DECLARATION OF DR. PAULO SHAKARIAN

I, Paulo Shakarian, hereby declare under penalty of perjury that the facts set forth herein are true and correct to the best of my knowledge and belief. If called as a witness, I can testify accurately to the matters discussed in this declaration.

1. My name is Paulo Shakarian and I have prepared this declaration at the request of Skysong Innovations, LLC ("Skysong"). I am the K.G. Tan Endowed Professor of Artificial Intelligence at Syracuse University where I direct the Leibniz Lab. I am a named inventor of U.S. Patent No. 11,892,897 ("'897 Patent"). My CV is attached as Appendix A.

2. My education and experience in Artificial Intelligence and Cybersecurity trace back to my military service. I am a graduate of the United States Military Academy at West Point, where I earned a Bachelor of Science degree in Computer Science with a Depth of Study in Information Assurance, and where I was commissioned as a Military Intelligence officer. I spent most of my military career stationed overseas and in Iraq, where I served two combat tours and earned the Bronze Star, an Army Commendation Medal for valor, and a Combat Action Badge, in addition to a foreign award for valor by the Iraqi National Police. Afterwards, I was selected to serve as a Military Fellow to the Defense Advanced Research Project Agency ("DARPA"), where the DARPA Director, Dr. Anthony

Tether, awarded me a Certificate of Achievement for my work in Artificial Intelligence. The Army then sent me to the University of Maryland, where I earned Master of Science and Doctor of Philosophy degrees in Computer Science under Prof. V.S. Subramanian, who has since held endowed chairs at Dartmouth University and Northwestern University. After my graduate education, I served as an Assistant Professor of Computer Science at the United States Military Academy at West Point, where I earned my second Meritorious Service Medal and was promoted to the rank of Major. By the time I completed my active duty as an Army officer, I had also earned several additional military awards, including a Presidential Unit Citation Award, a Meritorious Unit Citation Award, a National Defense Service Medal, an Iraq Campaign Medal (two stars), and a Global War on Terrorism Expeditionary Medal and Service Medals.

3. After leaving active duty, I served as Research Director at the School of Computing and AI at Arizona State University where I was also a tenured faculty member. My academic accomplishments include four best-paper awards, over 100 peer-reviewed articles, 12 issued patents, and 8 published books. My books include *Introduction to Cyber Warfare a Multidisciplinary Approach* which is utilized as required reading in and is still frequently cited by military cyber

warfare schools across the U.S. armed forces, including the Naval Postgraduate School.[1]

4. I am also the former CEO and co-founder of Cyber Reconnaissance, Inc., a cyber security startup which raised over $8 million in venture capital, obtained 80 paying customers, and was successfully acquired in 2022.

5. During my career, I have secured over $7 million in grant funding from a wide range of government and industry sponsors that included highly competitive grants such as the AFOSR Young Investigator Award and multiple awards from DARPA, IARPA, ARPA-H, ARO, and ONR. My cyber security research work was sponsored by the Office of the Director of National Intelligence, **I**ntelligence **A**dvanced **R**esearch **P**rojects **A**ctivity (IARPA), and specifically, the **C**yber-**A**ttack **A**utomated **U**nconventional **S**ensor **E**nvironment (CAUSE) program.[2] I secured a grant of approximately $1 million for this work in the 2016–2019 time frame, for which I was the principal investigator. Closely technologically related, I was also the principal investigator for several projects sponsored by **N**aval **E**nterprise **P**artnership **T**eaming with **U**niversities for **N**ational **E**xcellence (NEPTUNE) program in the **O**ffice of **N**aval **R**esearch (ONR).[3] The relevant projects were "NEPTUNE," ONR, from 2015–2018, and "Next

[1] https://faculty.nps.edu/ncrowe/natodistinct_final.htm (current exemplary cite to my work).
[2] https://www.iarpa.gov/research-programs/cause.
[3] https://www.onr.navy.mil/organization/departments/code-33/division-333/neptune.

Generation Energy Technologies and Systems for Civilian and Military Applications," ONR, from 2016–2019. These projects heavily focus on technology that is deemed mission critical to national cyber-security efforts.

6. The '897 patent discloses assessing the likelihood of exploitation of software vulnerabilities, and in particular artificial intelligence-based systems and methods for predicting which software vulnerabilities will be exploited by malicious hackers and hence prioritized by patching. *See, e.g.*, EX1001, 1:24-28, 3:54-67.

7. In approximately late 2018 or early 2019, I attended the RSA Conference[4] in San Francisco, California, which is a prominent cybersecurity event. At the conference, I met with representatives from CrowdStrike, Inc., including Dmitri Alperovich (Co-Founder and Chief Technology Officer), Justin Weissert (Director of Proactive Services), and Mike Sullivan (Vice President of Global Financial Services). During this meeting, I briefed the CrowdStrike representatives on the cybersecurity technologies, including those claimed in the '897 patent, and disclosed technical details of my research on AI-driven threat mitigation, specifically including the subject matter of what is now the '897 Patent.

[4] For RSA Conference USA 2019 *See* https://www.rsaconference.com/library/blog/welcome-to-rsa-conference-usa-2019

8. At the request of CrowdStrike, I discussed application of my inventions, including those of the ’897 patent, with Mr. Dmitri Alperovich, Mr. Justin Weissert, and Mr. Mike Sullivan. We specifically discussed the relevance of my technology to CrowdStrike’s Falcon Platform, particularly including proactive services (e.g., pre-breach vulnerability scanning) and financial services.

9. I disclosed to Mr. Dmitri Alperovich, Mr. Justin Weissert, and Mr. Mike Sullivan that these disclosures included confidential and patent pending subject matter, and I explicitly informed CrowdStrike of efforts to patent my inventions. During the meeting, I used the same slide materials that I typically employ when briefing companies, including CrowdStrike, which expressly reference the patent filings covering, and describe the technical subject matter of, my inventions. Representative examples of these slides are included in Appendix B. In those materials, I specifically referenced provisional patent application No. 62/581,123, filed November 3, 2017, which includes the inventions of and is the priority basis for the ’897 Patent, as well as international patent application PCT/US18/57812, filed October 26, 2018, claiming priority to that provisional application. Thus, CrowdStrike was aware of the inventions claimed in the ’897 Patent since at least early 2019.

10. Although I offered, CrowdStrike did not pursue licensing or collaboration discussions. CrowdStrike did not indicate at any time that it intended

to challenge the patentability of my inventions or the validity of the patents covering my inventions.

11. My research focuses on proactive cybersecurity measures, such as the ’897 patent’s early detection and mitigation algorithms. This technology is new and state-of-the-art in a field that is very rapidly evolving. Focusing time, attention, and resources on repetitive reexamination proceedings—particularly those that rehash old art and arguments that the office has previously rejected during the original prosecution of the ’897 patent—is detrimental to further important research and development efforts in this area, which, in my opinion, is of extreme importance to U.S. national security and military defense strategies. The institution of such proceedings alone, even if eventually unsuccessful, greatly deters investment in these ASU-derived critical national defense technologies.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the U.S. Code.

Date: October 8, 2025

By: Paulo Shakarian

Paulo Shakarian, Ph.D.

Dept. of Electrical Engineering and Computer Science

Syracuse University

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Paulo Shakarian is the K.G. Tan Endowed Professor of Artificial Intelligence at Syracuse University where he directs the Leibniz Lab. Shakarian has made notable contributions in the areas of logic programming, neurosymbolic AI, security, and data mining. His academic accomplishments include four best-paper awards, over 100 peer-reviewed articles, 12 issued patents, and 8 published books. Shakarian has secured over $7 million in grant funding from a wide range of government and industry sponsors that included highly competitive grants such as the AFOSR Young Investigator Award and multiple awards from DARPA, IARPA, ARO, and ONR. Paulo's work on the use of AI methods to predict software vulnerabilities was commercialized in a startup that raised over $8 million in venture capital, obtained 80 paying customers, and was acquired in 2022. Previously, Shakarian held fellowships with DARPA and the New America Foundation, a faculty position at the U.S. Military Academy (West Point), and served as Research Director at the School of Computing and AI at Arizona State University where he was also tenured faculty. Prior to his academic career, he was a field-grade officer in the U.S. Army where he served two combat tours in Iraq earning the Bronze Star and Army Commendation Medal with Valor Device. He holds a Ph.D. and M.S. in computer science from the University of Maryland (College Park) and a B.S. in computer science from the U.S. Military Academy (West Point).

