Nathan Sobotka

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Education

Stanford — **Stanford, CA**
PhD Student | Computer Science — *2029*

University of Pennsylvania — **Philadelphia, PA**
Master's of Science in Engineering | Computer and Information Science | GPA: 4.00/4.00 — *May 2024*
Bachelor's of Science in Engineering | Computer Science, Minor: Mathematics | GPA: 3.98/4.00 — *May 2024*

Saint Paul Academy and Summit School (SPA) — **St. Paul, MN**
ACT: 36 | National Merit Finalist | Rensselaer Medal Awardee — *June 2020*

Research and Work

Reconfigurable Dataflow Architecture Research — **Stanford, CA**
PhD | Professor Kunle Olukotun — *September 2024 – December 2024*

- Developing a hardware simulator for reconfigurable dataflow architectures, focusing on creating a dynamic memory system capable of handling dynamism commonly seen in mixture of expert models.
- Implemented and tested the system in a hardware description language (BlueSpec), compiling down from STeP.

Taint Primitive Tracking (TPT) — **Stanford, CA**
PhD Rotation | Professor Caroline Trippel — *September 2024 – December 2024*

- Optimized hardware/software co-designed Spectre defense by developing a lightweight hardware extension to efficiently and accurately track protection of data in memory. Simulated in Gem5 using the O3 CPU
- Evaluated TPT on SPEC benchmarks, reducing secure overhead in comparison to an unoptimized version of TPT, as well as comparing overheads to prior work such as Speculative Privacy Tracking.

Robust Profile Guided Runtime Prefetch Generation (RPG2) — **Philadelphia, PA**
Research Assistant | Professor Devietti — *May 2023 – August 2023*

- Achieved up to 2.15x speedup on C/C++ binaries by dynamic insertion of cache prefetch instructions followed by systematic tuning of prefetch distances, under the guidance of Professor Joe Devietti
- Evaluated RPG2 on hundreds of benchmarks, scrutinizing speedup, MPKI, IPC, and comparing with APT-GET. Advanced prior work by retaining speedup and eliminating slowdown by dynamically disabling prefetching

NASA Langley Research Center | Safety Critical Avionics Systems Branch — **Hampton, VA**
Combinatorial and Property Based Testing Intern — *May 2023 – August 2023*

- Developed a Haskell library to enhance NASA's testing technology by combining static analysis with property based testing, identifying program inputs that are unlikely to be found with random or enumeration based testing
- Implemented software to address limitations found after reviewing multiple academic papers on testing techniques in functional programming languages. This included failings of symbolic execution and randomized testing

DeepSpec NSF Expedition: The Vellvm Project — **Philadelphia, PA**
Research Assistant | Professor Zdancewic — *May 2022 – January 2023*

- Developed a Coq monad library for public use by defining equivalence for the error, option, list, set, multiset, CPS, ID, and state monad. Proved fundamental theorems true, including the monad laws, for ease of future use
- Tested VELLVM's memory model using unit tests written in LLVM and C and automated tests written in QuickChick. Proved LLVM compiler optimizations correct in Coq with Professor Zdancewic (GitHub: Vellvm)

University of Pennsylvania Computer and Information Science Department — **Philadelphia, PA**
TA (CIS-5710, CIS-2400) & Peer Tutor (MATH-3120, CIS-1600) — *Jan 2022 – May 2024*

- Taught 270 graduate students Computer Organization and Design, covering OOO multiprocessors, branch prediction, and caching, concluding by implementing a two-way five-stage superscalar pipelined processor in Verilog
- Taught 200 students computer architecture through Introduction to Computer Systems, covering transistors, basic hardware structures, an assembly language, and an introduction to C, followed by implementing a compiler
- Reinforced foundational concepts for seven students in Linear Algebra and Mathematical Foundations of CS

Publications

Architectural Support for Programming Languages and Operating Systems (ASPLOS) — *April 2024*

- Yuxuan Zhang, Nathan Sobotka, Soyoon Park, Saba Jamilan, Tanvir Khan, Baris Kasikci, Gilles A Pokam, Heiner Litz, Joseph Devietti. Robust Profile Guided Runtime Prefetch Generation. In 2024 ASPLOS.

Journal of Emerging Investigators — *January 2020*

- "The Effects of Various Plastic Pollutants on the Growth of the Wisconsin Fast Plant," *Journal of Emerging Investigators*. Research done in 2017-2018
- Presented the paper and findings at the Minnesota State Science and Engineering Fair, ending in the top 10 percent of projects, and winning the Seagate Emerging Scientist Award

Community & Leadership

Balloon Team Software Lead | *Aerospace Club* *September 2020 – Present*

- Gather high altitude data using hand-built apps and payload. Currently planning a transatlantic launch
- Led seven person software team in data collection and web dev using MERN for live balloon tracking at 70k feet

Tennis | *Penn Club Tennis (PCT)* | *Fred Wells Tennis and Education Center (FWTEC)* | *SPA August 2016 – Present*

- Treasurer for PCT, managing the budget for a 120 person club engaged in local events and national tournaments
- Community Service Lead for PCT, organizing free tennis lessons for children in Philadelphia
- Mentored and coached through TennisWorks at FWTEC, a program providing children free access to tennis
- Placed 5th in singles in Minnesota, 2nd as a team multiple times while playing one singles for SPA *May 2019*

Hospital Volunteer | *Minneapolis Veterans Affairs Medical Center* *June 2018 – August 2018*

- Shadowed cardiologists as they communicated with patients and families and performed surgeries
- Aided patients and families in any way they needed, including but not limited to transportation and providing necessary resources for their physical and mental well-being throughout their stay

Projects

Search Engine | *Java* *March 2023 – May 2023*

CIS-5550: Internet and Web Systems Project

- Employed Amazon AWS to host a highly distributed search engine with over 125-thousand results, utilizing a hand-built crawler to find pages, an indexer to compute pagerank / tf / idf values, and a frontend to display findings
- Implemented entire backend, including a webserver, KVS, and version of Apache Spark to maximize parallelizability

Operating System | *C* *October 2022 – December 2022*

CIS-3800: Operating Systems Project

- Developed a UNIX-like operating system, complete with three level priority scheduling and a FAT file system
- Simulated using user threads to emulate OS context switches, along with a custom shell to interact with the OS
- Tested using a logging system to verify features like background processes, blocking, waiting, and CPU utilization

Superscalar Pipelined Processor | *System Verilog* *Jan 2022 – May 2022*

CIS-5710: Computer Organization and Design Project

- Implemented a RISC-V (5 stage, supserscalar) processor in System Verilog, then programmed it onto an FPGA
- Developed knowledge regarding branch prediction, caching, out of order, and multi-core processors

Minecraft | *C++* *March 2023 – May 2023*

CIS-4600: Interactive Computer Graphics Project

- Rendered a version of Minecraft with realistic player physics and block interactions such as placement and deletion
- Developed aesthetic features such as shadow mapping, block animation, and Turing-complete redstone
- Included multithreading and efficient random infinite terrain generation to make gameplay enjoyable and realistic

Technical Skills & Interests

Computer	C, C++, Python, Java, Coq, Haskell, Verilog, OCaml, SQL (mySQL, Oracle), MongoDB, OpenGL
Interests	Silicon Engineering, CPU and GPU Engineering, Functional Programming, Computer Systems
Coursework	Computer Architecture, Operating Systems, Data Structures, Algorithms, Computability & Complexity, AI, Web Systems, Graphics, Probability & Statistics, ODEs & PDEs, and Linear Algebra
Languages	English (fluent), German (intermediate)