8, 2013.
- T-33. “Characterization Results for the $L(2,1)$ -Labeling Problem on Trees,” *AMS Sectional Meeting, RIT, Rochester, NY*. September 22, 2012.
- T-34. “Chaos-Based Symmetric Key Cryptosystems,” *RIT Graduate Research Symposium, RIT, Rochester, NY*. July 22, 2011.
- T-35. “Layered Driver Rootkit Detection on Microsoft Windows PCs,” *RIT Undergraduate Research Symposium, RIT, Rochester, NY*. August 24, 2009.

PATENTS

- F-1. I. Solis, G. Scott, C. Wood, “Content Negotiation in CCN,” filed.
- F-2. G. Scott, C. Wood, “Transport Stack Name Scheme and Identity Management,” filed.
- F-3. G. Scott, C. Wood, “Flexible Command and Control In CCN,” filed.
- F-4. J. Kurihara, E. Uzun, C. Wood, “Access Control Framework for Content Centric Networking,” filed.
- F-5. M. Mosko, E. Uzun, C. Wood, “Trust Enforcement Framework for Content Centric Networking,” filed.
- F-6. M. Mosko, I. Solis, G. Scott, C. Wood, “Order Encoded Manifests,” filed.
- F-7. P. Bajorski, A. Kaminsky, M. Kurdziel, M. Lukowiak, S. P. Radziszowski, and C. Wood, “Electronic Key Management Using PKI to Support Group Key Establishment in the Tactical Environment,” U.S. Patent Number 8,873,759. October 28, 2014.

PROFESSIONAL EXPERIENCE

Apple, Inc. October 2016 - present
Cupertino, CA Secure Transports Engineer
– Work on securing data in transit.

Palo Alto Research Center September 2014 - October 2016
Computer Science Laboratory, Palo Alto, CA Software Engineer and Researcher
– Developed the CCNx 1.0 network stack, security libraries, APIs, and applications.
– Led CCNx technical meetings and drove IRTF RFC drafts for the ICNRG.
– Contributed to the PARC CCN patent portfolio.
– Implemented internal code measurement tools for quantifiable software quality improvements.

Palo Alto Research Center June 2014 - September 2014
Computer Science Laboratory, Palo Alto, CA Security and Privacy Research Intern
– Designed manifests and a manifest-based access control framework for CCNx.
– Implemented encryption-based access control modules based on Broadcast Encryption and Proxy Re-Encryption for CCNx.
– Designed and implemented trust enforcement mechanics in the transport stack for CCNx.

Cigital, Inc. March 2014 - July 2014
Dulles, MD Security Consultant Contractor
– Contributed to security-oriented C/C++ source code review and architectural analyses.

Palo Alto Research Center July 2013 - September 2013
Computer Science Laboratory, Palo Alto, CA Security and Privacy Research Intern
– Researched security and privacy aspects related to content-centric network (CCN).
– Implemented the Green-Ateniese (pairing-based) and Chow-Weng-Yang-Deng (Schnorr- and ElGamal-based) Proxy Re-Encryption schemes in Java for use in a CCNx application.
– Studied and tested various techniques for securing content.
– Experimented with techniques for improving name privacy in CCN.

Intel Corporation June 2012 - August 2012
Virtual & Parallel Computing Group, Folsom, CA Graphics Software Engineer Intern
– Developed production features for tool that processes hardware specifications to generate web content and source code for VHDL and C/C++ testbeds.
– Interacted with internal customers within the VPG to utilize debug tools and environments for architecture specification and post-silicon testing.

L-3 Communications

Victor, NY

March 2011 - August 2011

Software Engineer Intern

- Designed and implemented a library and supporting drivers for the μ -blox NEO5/6 GPS receiver driven by an Analog Devices Blackfin processor.
- Extended an existing FAT file system driver to add support for SD devices.
- Improved functionality of a CPLD controller for an embedded power supply.

ACADEMIC EXPERIENCE

Advanced Cryptography

May 5, 2015

Guest Lecturer for Dr. Stanisław Radziszowski (CS)

(RIT)

- Lectured about digital signature algorithms, ElGamal and ECDSA batch verification techniques, standard public key infrastructures, and the OMC and ECQV implicit certificate schemes.

Cryptography II

April 8, 2013

Guest Lecturer for Dr. Stanisław Radziszowski (CS)

(RIT)

- Lectured about recent research on the security and (hardware) implementation efficiency of cryptographic S-boxes.

Hardware and Software Design with Cryptographic Applications

February 2011 - May 2013

Teaching Assistant and Lecturer for Dr. Marcin Lukowiak (CE)

(RIT)

- Developed and delivered lecture material on cryptography, embedded software optimization techniques, the Impulse C high-level synthesis tool, and AES cache timing attacks.
- Assisted students with weekly assignments and graded lab and project deliverables.

Computer Science I, II, and IV

January 2009 - May 2013

Student Lab Assistant and Grader

(RIT)

- Proctored problem solving sessions and ran lab meetings with lectures of weekly material.
- Graded weekly lab assignments and midterm examinations.

Personal Software Engineering

December 2011 - March 2012

Teaching Assistant for Professor Tom Reichlmayr (SE)

(RIT)

- Assisted students with in-class programming assignments and course projects.
- Graded projects written in C/C++ and Ruby (with Ruby on Rails).

Engineering of Software Subsystems

September 2011 - December 2011

Teaching Assistant for Dr. James Vallino (SE)

(RIT)

- Assisted students with in-class exercises and unit questions based on a subset of the design patterns taught during the course.
- Spent time with each student team to discuss course projects, including design decisions, application of design patterns, and alternatives considered.

MEMBERSHIPS

IEEE, Student Member
ACM, Student Member
SIAM, Student Member
IACR, Student Member
Internet Society, Member
Tau Beta Pi, Member

HONORS AND ACTIVITIES

- NSF GRFP fellowship recipient, 2014
- RIT Honors Program, 2009 – 2013
- RIT Tau Beta Pi Engineering Honors Society, 2011 – 2013
- RIT Outstanding Undergraduate Student award, selected, Winter 2012
- RIT Computer Science MS Student Delegate, selected, Winter 2012
- Recipient of Golisano College Honors research assistantship stipend, Winter 2009/2010
- Recipient of Golisano College Honors research assistantship stipend, Spring 2011
- Recipient of RIT undergraduate research award stipend, Summer 2009
- RIT Golisano College Dean's List, 2008 – 2013