Shakarian is also an educator and has taught numerous courses across all modalities (in-person, online, and hybrid) and of all sizes (from courses consisting of less than 10 students to courses with over 200 hundred). Courses taught include Introduction to AI (both undergraduate and graduate), Data Mining (graduate), Machine Learning (undergraduate), Introduction to Programming (undergraduate), and range of special topics at all levels. Shakarian serve as Course Director for undergraduate AI and Machine Learning courses at ASU where he redesigned both courses from scratch to support learning across multiple modalities, and he oversees other faculty that have adopted the course. He has personally taught over 700 undergraduate students machine learning since 2022, and both courses have maintained high ratings from students since inception. Shakarian has also made many of his lectures available along with those of his colleagues on the Neuro Symbolic Channel (YouTube) that he founded in 2022 and has over 4,400 subscribers.

Shakarian's graduate research students have gained significant attention. He has graduated six Ph.D. students, two of which now have academic positions. The others have taken positions as some of the top technology firms focused on AI, including Google DeepMind, Amazon AGI, Palantir, and Microsoft. Many of Shakarian's undergraduate researchers have achieved great success – with two undergraduates earning NSF Graduate Research Fellowships and two undergraduates who did research with Shakarian eventually taking faculty positions.

K.G. Tan Endowed Professor of Artificial Intelligence
Syracuse University

PROFESSIONAL EXPERIENCE:

2025-Present **K.G. Tan Endowed Professor of Artificial Intelligence**, Syracuse University, Syracuse NY

2025-Present **Full Professor (w. tenure)**, Syracuse University, Syracuse NY

2025-Present **Adjutant Professor**, Arizona State University, Tempe AZ

2024-2025 **Research Director**, School for Computing and Augmented Intelligence, Arizona State University, Tempe, AZ

- Also represented the School for Computing and Augmented Intelligence on the Dean's Research advisory council from 2022-2023 before the role was elevated to a director-level position.

2020-2025 **Associate Professor (w. tenure)**, Arizona State University, Tempe AZ

- Course director, CSE475 (Machine Learning) 2022-2025
- Course director, CSE471 (Artificial Intelligence) 2023-2025

2016-2022 **CEO and Co-Founder**, Cyber Reconnaissance, Inc.

- Raised $8 million in venture capital
- Obtained over 80 paying customers
- Acquired in 2022 by Cyber Security Works

2014-2020 **Assistant Professor**, Arizona State University, Tempe AZ

- Served as rotating Fulton Entrepreneurial Professor (2016-2018)
- Served as a rotating Fellow at New America Foundation (2017)
- Selected for ASU Leadership Academy (2016)

2011-2014 **Assistant Professor**, U.S. Military Academy, West Point NY

2008-2011 **Graduate Research Assistant**, University of Maryland, College Park, MD, 2008-2011

2007 **DARPA Military Fellow**, DARPA Service Chiefs' Fellows Program

2002-2014 **Commissioned Officer**, U.S. Army (with service in Germany, Iraq, Arizona, Maryland, and New York)

- Combat tour with First Infantry Division to Baghdad, Iraq (13 months), (2006-2007)
- Combat tour with First Armor Division to Baghdad, Iraq (14 months), (2003-2004)
- Anti-Terrorism Force Protection Level 2 course (2007)
- Military Intelligence Carrer and Basic courses (2002, 2008)

EDUCATION:

University of Maryland College Park, Computer Science, Ph.D., 2011
University of Maryland College Park, Computer Science, Master of Science, 2009
U.S. Military Academy, Computer Science, Bachelor of Science, 2002

PROFESSIONAL ADVISORY BOARDS:

- Advisor, Cuse AI (Syracuse student group) (2025-Present)
- Member, Arizona Technology Council Artificial Intelligence Committee (2023-2025)
- Member, Arizona Cyber Team, Emerging Technologies subgroup (2018-2021)
- Member, Arizona Technology Council Committee of Cybersecurity (2018-2021)
- Advisor, Fulton Student Veterans Organization (ASU) (2016-2021)

AWARDS AND ACCOLADES:

- Editor's Choice Article (Cover article), Big Data and Cognitive Computing (Q1 Journal), "Argumentation-based Query Answering under Uncertainty with Application to Cybersecurity," 2022.
- Best Presentation, IEEE CCWC 2020 for "Inductive and Deductive Reasoning to Assist in Cyber-Attack Prediction"
- Best Paper, IEEE ICDIS-2019 for "An End-to-End Framework to Identify Pathogenic Social Media Accounts on Twitter"
- Best Paper, IEEE ICDIS-2018 for "Mining Key-Hackers on Darkweb Forums"
- Best Paper, IEEE ASONAM-2016 (FOSINT-SI track) for "Argumentation Models for Cyber Attribution"
- One of 100 scientists selected for DARPA AI Forward 2023
- Paper "Darknet and deepnet mining for proactive cybersecurity threat intelligence" was the second most cited article of the IEEE ISI conference in its 14 year history (2023)
- Paper "A review of evolutionary graph theory with applications to game theory" was the most cited article of the Elsevier journal *BioSystems* (2017)
- MIT Technology Review "Best of 2013" (2013) for "A Scalable Heuristic for Viral Marketing Under the Tipping Model"
    - selected as one of 12 academic papers uploaded to arXiv in 2013 - selected from across all scientific disciplines
- Best paper nomination, KDD 2015 for "Early Identification of Violent Criminal Gang Members"
- Best paper nomination, ASONAM 2012 for "Large Social Networks can be Targeted for Viral Marketing with Small Seed Sets"
- AFOSR Young Investigator Award (2015)
    - One of 59 funded proposals (over 200 proposals submitted)
- Co-Principal Investigator for a DoD Minerva award (2015)
    - One of 11 teams awarded the grant (297 proposals submitted)
- Defense University Research Instrumentation Program (DURIP) award (2024 and 2016)
    - 2024: one of 112 funded proposals
    - 2016: one of 176 funded proposals (622 submitted)
- Finalist, Skysong Venture Challenge, 2023 ($25,000 investment award for company BAT, LLC)
- State of Arizona EmergeAZ grant 2021 ($50K prize for Cyber Reconnaissance, Inc.)
- Winner, Trumpf Venture Challenge, 2019 ($1M investment for Cyber Reconnaissance, Inc.)

- Finalist, CISO choice awards (2020)
- Finalist for the Arizona Technology Council's "Best Startup" award (2017)
- Finalist for PwC's Most Promising Company award (2017)
- Winner, Defense Innovation Technology Challenge (2017)
- Semi-Finalist, *Cisco Innovation Grand Challenge* (2016)
- I-Corps grant award (2016)
- Named a KDD Rising Stars by Microsoft Research Asia (2016)
- DARPA Service Chiefs' Fellowship (2007)
    - selected as one of four military officers from FORCECOM
- ASU Leadership Academy (2016)
    - Selected through a nomination process
- Winner, Lorenz e-Science 2019 (co-author with Vincent Lengkeek, Roy Lindelauf, Arnout van de Rijt, and V.S. Subrahmanian)
- Selected for Innovation Showcase at TechConnect 2016 for invention "Improved Malware Detection Technology".
- Military Awards
    - Several awards for military service not related to scientific or academic contributions including the Bronze Star (2007), the Army Commendation Medal for Valor (2007), and the Combat Action Badge (2005)
    - Meritorious Service Medal (2014)
        - awarded by West Point "For exceptionally meritorious service as an Assistant Professor in the Dept. of Electrical Engineering and Computer Science."

