Matthew Cole

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🏛 Department of Computer Science
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Curriculum Vitae

Education

May 2024 (expected)	**Ph.D. Computer Science**, State University of New York at Binghamton University, Binghamton, New York.
	Dissertation: *Enforcing Integrity Models Through Hardware-Software Cohesive Systems*
August 2018	**M.Sc. Computer Science**, State University of New York at Binghamton University, Binghamton, New York.
	Thesis: *Integrity Models*
May 2005	**B.Sc. Computer Science**, United States Naval Academy, Annapolis, Maryland.
	Graduated *With Merit*, Upsilon Pi Epsilon

Dissertation

Advisor: Aravind Prakash

Integrity models are a principled defense mechanism that express a property of well-functioning software, then enforce that property continually at runtime. Unfortunately, these integrity models are often implemented in a way that compartmentalizes hardware from software. We present work that unifies these in a single cohesive view. First, we show that existing hardware resources can be repurposed to support software-layer defenses without onerous impacts to performance. Then, we present a modified LLVM compiler toolchain used to enforce a diverse body of integrity models through code and data tagging. Next, we investigate how to optimize a label-based integrity model to minimize binary size increases while maximizing expressiveness of the integrity model. Finally, we propose using tagging to enforce a read- and write-limited data model, thus bringing forward compile-time data type qualifiers as run-time assurances.

Experience

Research Experience

2018-2022	**Research Assistant** Research Foundation for the State University of New York. Binghamton, New York

➤ Repurposed Intel Memory Protection Extensions for generalized storage, and implemented analyses for the LLVM compiler toolchain to replace memory accesses with these inlined register operations.

➤ Engineered an implementation of the RISC-V architecture employing inline code for integrity models from compiler-driven static program analysis techniques, using the LLVM compiler toolchain.

➤ Extended our implementation of the RISC-V architecture and LLVM compiler toolchain to perform out-of-band data tagging, with the ability to perform relaxation and linkage resolution at link-time using a modified version of the LLD linker.

➤ Developed a prototype extending data tagging for a read- and write-limited data model that specifically enforces compile-time `const` qualifiers as run-time assurances.

Experience (continued)

2015-2016   **Graduate Assistant** Binghamton University. Binghamton, New York
- ➢ Developed a technique for extracting design patterns from C++ source code and encoding as a finite state machine with an XML machine-readable representation
- ➢ Researched scientific utilization of performance benchmark tools for the computer security domain.

Research Interests

Hardware-software cohesive design for resilient system security through compiler design, program analysis, and reverse engineering.

Teaching Experience

2022-Present   **Lecturer** Binghamton University. Binghamton, New York
- Fall 2023 – CS 580U: Programming Systems and Tools
- Fall 2022 – CS 580U: Programming Systems and Tools
- Spring 2022 – CS 458, CS 558: Introduction to Computer Security

2017-2018   **Teaching Assistant** Binghamton University. Binghamton, New York
- Spring 2023 – CS 458, CS 558: Introduction to Computer Security
- Spring 2018 – CS 480, CS 580: Special Topics: Software Security
- Fall 2017 – CS 220: Computer Systems II, Architecture and C Programming

Courses Prepared to Teach
- Systems programming in C, Rust, and Assembly Languages.
- Compilers: lexers, parsers, optimizers, and code generation.
- Computer security: authentication and cryptographic techniques, intrusion detection, access control, security policies, reverse engineering, offensive and defensive technologies in software security.
- Programming systems and tools with C, C++ or Python.

Professional Experience

2011-2014   **Instructor**, Trident Training Facility, Bangor, WA.
- ➢ Qualified as Instructor, Instructor Evaluator and Course Supervisor. Served as Navigation Department Director, managing a department of 40 instructors and 11 labs. Awarded Navy and Marine Corps Commendation Medal with Gold Star.
- ➢ Improved annual throughput in a ship piloting simulator by 18% (75 sessions) by repairing over 30 script files and qualifying two new instructors. Created an additional 32 trainer sessions per month by guiding a comprehensive lab redesign.
- ➢ Delivered lectures for 120 submarine officers annually (66% increase) and practical skills training for 23 ships, earning a "highly effective" rating by external auditors.

           Intern, United States Naval Research Laboratory, Washington, DC.
- ➢ Prototyped a Java Management Extension (JMX) for Mobile Ad Hoc Wireless Networks (MANETs) serving city-sized distributed sensor networks in real-time.

Service

Professional Service

2021	ACSAC Artifact Committee https://www.acsac.org/2021/committees/artifact/
2020	ACSAC Artifact Committee https://www.acsac.org/2020/committees/artifact/
2017	ACSAC Artifact Committee https://www.acsac.org/2017/committees/#artifact

Service (continued)

University Service

2018-2019	Binghamton University Graduate Student Organization Judicial Officer
2016-2018	Binghamton University Graduate Student Organization Senate

Skills

Languages	C, C++, Python, x86/RISC-V/ARM assembly, LLVM IR, Rust, Java
Operating Systems	Unix/Linux (Debian/Ubuntu/Solaris), MacOS
Benchmarking	SPEC CPU 2006/2017, Hayai, Google Benchmark
Testing	CUnit, Google Test, Boost.Test, Python unittest, LLVM Lit
Build/Deploy	GNU Make, CMake, Github Actions, Travis-CI, Git
Reverse Engineering	Ghidra, Hopper

Miscellaneous

Citizenship and Security Clearance

U.S. Citizen. Held SECRET (2001-2006) and TOP SECRET/SCI (2006-2014) clearances.

Links

Github Pages	https://colematt.github.io
Github	https://github.com/colematt
Google Scholar	https://scholar.google.com/citations?user=GfQ-ozgAAAAJ
OrcID	https://orcid.org/0000-0003-1743-1504
LinkedIn	https://www.linkedin.com/in/matthewcole4/
Keybase	https://keybase.io/colematthew