CURRENT GRANT AWARDS:

- Principle Investigator for Syracuse subcontract of "MINDSET: Modeling Intelligent Detection System using Expert Thoughts," ARPA-H (UPGRADE program), Phase 1 for the Syracuse subaward is $517K).
- Principle Investigator for "Reasoning about Machine Learning," ARO, $500K (single investigator), 2023-2026.
- Co-PI for CONNECT, DARPA, $180K of a $684K award, (Prime: Arizona State)2025.
- Principle Investigator for DURIP "Computational Infrastructure for DoD-Focused Metacognitive and Neurosymbolic Artificial Intelligence Research," ARO, $245K, 2025.
    - Public announcement from the DoD

PREVIOUS GRANT AWARDS:

- Large grant ($100K+) as PI:
    - Principle Investigator for MCAI (Metacognitive Composable AI), DARPA $238K, 2024-2025.
    - Principle Investigator for "Reasoning about Global Supply Networks," ONR, $559K (single investigator), 2023-2025.
    - Principle Investigator for "AI Enabled Emergency Management and Preparedness," State of Arizona, $1.7M, 2025-2028. (Led proposal team to win

award, turned over PI leadership due to departure from ASU; remained involved as a consultant/advisor)
  - Principle Investigator for "AI Pilot Assist – New Technology Exploration," Honeywell, $135K, 2025 (includes $60K in matching funds from ASU). (Led proposal team to win award, turned over PI leadership due to departure from ASU; remained involved as a consultant/advisor)
  - Principle Investigator for "Transferable Agent Learning using Neuro Symbolic Methods," MADE Science and Technology Center, co-funded by the Arizona New Economic Initiative and SSCI, $156K (2 years), 2023-2025.
  - Principle Investigator for "Seeding System1-System2 Strengthening of AI with Application to Disaster Decision Support," ASU internal funding, $150K (1 year), 2024-2025.
  - Principle Investigator (ASU team, sub to Leidos) for "Hidden ActivitY Signal and Trajectory Anomaly Characterization (HAYSTAC)," IARPA, $238K, 2023-2024.
  - Principle Investigator (of sub-prime to both USC ISI and Leidos) for IARPA CAUSE Phase II program, $472K (portion for sub), 2018-2019.
  - Principle Investigator (of sub-prime to USC ISI) for IARPA CAUSE Phase I program, $623K (portion to sub), 2016-2018.
  - Principal Investigator for "Understanding Social Influence without Markov Assumptions," ARO Single Investigator Program, $469K, 2015-2018.
  - Principal Investigator for "Reasoning about Cyber-Attribution," ONR, $400K, 2015-2018.
  - Principal Investigator for "Toward Anti-Inhibitory Influence of Online Social Networks," USAFOSR (Young Investigator Award) $354K, 2015-2018.
  - Principal Investigator for "Viral Marketing for Social Networks" USAF A2II, $100K, 2013-2014
  - Principal Investigator for "Combinatorial and Scalable Initiation in Complex Networks," ARO Single Investigator Program, project 2GDATXR042, $249K, 2012-2014.
- Large grants as Co-PI or senior personnel:
  - Co-Principal Investigator for "New Analytics for Measuring and Countering Social Influence and Persuasion of Extremist Groups" DoD (Minerva), $1.2M (total, over multiple investigators), 2015-2018.
  - Senior Personnel, "Crisis and Collective Problem-Solving on the Darkweb: Understanding Crisis Inform," ARO, $121K, 2019-2023.
  - Senior Personnel, "Next Generation Energy Technologies and Systems for Civilian and Military Applications," ONR, $260K, 2016-2019.
  - Senior Personnel "NEPTUNE," ONR, $210K, 2015-2018.
- Small Grants and Gifts:
  - Received $40K in donated EPYC processors from AMD (2025).
  - Principle Investigator for "Perceptual Introspection," Cox Communications, $50K, (1 year) 2023-2024.
  - Principle Investigator for "Workshop on Metacognitive Prediction of AI Behavior," Army Research Office, $30K (2023).

- Principle Investigator (ASU team, sub to Charles River Analytics) for "Explainable AI for Complex Decision Making for Command and Control in MDO (STTR)," Army Research Office, $73K (Phase I, ASU portion, 2023).
- Principle Investigator, State of Arizona EmergeAZ grant $50K, 2021.
- Senior Personnel, "Ideological Techniques and Operational Procedures: Analyzing the Tactics of Propaganda and Disinformation," $49K (total award $497K), DoS, 2018-2019.
- Principle Investigator for "Commercialization of Social Influence Algorithms for Information Operations", DoD @ I-Corps grant, $70K, 2016-2017.
- Principle Investigator for "High-memory workstations in support of cyber-socio research," ARO DURIP, $52K, 2016.
- Principle Investigator for "Undergraduate and High School Network Science Education," ARO, $6K, 2016.
- Principal Investigator for "Arabic-Language Extremist Darknet Study," ASU Global Security Initiative (GSI), $80K, 2016.
- Principal Investigator for "Behavioral Analysis of Hacking Groups," ASU Global Security Initiative (GSI), $74K, 2015.
- Principal Investigator, DARPA UROP program, R.0004972.001, $21K, 2013-2014
- Consultant (to the Program Manager), "Integrated Cognitive-Neuroscience Architectures for Understanding Sensemaking (ICArUS)" IARPA, 2012-2014.
- Principal Investigator for "Landowner-Red (LOR)," DoD project N4175613MP50287, $50K, 2013.
- Principal Investigator for "Searching Huge Attribute and Relational Knowledgebases (SHARK)," DoD project N4175613MP50285, $50K, 2013.
- Principal Investigator for "Allocation of Special Forces Resources in a COIN Environment," DoD project F1AF262025G001, $23K, 2012.

KEYNOTE AND PLENARY PRESENTATIONS:

2025 P. Shakarian, *Toward Hybrid AI for Bot Detection,* **Keynote** talk at *Amazon Bot Busters Summit,* Aug. 22, 2025.

2023 P. Shakarian, *The New Challenges of Artificial Intelligence*, **Keynote** talk at *Cactuscon-11*, Mesa, AZ, Jan. 27, 2023.

2020 P. Shakarian, *Getting Ahead Of Hackers: Predicting The Next Exploit And Ramifications For The Software Supply Chain,* **Keynote** talk at SIP-CPS Symposium 2020 on Cross-Ministerial Strategic Innovation Promotion Program (SIP), Japan, Nov. 2020.

2019 P. Shakarian, *Proactive Cybersecurity,* IEEE ICDIS-2019, **Keynote** speaker

2017 P. Shakarian, *Leveraging Actionable Cyber Threat Intelligence from the Darkweb using Machine Learning*, StateFarm #doITdifferently, Dec. 2017, invited **keynote**.

2016 P. Shakarian, The Cyber Battlefield: Now and the Near Future. Combatting Terrorism Technical Support Office (CTTSO) Threat Day, Washington, D.C., Jan. 2016, invited **keynote**.

2016 P. Shakarian, Reducing Risk in the Face of Adaptive Threats in Cyberspace, *IEEE ISI 2016*, ***plenary*** talk, Sep. 2016.

TUTORIALS (PEER REVIEWED):

2023 P. Shakarian, G.I. Simari, C. Baral, *B. Xi., L. Pokala*, Advances in Neuro Symbolic Reasoning, AAAI Tutorial, Washington, D.C., Feb., 2023.
2016 P. Shakarian, Diffusion in Social Networks. AAAI Tutorial, Phoenix, AZ, Feb., 2016.
2015 P. Shakarian, Diffusion in Social Networks. IJCAI Tutorial, July, 2015.

SELECTED INVITED TALKS:

2025 P. Shakarian, *Logic for Orchestration and Meta-Reasoning,* Invited talk at the Syracuse Dept. of Mechanical and Aerospace Engineering, Sep. 5, 2025.
2025 P. Shakarian, *New Directions in AI,* Invited talk at Syracuse University, Jan. 27, 2025.
2025 P. Shakarian, *Establishing Leadership in Data Science Research,* Invited talk at the University of Virginia, Jan. 23, 2025.
2024 P. Shakarian, *New Directions in Defense-Focused AI*, Invited talk at Virginia Tech, Dec. 10, 2024.
2023 Invited Panelist at *IEEE TransAI*, Sep. 25, 2023.
2023 P. Shakarian, *Learning and Reasoning: Pathways to Artificial General Intelligence*, Invited talk at Machine Learning Day, ASU West Campus, Apr. 14, 2023.
2022 P. Shakarian, *Cybersecurity Applications of Artificial Intelligence,* Simposio Argentino de Inteligencia Artificial, Argentina, Oct. 26, 2022
2022 P. Shakarian, *Generalized Annotated Logic and an Equivalent Neural Architecture*, Invited talk at Hughes Research Labs (HRL), Malibu, CA, Aug. 10, 2022.
2022 P. Shakarian, *Annotated Logic and Neuro Symbolic Reasoning*, Invited talk at BBN, Cambridge, MA, July 14, 2022.
2021 P. Shakarian, *Toward Proactive Appsec thru Machine Learning augmented CI/CD*, Invited talk at Florida Institute of Technology, Sep. 2021.
2021 P. Shakarian, *Proactive Cybersecurity: The Case for Artificial Intelligence*, Invited talk at CalPoly Pomona, July 2021.
2021 P. Shakarian, *Primer on Artificial Intelligence and Machine Learning for Cybersecurity*, Invited talk at NYU, Feb. 2021.
2019 P. Shakarian, *Proactive Cybersecurity: The Case for Artificial Intelligence*, Invited talk at NYU, Oct. 2019
2019 P. Shakarian, *Can Artificial Intelligence Replace Threat Intelligence*, panel chair, SINET, New York, NY, June 2019.
2019 P. Shakarian, *Cyber Reconnaissance,* Invited talk at DARPA, Feb. 2019.
2018 V. Paliath, P. Shakarian, *Defending Against Chained Cyber-attacks By Adversarial Agents: An Optimization Approach*, InForms, Nov. 2018.
2018 P. Shakarian, *When Patching 'Critical' Vulnerabilities Doesn't Cut It*, ISC(2) Congress, Oct. 2018.
2018 P. Shakarian, *Staying ahead of cyber attacks,* ASU KED Talk, Oct. 2018.
2018 P. Shakarian, C. DeVar, Jennifer Martin, A*voiding Cyber Attacks by Understanding Hacker Communities,* National Association of State Treasurers Annual Conference, invited panel, Sep. 2018.
2018 P. Shakarian, et al., *Cybersecurity Solutions/Trends.* Panel discussion, Arizona Tech Council 2018 Cybersecurity Summit, May 2018.

2018 P. Shakarian, et al., *The IoT, Cybersecurity, and GDPR: What's keeping CISOs up at night?* Panel discussion, RSA (sponsored by A10 networks)
2018 P. Shakarian, *Countering Cyber Threats with Machine Learning and Darkweb Threat Intelligence*, Future of Global Aerospace Market, 2018
2018 P. Shakarian, *Panel on DoD Research,* ASU Fulton Schools of Engineering, Jan. 2018.
2017 S. Geftic, R. Ayoub, P. Shakarian, Cutting Through the FUD Factor – the Reality of Machine Learning, ISC(2) ThinkTank (sponsored by Sophos), webinar, November 2017. 271 viewers. (invited panel)
2017 M. Almukaynizi, P. Shakarian, *Online Vulnerabilities and Exploits, CactusCon*, September, 2017.
2017 P. Shakarian (invited panelist for panel moderated by Rep. Tom O'Halleran), ASU Congressional Conference on Cybersecurity, August 2017.
2017 P. Shakarian, Threat Intelligence, ISC(2) Phoenix chapter meeting, August 2017.
2017 S. Merchant, P. Shakarian, Scaling Up Network Security - Shifting Control Back to the Defenders, ISC(2) ThinkTank (sponsored by Gigamon), webinar, August 2017. 285 viewers. (invited panel)
2017 R. Leong, R. Los, P. Shakarian, Machine Learning and Malware: What You Need to Know, ISC(2) ThinkTank (sponsored by McAfee), webinar, April 2017. 448 viewers. (invited panel)
2016 P. Shakarian, Scaling to the Adversary: Machine Learning Driven Mining of Threat Intel from the Darkweb, POC Security Conference, Seoul, Korea, Nov., 2016 (invited talk).
2016 P. Shakarian, Toward a Threat-Centric Paradigm, *Army Cyber Talks,* New York, NY, Sep. 2016.
2016 P. Shakarian, Data-Driven Modeling and Reasoning About Cyber Adversaries, Invited talk at Kings College, London, UK, June 2016.
2016 P. Shakarian, Influence and Inhibition in Information Cascades, *EU RISE Workshop, Prague*, Czech Republic, June 2016.
2016 P. Shakarian, Cybersecurity Initiative Business – Policy Roundtable #11: The Darkweb with New America Fellow Dr. Paulo Shakarian, *New America Foundation*, Washington D.C., June 2016.
2016 P. Shakarian, Leveraging Game Theory and Machine Learning for Proactive Cyber Threat Intelligence, *CactusCon*, May, 2016
2016 P. Shakarian, Contemporary Cyber Threat Intelligence From the Deep and Dark Web. Invited lecture to Microsoft IT Security, Apr. 2016.
2016 P. Shakarian, Pre-reconnaissance Cyber Security Understanding Cyber Threats Before They Strike. SERENE-RISC, Vancouver, Canada, Apr. 2016 (Invited lecture).
2016 P. Shakarian, Diffusion in Social Networks. *NIMBioS*, Knoxville, TN, Apr. 2016 (Invited lecture).
2015 P. Shakarian, The Cyber Battlefield: Now and the Near Future. Invited talks, ISC2, Phoenix Chapter, Phoenix, AZ, Oct. 2015
2015 P. Shakarian, New Analytics for Cyber Security. Invited Presentation for the Information Systems Security Association (ISSA) Phoenix Chapter, Tempe, Arizona, July 2015.
2015 P. Shakarian, Malware Task Identification: A Data Driven Approach. Invited Presentation to Microsoft, Redmond, Washington, June 2015.

2015 P. Shakarian, Predictive Mining in Social Systems. Invited Presentation at the University of Southern California (Information Sciences Institute), Marina Del Rey, California, June 2015.
2015 P. Shakarian, The Cyber Battlefield: Now and the Near Future. Invited Presentation DHS/START/MINERVA/SMA Technical Lecture Series, June 2015.
2015 P. Shakarian, The Cyber Battlefield: Now and the Near Future. Invited Presentation to the Danish Defense College, Copenhagen, Denmark, May 2015.
2015 P. Shakarian, Malware Task Identification. *CyberWest,* Phoenix, AZ, March, 2015.
2015 P. Shakarian, *E. Nunes*, Automatic identification of malware tasks. *CactusCon-15,* Tempe, AZ, March, 2015.
2014 P. Shakarian, Preparing for the New Threat Environment. Presentation to the U.S. Army Intelligence Center of Excellence, Ft. Huachuca, AZ, Dec. 2014.
2014 P. Shakarian, Cyber-Warfare. *ASU 4th Annual International Humanitarian Law Workshop,* Oct. 2014.
2014 P. Shakarian, Cascades in Complex Networks. Invited Presentation at the University of Notre Dame, Feb. 2014.
2014 P. Shakarian, Cyber-Warfare: A Primer. Presentation to the Danish Defense College, Copenhagen, Denmark May 2014.
2014 P. Shakarian, Mining Complex Networks to Leverage Cascading Processes. *AAAI Spring Symposium 2014* (invited lecture), Stanford, CA, March 2014.
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2014 **P. Shakarian,** *J. Salmento*, W. Pulleyblank, J. Bertetto. Reducing Gang Violence through Network Influence Based Targeting of Social Programs. *20th ACM SIGKDD Conference on Knowledge, Discovery, and Data Mining (KDD)* (Aug. 2014). 22% acceptance rate. A-rated conference.

2014 **P. Shakarian,** *D. Paulo*, M. Albanese, S. Jajodia. Keeping Intruders at Large: A Graph-Theoretic Approach to Reducing the Probability of Successful Network Intrusions. *11th Intl. Conf. on Security and Cryptography (SECRYPT)* (Aug. 2014). 9% acceptance rate. Selected for inclusion in a subsequent edited volume.

2014 **P. Shakarian,** G. Simari, *G. Moores*, S. Parsons, M. Falappa. An Argumentation Based Framework to Address the Attribution Problem in Cyber Warfare. *Cyber Security 2014* (May 2014).

2014 **P. Shakarian,** H. Lei, R. Lindelauf. Power Grid Defense Against Malicious Cascading Failure. *13th Intl. Conf. on Autonomous Agents and Multiagent Systems* (AAMAS-14) (May 2014). 23.8% acceptance rate. Featured in *Foreign Policy* (online). A-rated conference.

2014 **P. Shakarian,** G. Simari, M. Falappa. Belief Revision in Structured Probabilistic Argumentation. *Foundations of Information and Knowledge Systems 2014 (FoIKS 2014)* (Mar. 2014). 26.9% acceptance rate. Selected for journal version (42% of accepted papers).

2014 *J. Hannigan*, S. Matthews, J. Wickiser and **P. Shakarian.** A Network-Based Approach for Identifying Cancer Causing Pathogens. *ACM SE 2014* (Mar. 2014). Poster version was selected as "Best Student Poster" at ACM Tapia 2014.

2014 **P. Shakarian,** L. Gerdes, H. Lei. Circle-Based Tipping Cascades in Social Networks. *WSDM 2014 Workshop on Diffusion Networks and Cascade Analytics* (Feb. 2014).

2013 *J. Hannigan, G. Hernandez*, R. Medina, P. Roos, **P. Shakarian.** Mining for Spatially-Near Communities in Geo-Located Social Networks. *AAAI Fall Symposium* (Nov. 2013).

2013 *D. Paulo, B. Fischl*, T. Markow, M. Martin, **P. Shakarian**. Social Network Intelligence Analysis to Combat Street Gang Violence. *ASONAM '13: Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining* (Aug. 2013). Featured in the Jan. 2014 print edition of *Popular Science.*

2013 **P. Shakarian,** P. Roos, D. Callahan, *C. Kirk*. Mining for Geographically Disperse Communities in Social Networks by Leveraging Distance Modularity. *19th ACM SIGKDD Conference on Knowledge, Discovery, and Data Mining* (KDD) (Aug. 2013). 17% acceptance rate. A-rated conference.

2013 **P. Shakarian,** G.I. Simari, D. Callahan. Reasoning about Complex Networks: A Logic Programming Approach. *29th Intl. Conference on Logic Programming* (ICLP-13) (Aug. 2013). A-rated conference.

2013 **P. Shakarian,** G.I. Simari, R. Schroeder. MANCaLog: A Logic for Multi-Attribute Network Cascades. *12th Intl. Conf. on Autonomous Agents and Multiagent Systems* (AAMAS-13) (May 2013). A-rated conference.

2013 **P. Shakarian,** V.S. Subrahmanian. Geospatial Optimization Problems. *IEEE Network Science Workshop* (April 2013).

2012 D. Callahan, **P. Shakarian,** *J. Nielsen*, A.N. Johnson. Shaping Operations to Attack Robust Terror Networks. *Social Informatics 2012* (Dec. 2012). 11.5% acceptance rate, selected for journal publication (top 3% of papers); featured in WIRED (online); presented to senior staffers from the House Permanent Select Committee on Intelligence (HPSC-I) at the U.S. Capitol; presented at the Central Intelligence Agency.

2012 **P. Shakarian**, D. Paulo. Large Social Networks can be Targeted for Viral Marketing with Small Seed Sets. *2012 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining* (ASONAM-2012) (Aug. 2012). 16% acceptance rate, Nominated for best paper and invited for journal publication. MIT Technology Review "Best of 2013."

2012 M. Albanese, A. De Benedictis, S. Jajodia, **P. Shakarian**. A Probabilistic Framework for the Localization of Attackers in MANETs. *17th European Symposium on Research in Computer Security* (ESORICS 2012) (Sep. 2012). 21% acceptance rate. A-rated conference.

2011 **P. Shakarian**, P. Roos. Fast and Deterministic Computation of Fixation Probability in Evolutionary Graphs. *6th International Conference on Computational Intelligence and Bioinformatics* (CIB-11) (Nov. 2011).

2011 G. Johnson, **P. Shakarian**, N. Gupta, A. Agrawala. Towards Shrink-Wrapped Security: Practically Incorporating Context into Security Services. *Intl. Symposium on Frontiers in Ambient and Mobile Systems* (FAMS-2011) (Sep. 2011).

2011 **P. Shakarian**, M. K. Nagel, B. E. Schuetzle, V.S. Subrahmanian. Abductive Inference for Combat: Using SCARE-S2 to Find High-Value Targets in Afghanistan. *23rd Innovative Applications of Artificial Intelligence* (IAAI-11, held in conjunction with AAAI) (Aug. 2011). Featured in *The Economist* in April, 2012.

2010 M. Broecheler, **P. Shakarian**, V.S. Subrahmanian. A Scalable Framework for Modeling Competitive Diffusion in Social Networks. *2nd IEEE International Conference on Social Computing* (SocialCom-10) (symposium section) (Aug. 2012)

2010 **P. Shakarian**, V.S. Subrahmanian, M.L. Sapino. Using Generalized Annotated Programs to Solve Social Network Optimization Problems. *26th Intl. Conference on Logic Programming* (ICLP-10) (Jul. 2010). A-rated conference.

2009 **P. Shakarian**, V.S. Subrahmanian, M.L. Sapino. SCARE: A Case Study with Baghdad. *3rd Intl. Conference on Computational Cultural Dynamics* (ICCCD-09) (Dec. 2009). Featured in the *Baltimore Sun* and the online edition of *Popular Science* in Dec., 2009.

SELECTED PREPRINTS AND SUBMISSIONS:

2025 **P. Shakarian,** Toward Artificial Metacognition, submitted.

2025 *K. Mukherji, J. Patil, D. Aditya,* **P. Shakarian,** *D. Parkar, L. Pokala,* C. Dorman, G. I. Simari, Lattice Annotated Temporal (LAT) Logic for Non-Markovian Reasoning, journal paper submission.

2025 *J. Patil, N. Lee, A. M. S. Chowdhury,* YooJung Choi, **P. Shakarian,** Probabilistic Circuits for Knowledge Graph Completion with Reduced Rule Sets, submitted.

2025 M. Leiva, *N. Ngu, J. S. Kricheli, A. Taparia,* R. Senanayake, **P. Shakarian,** N.D. Bastian, J. Cororan, G. Simari, Consistency-based Abductive Reasoning over Perceptual Errors of Multiple Pre-trained Models in Novel Environments, submitted.

2025 *A. Taparia, N. Ngu,* M. Leiva, *J. S. Kricheli,* J. Cororan, N.D. Bastian, G. Simari, **P. Shakarian,** R. Senanayake, VLC Fusion: Vision-Language Conditioned Sensor Fusion for Robust Object Detection, submitted.

2025 L. Da, J. Turnau, T.P. Kutralingam, A. Velazquez, **P. Shakarian,** H. Wei, A Survey of Sim-to-Real Methods in RL: Progress, Prospects and Challenges with Foundation Models, preprint.

2025 J. Parades, M. Falappa, **P. Shakarian**, M. Martinez, G. I. Simari, Combining Existential Rules with Network Diffusion Processes for Automated Generation of Hypotheses. (journal paper submission).

2025 *N. Lee, N. Ngu, H. Sahdev, P. Motaganahalli, A. Chowdhury, B. Xi,* **P. Shakarian**, Metal Price Spike Prediction via a Neurosymbolic Ensemble Approach, (journal version, submitted).

OTHER PUBLICATIONS (SOME NOT PEER-REVIEWED, STUDENT CO-AUTHORS IN ITALICS):

2021 **P. Shakarian,** North Korea targeted cybersecurity researchers using a blend of hacking and espionage, The Conversation, Feb. 2021.
2020 **P. Shakarian,** The Sunburst hack was massive and devastating – 5 observations from a cybersecurity expert, The Conversation, Dec. 2020.
2017 **P. Shakarian,** The Enemy has a Voice, *New America Cybersecurity Initiative* (policy paper), 2017. Featured in *National Defense Magazine,* in Apr., 2017.
2016 **P. Shakarian,** Combating the Dangers of Big Data Analysis, *NGA Pathfinder*, 14(2), 2016.
2015 A. Kott, D. Alberts, A. Zalman, **P. Shakarian**, F. Maymi, C. Wang, G. Qu. Visualizing the Tactical Ground Battlefield in the Year 2050: Workshop Report. *U.S. Army Research Laboratory,* ARL-SR-0327, June 201 5.
2015 J. Shakarian, **P. Shakarian,** A. Ruef. Cyber Attacks and Public Embarrassment: A Survey of Some Notable Hacks. *Elsevier SciTechConnect,* January, 2015.
2013 **P. Shakarian**, J. Shakarian, A. Ruef, The Dragon and the Computer: Why Intellectual Property Theft is Compatible with Chinese Cyber-Warfare Doctrine. *Elsevier SciTechConnect,* July, 2013.
2012 *S. Eyre, R. Rotte, T. Taggart*, C. Chewar, A. Johnson, P. Roos, **P. Shakarian**. Using RASCAL to Find Key Villages in Afghanistan. *Small Wars Journal.*
2011 **P. Shakarian**. Stuxnet: Cyberwar Revolution in Military Affairs. *Small Wars Journal.*
2008 **P. Shakarian**. The Future of Analytical Tools: Prediction in a Counterinsurgency Fight. *Military Intelligence Professional Bulletin* 34(8).
2008 **P. Shakarian**. Precision Employment. *CTC Quarterly Bulletin, Center for Army Lessons Learned (CALL)* 8(18).
2007 **P. Shakarian**. Stand and Fight: Lessons for the Transition Mission in Iraq. *Armor Magazine.*
2007 **P. Shakarian**. Beyond Mentoring: Leveraging Indigenous Intelligence Assets through Reporting. *CTC Quarterly Bulletin, Center for Army Lessons Learned (CALL)* 7(32).
2005 T. Higgins, **P. Shakarian**, R. E. Ferguson. No Stone Unturned: A Thorough Search for Tactical Intelligence. *American Intelligence Journal* 23.

ARTICLES TRANSLATED INTO OTHER LANGUAGES:

2013 **P. Shakarian**, J. Shakarian, A. Ruef. El Dragón y la Computadora: Por qué el Robo de la Propiedad Intelectual es Compatible con la Doctrina China de la Guerra Cibernética. *Air and Space Power Journal, Edicion en Espanol,* 3rd quarter, 2013.
2013 **P. Shakarian.** 震网——掀起网空战争军事革命. *Air and Space Power Journa l-Chinese,* 1Q 2013.
2012 **P. Shakarian**. Stuxnet: Revolucion de la Ciberguerra en los Asuntos Militares. *Air and Space Power Journal, Edicion en Espanol* 24(3).

PATENTS ISSUED:

1. US12436827 (Oct. 7, 2025) Systems and Methods for Predicting Which Software Vulnerabilities Will be Exploited by Malicious Hackers to Prioritize for Patching (second patent)
2. US12235969B2 (Feb. 25, 2025) System and method for calculating and understanding aggregation risk and systemic risk across a population of organizations

   a. Invention owned by Securin, Inc.
   b. Also published as PCT: WO2020236960A1 (Nov. 26, 2020)
3. US12170684B2 (Dec. 17, 2024) Systems and methods for predicting the likelihood of cyber-threats leveraging intelligence associated with hacker communities
   a. ASU invention M18-234P
   b. Currently licensed
4. US11892897 (Feb. 6, 2024) Systems and methods for prioritizing software vulnerabilities for patching
   a. ASU invention M18-009P
   b. Published in US, EU, and Israel
5. US11693972B2 (Jul. 4, 2023) Systems and methods for an at-risk system identification via analysis of online hacker community discussions
   a. ASU invention M19-268P
6. US11552976B2 (Jan. 10, 2023) Systems and methods for social network analysis on dark web forums to predict enterprise cyber incidents
   a. ASU invention M19-002P
7. US11520900B2 (Dec. 6, 2022) Systems and Methods for a Text Mining Approach for the Prediction of Exploited Software Vulnerabilities
   a. ASU invention M18-247P
   b. Currently licensed
8. US11336673B2 (May 17, 2022) Systems and Methods for Third Party Risk Assessment
   a. ASU invention M18-175P
9. US11275900B2 (Mar. 15, 2022) Systems and methods for automatically assigning one or more labels to discussion topics shown in online forums on the dark web
   a. ASU invention M18-191P
10. US11126679B2 (Sep. 21, 2021) Systems and methods for detecting pathogenic social media accounts without content or network structure
    a. PCT application WO2019157335A1
    b. ASU invention M18-147P
11. US10437945B2 (Oct. 8, 2019) Systems and methods for order-of-magnitude viral cascade prediction in social networks
    a. ASU invention M15-222P
12. US10313385B2 (Jun. 4, 2019) Systems and methods for data driven game theoretic cyber threat mitigation
    a. ASU invention M16-040P
13. US10176438B2 (Jan. 8, 2019) Systems and Methods for Data Driven Malware Task Identification
    a. ASU invention M15-167P

PUBLISHED PATENT APPLICATIONS (NOT YET ISSUED):

1. US20240427986A1 (Dec. 26, 2024) Large language model screening system and methods thereof

   a. ASU invention M23-184P
2. US20250252328A1 (Aug. 7, 2025) Systems and Methods for Open World Temporal Logic

REGISTERED COPYRIGHT

1. Intelligent darkweb crawling infrastructure for cyber threat intelligence collection (2016)
   a. ASU invention M16-090P
   b. Software copyright

INVENTION DISCLOSURES NOT ASSOCIATED WITH A PUBLISHED PATENT OR COPYRIGHT.

1. ASU Invention M25-190P: Systems and methods for predicting future locations of maritime vessels based on partial trajectory information (Jan. 3, 2025)
   U.S. Provisional patent 63/745,753 (Jan. 15, 2025)
2. ASU Invention M23-101: Systems and methods for identification of trade indicators
   - U.S. Provisional patent 63/511,149 (June 29, 2023) "Systems and Methods for Identification of Trade Indicators"
   - Also submitted for copyright registration of source code
   - Currently under exclusive option to license

CURRENT DOCTORAL STUDENTS (PRIMARY ADVISOR)

- Divyagna Bavikadi (Ph.D., Computer and Information Systems Engineering, Syracuse University) (Fall 2022- present)
- Kaustuv Mukherji (Ph.D., Electrical and Computer Engineering, Syracuse University) (Fall 2022- present)
- Joshua Shay Kricheli (Ph.D., Electrical and Computer Engineering, Syracuse University) (Fall 2023 - present)
- Jaikrishna Patil (Ph.D., Electrical and Computer Engineering, Syracuse University) (Fall 2023 - present)

CURRENT DOCTORAL STUDENTS (COMMITTEE MEMBER)

- Shwetha Koushik (Ph.D., Computer and Information Systems Engineering, Syracuse University) (ongoing)
- A. M. Sadaat Chowdhury (Ph.D., Computer Science, Arizona State University) (ongoing)

GRADUATED DOCTORAL STUDENTS (AS PRIMARY ADVISOR)

- Eric Nunes (Ph.D., Computer Engineering, ASU, successfully defended in 2018, graduated in 2019, now at Palantir)
  - *Reasoning about Cyber Threat Actors*
- Elham Shaabani (Ph.D., Computer Science, ASU, successfully defended in 2019, graduated in 2019, now at Microsoft (LinkedIn))
  - *Data Driven Inference in Populations of Agents*

- Mohammed Almukaynizi (Ph.D., Computer Science, successfully defended in 2019, graduated in 2019, now an Assistant Professor King Saud University)
  - *Proactive Identification of Cybersecurity Threats using Online Sources*
- Hamid Alvari (Ph.D., Computer Science, successfully defended in 2020, graduated in 2020, currently researcher at Google DeepMind)
  - *Understanding Propagation of Malicious Information Online*
- Soumajyoti Sarkar (Ph.D., Computer Science, successfully defended in 2020, graduated in 2020, currently a scientist at Amazon AWS)
  - *Measuring the Impact of Social Network Interactions*
- Ericsson Marin (Ph.D., Computer Science, ASU, successfully defended in 2020, graduated in 2020, currently an Assistant Professor at CalPoly Pomona)
  - *A Hacker-Centric Perspective to Empower Cyber Defense*

FORMER STUDENTS HOLDING ACADEMIC POSITIONS

- Mohammed Almukaynizi, King Saud University (Assistant Professor)
- Ericsson Marin, CalPoly (Assistant Professor)
- Geoffrey Moores, West Point (Lecturer)
- Joseph Salmento, West Point (Lecturer)

GRADUATED STUDENTS (MS THESIS ADVISOR)

- Brian Vincent (M.S., Computer Science) graduated in 2018
  - *Understanding Hacking-as-a-Service Markets*
- Krishna Dharaiya (M.S., Computer Science) graduated in 2018
  - *Identifying Financial Fraud on the Darkweb*
- Revanth Patil (MS, Computer Science) graduated in 2018
  - *Multi-class and Multi-label classification of Darkweb Data*
- Nikhil Kumar (MS, Computer Science) graduated in the summer of 2016
  - *An Empirical Evaluation of Social Influence Metrics*

OTHER ASU UNDERGRADUATE AND GRADUATE MENTORSHIP:

- UNDERGRADUATE HONORS THESIS:
  - Roman Smith (B.S., Computer Science, graduated in 2023)
  - Colton Payne (B.S., Computer Science, graduated in 2023)
  - Iden Alba (B.S., Computer Science, ASU, graduated in 2018)
  - Andrew Polican (B.S., Computer Science, ASU, graduated in 2018)
  - James Hutchins (B.S., Computer Science, ASU, graduated in 2017)
  - John Robertson (B.S., Computer Science, ASU, graduated in 2016)
- ASU Master's Opportunity for Research in Engineering (MORE)
  - Aniruddha Datta (MS, Computer Science)
- Master's Capstone Project
  - Gilles-armel Aye (MS, Systems Engineering, Robotics and Autonomous Systems)
- ASU Fulton Undergraduate Research Initiative (FURI):
  - Noel Ngu, Fall 2023
  - Bryan Lee, Summer 2022

    - Cody Iwertz, Fall 2017
    - Nidhal Selmi, Spring 2017
    - John Robertson, Fall 2015, Spring 2016
    - James Hutchins, Fall 2016
    - Riyan Setiadji, Spring 2015
    - Amanda Thart, Fall 2015
    - Adam Tse, Spring 2015, Fall 2015
    - Spencer Offenberger, Spring 2015, Fall 2015
- ASU Grand Challenge Scholar Program (GCSP) Research Stipend
    - Rohan Nair, Spring 2023
    - Cody Iwertz, Fall 2016
- Army Research Office Undergraduate Research Program
    - John Robertson (2016)
- ASU Barrett Honors contract
    - Sai Punit Arani (2023)
    - Taehoon Kwon (2023)
    - Harikrishna Kommineni (2023)

EDITORIAL BOARD MEMBERSHIPS:

- Lead Guest Editor, *IEEE Intelligent Systems* (Special Issue on Metacognitive Prediction of AI Behavior) (2025).
- Editorial board member, *Springer Social Network Analysis and Mining* (2021-2022)
- Editorial board member, *Cyber Defense Review* (2017-2022)
- Guest editor, *Neurosymbolic Artificial Intelligence* (Special Issue on Neuro-Symbolic AI and Domain Specific Conceptual Modelling) (2024).
- Guest editor, *Information* (special issue "Social Influence") (2020)
- Guest editor, *Information* (special issue "Darkweb Cyber Threat Intelligence Mining") (2018)
- Guest editor, Springer *Social Network Analysis and Mining* (special issue "Diffusion of Influence and Information in Social Networks") (2016)

CONFERENCE ORGANIZING ACTIVITY:

- Chair and Founder, "Workshop on Metacognitive Prediction of AI Behavior"
    - May, 2025: Second edition, sponsored by SSCI, part of SDM-2025, to be held in Alexandria, VA
    - Nov., 2023: First edition, sponsored by Army Research Office, Scottsdale, AZ.
- Organizing committee, AAAI-MAKE series (AAAI Spring Symposium)
    - 2025: "Machine Learning and Knowledge Engineering for Trustworthy Multimodal and Generative AI (AAAI-MAKE)"
    - 2024: "Empowering Machine Learning and Large Language Models with Domain and Commonsense Knowledge (AAAI-MAKE)"
- Co-Chair and Co-Founder, *Workshop on Social Influence (SI)* (held in conjunction with ASONAM) (I was involved in the first seven iterations: 2014, 2016-2021; though I am no longer involved, this workshop is still held annually as of 2024)

- Co-Chair, "International Workshop on Hybrid AI Machine Learning Systems (AIMS)," co-located at CAISE, 2024 (CAISE is an A-rated conference).
- General Chair, FOSINT-SI 2021-2022
- Co-Chair, FOSINT-SI, 2019-2020
- Program Committee Co-Chair, IEEE *International Conference on Data Intelligence and Security (ICDIS)*, 2020.
- Co-Chair, *Artificial Intelligence and Cybersecurity* (Lorenz eScience winner), 2019
- Co-Chair, *ARO Workshop on Cyber Warfare: Building the Scientific Foundation,* 2014

PROFESSIONAL MEMBERSHIPS:
- Member, American Association for the Advancement of Science (AAAS)
- Member, Association for the Advancement of Artificial Intelligence (AAAI)
- Member, IEEE Computer Society
- Member, Society for Industrial and Applied Mathematics (SIAM)
- Member, Association for Computing Machinery (ACM)
- Member, National Academy of Inventors (NAI), ASU Chapter

OTHER EXTERNAL SERVICE:
- PC member, NeSy 2024, 2025 (Int'l. Conf. on Neural-Symbolic Learning and Reasoning)
- PC member KDD doctoral consortium (2025)
- PC member, KDD (2015, 2016)
- AAAI Senior Program Committee 2026
- PC member, AAAI-2016, 2023, 2024, 2025
- PC member, KR 2024, 2025
- Springer book reviewer for "Applications of Neuro-Symbolic Artificial Intelligence," 2023
- Cambridge University Press book reviewer for "Knowledge-infused Learning: Knowledge-powered NeuroSymbolic AI for Explainability, Interpretability, and Safety," 2023
- PC Member for KDD Workshop on Artificial Intelligence-Enabled Cybersecurity Analytics (2024)
- PC member for European Conference on Logics in Artificial Intelligence (JELIA) 2023
- PC member for Knowledge-Guided Machine Learning at ECML/PKDD 2023
- Reviewer for book "Neuro-Symbolic AI" (Packt Publishing) 2023
- AAMAS Senior Program Committee, AAMAS (2018-2019)
- PC member, ASONAM (2019)
- PC member, IJCAI (2018, 2019)
- PC member, FOSINT-SI (co-located with ASONAM) (2014-2017)
- PC member, AAMAS (2015, 2016)
- Journal Reviewer Duties
    - Reviewer for Computer Science Review (2025) (Q1)
    - Reviewer for Intl. Journal of Approximate Reasoning (2023) (Q1)
    - Reviewer for Neurosymbolic Artificial Intelligence (2023)
    - Reviewer for ACM Digital Threats (2022)
    - Reviewer for Elsevier Computers and Security (2021) (Q1)

  - Reviewer for Springer-Nature Scientific Reports (2018) (Q1)
  - Reviewer for journal IEEE Transaction on Big Data (2017) (Q1)
  - Reviewer for Cambridge *Knowledge Engineering Review* (2016) (Q1)
  - Reviewer for *Proceedings of the Royal Society A* (PRSA) (2013, 2015) (Q1)
  - Reviewer for ACM journal *Transactions of Knowledge Discovery from Data* (TKDD) (2012) (Q1)
- Funding Agency Reviewer Duties
  - Reviewer for Department of Energy (DOE) grant proposals (2024)
  - Reviewer for Army Research Office (ARO) grant proposals (2012-2013, 2015-2018, 2023, 2025)
  - Reviewer for National Science Foundation (NSF) grant proposals (2022)
  - Reviewer for Air Force Office of Scientific Research (AFOSR) grant proposals (2017)
  - Reviewer for DARPA proposals (2014)

UNIVERSITY SERVICE:

- DEPARTMENT/SCHOOL-LEVEL:
  - Co-Chair, AI Curriculum Committee (Syracuse, EECS), 2025-Presnet
  - Committee Member, Personnel Committee, (SCAI, ASU) 2023-2025
  - Committee Member, Smart Data Engineering Search, (SCAI, ASU) 2022-2023
  - Committee Member, Admissions Committee, CIDSE (ASU) 2014-2016
  - Faculty Advisor, West Point UPE (Computer Science Honor Society) Chapter, 2011-2014
  - Faculty Advisor, Department Scholarship Program, West Point, 2011-2014
  - Department Academic Counselor (Computer Science), West Point, 2011- 2014
- COLLEGE-LEVEL:
  - SCAI Representative for the FSE Dean's Research Advisory Council (RAC, ASU), 2022-2023
  - Reviewer for GCSP scholarship applications (ASU) 2023, 2024
  - Reviewer for FURI scholarship applications, ASU, 2023
  - Judge for the Fulton Entrepreneurial Professorship, ASU 2023
  - Judge for the New Economic Initiative entrepreneurial post doc position, ASU 2022
  - Mentor, Fulton Undergraduate Research Initiative (FURI) (ASU) 2015-2025
  - Head Faculty Advisor, Fulton Student Veterans Organization (ASU) 2019-2021
  - Faculty Advisor, Fulton Student Veterans Organization (ASU) 2016-2019

- UNIVERSITY-LEVEL:
  - Member, Provost's AI Working Group, Syracuse University, 2025-Present
  - Voting Committee Member, Financial Conflict of Interest Committee (FCOI), Syracuse University, 2025-Present
  - Reviewer, limited submission grant proposals for Knowledge Enterprise (KE) (ASU) (2023-2025)
  - Interviewer for applicants for senior position at ASURE including director (ASU) (2023)
  - Honors Faculty, Barrett, The Honors College (ASU), 2015-2025
  - Affiliate Faculty, Institute for Social Science Research (ASU), 2017-2025
  - Affiliate Faculty, Center for Cybersecurity and Digital Forensics (ASU), 2015-2025
  - Affiliate Faculty, Center for Assured and Scalable Data Engineering (ASU), 2015-2025
  - Affiliate Faculty, Center for the Future of War (ASU), 2014-2025
  - Affiliate Faculty, West Point Network Science Center, 2011-2014

SAMPLE LECTURES:

- Various lectures on the "Neuro Symbolic" YouTube channel we created (2022-present) https://www.youtube.com/@neurosymbolic
- ASU KED Talk: Staying ahead of cyber attacks (2018) https://www.youtube.com/watch?v=B-H2kaQNVNw&t=335s
- ISC2/McAfee: Malware and Machine Learning: What you need to know (2017) https://www.brighttalk.com/webcast/5385/254753
- Army Cyber Talks: Toward a Threat-Centric Paradigm (2016) https://www.youtube.com/watch?v=TFeFR_Jldcw
- New America Panel: Understanding the Future of Cyber Threat Intelligence (2016) http://www.ustream.tv/recorded/88353440
- Mining for Causal Relationships: A Data-Driven Study of the Islamic State (KDD 2015) https://www.youtube.com/watch?v=CNU5Ovs-L-g
- The "Science of Cyber" and the Next Generation of Security Tools (ShmooCon 2014) https://archive.org/details/ShmooCon2014_Science_of_Cyber_and_Next_Gen_Security_Tools
  https://www.youtube.com/watch?v=btvwhY-eMEw

COURSES TAUGHT:

- **Syracuse University (Fall 2025-Present):**
  - CIS700: Hybrid Artifi8cial Intelligence
- **Arizona State (Fall 2014-Spring 2025):**
  - Undergraduate:
    - CSE 475: Foundations of Machine Learning
      - Spring, 2024 (195 undergraduates), ASU I-Course (online)
      - Fall, 2023 (205 undergraduates), ASU I-Course (online)
      - Fall, 2023 (25 undergraduates), ASU Online
      - Spring, 2023 (175 undergraduates), hybrid version

- Fall, 2022 (132 undergraduate), hybrid version
  - Roll-out of redesigned online version of CSE475
- CSE471: Introduction to Artificial Intelligence
  - Spring, 2025 (70 undergraduates), hybrid version of course
  - Fall, 2024 (49 undergraduates), ASU Online
  - Fall, 2024 (168 undergraduates), ASU I-Course (online)
    - Roll-out of redesigned online version of CSE471
  - Spring, 2015 (43 undergraduate)
- CSE 494: Artificial Intelligence for Cybersecurity
  - Spring, 2019 (15 undergraduate)
- ASU 101: The ASU Experience
  - Multiple semesters from 2022-2025

- Graduate:
  - CSE 598: Perceptual Reasoning and Symbol Grounding
    - Fall, 2023 (40 graduate)
  - CSE 591: Neuro Symbolic Reasoning
    - Fall, 2022 (22 graduate)
  - CSE 591: Security Informatics
    - Spring, 2016 (14 graduate)
  - CSE 598: Introduction to Artificial Intelligence (Graduate version)
    - Spring 2015 (7 graduate)
  - CSE 573: Semantic Web Mining
    - Fall, 2015 (57 graduate)
  - CSE 591: Diffusion in Social Networks
    - Fall 2014, 25 total students (all graduate)

- **<u>West Point Fall 2011 – Spring 2014:</u>**
  (all undergraduate, West Point lectures are limited to 18 students per section, though multiple sections are often taught – each section is provided its own lecture for each lesson, **West Point provides no TA/GA support for any courses**)
  - IT300: Fundamentals of Programming
    (taught to non-computer science majors as all students at West Point are required to take an "engineering sequence" if not majoring in an engineering)
    - Fall, 2012 - 36 total students, 2 sections
  - CS486: Artificial Intelligence
    - Fall 2013, 6 students
    - Fall 2012, 5 students
  - IT305: Theory and Practice of Military IT Systems
    (mandatory course for all non-computer science majors)
    - Spring 2014, 36 students, 2 sections
    - Spring 2013, 54 students, 3 sections
    - Spring 2012, 54 students, 3 sections
    - Fall 2011, 54 students, 3 sections
  - CS489: Hard Problems in Complex Networks (pilot course)

        - Spring 2013, 3 students
        - Fall, 2012, 1 student
    - CS401/IT401: Software Systems Design I (capstone course)
        - Fall 2013, 6 students
    - XE402: Software Systems Design II (capstone course)
        - Spring 2014, 6 students

OTHER AWARDS WON BY MY STUDENTS:

- ARLIS RISC Internship Plenary Session – Pilar Glaser, Cailyn MacLellan, Sydney Rothstein (2025)
- Army Research Office High School Research Apprenticeship Program – Anay Gupta (2016/2017)
- NSF Graduate Research Fellowship Award – Geoffrey Moores 2014 (West Point)
- NSF Graduate Research Fellowship Award – Damon Paulo 2014 (West Point)
- NSF Graduate Research Fellowship Honorable Mention – Joseph Hannigan 2014 (West Point)
- 2014 DARPA Innovation Challenge Finalist Team (Guillermo Hernandez, Joseph Hannigan, Bradley Fischl, Christian Young, Evan Kenney, Jacob Lademan)
- Letter of Commendation from the Superintendent of the Chicago Police – Guillermo Hernandez 2014 (West Point)
- Best Student Poster – 2014 ACM Tapia Conference – Joseph Hannigan 2014 (West Point)
- Society of American Military Engineers (SAME) Fellowship – Geoffrey Moores 2013 (West Point)

GRADUATED STUDENTS FOR WHICH DR. SHAKARIAN IS ON A DISSERTAITON OR THESIS COMMITTEE (NOT PRIMARY ADVISOR):

- Doctorate
    - Anique Tahir (Ph.D., Computer Science, ASU; Thesis Chair: Huan Liu, graduated in spring 2025) "Towards Safe and Efficient AI"
    - Vivin Paliath (Ph.D., Computer Science, ASU; Thesis Chairs: Adam Doupe and Yan Shoshitaishvili, graduated fall 2023) "Modeling State to Improve Defensive Cyberattack Strategies."
    - Saadet Betul Ceran (Ph.D., Computer Science, ASU; Thesis Chair: Hasan Davulcu, graduated spring 2016) "Semantic Feature Extraction for Narrative Analysis."
    - Feng Wang (Ph.D., Computer Science, ASU; Thesis Chair: Ross Maciejewski, graduated spring, 2016) "Visual Analytics Methods for Exploring Geographically Networked Phenomena."
    - Jessica Bodford (Ph.D., Psychology, ASU; Thesis Chair: Virginia Kwan, graduated spring, 2016) "Blurring Safety Between Online and Offline Worlds: Archival, Correlational, and Experimental Evidence of Generalized Threat in the Digital Age."
    - Kai Zhu (Ph.D., Electrical Engineering, ASU; Thesis Chair: Lei Ying, graduated fall, 2015) "Social Network Analysis: Detection of the Information Source," currently at Google.

- Masters
  - Sravan Kumar Garipalli (M.S., Computer Science, ASU; Thesis Advisor: Hasan Davulcu, graduated fall, 2015) "Visualization Tool for Islamic Radical and Counter Radical Movements and their online followers"
  - Jessica Bodford (M.S., Psychology, ASU; Thesis Advisor: Virginia Kwan, graduated spring, 2015) "We are Legion: Hacktivism as a Product of Deindividuation, Power, and Social Injustice," currently a Ph.D. student at ASU

SELECTED MEDIA APPEARANCES:

- July, 2025: Coverage on joining Syracuse University as the KG Tan Endowed Professor of AI: https://ecs.syracuse.edu/about/news/paulo-shakarian-joins-department-of-electrical-engineering-and-computer-science-as-k-g-tan-professor-of-artificial-intelligence
- Feb. 2025: Further local coverage on ABOR grant for emergency management by KTAR (Phoenix-area radio and media): https://ktar.com/arizona-news/abor-grant-ai-disaster-response/5665455/, ABC15 https://www.abc15.com/news/state/artificial-intelligence-could-be-the-future-of-arizona-disaster-response, and ASU News: https://news.asu.edu/20250227-science-and-technology-ai-az-abor-funds-new-tools-state-emergency-response
- Feb. 2025: Coverage by the Arizona Board of Regents (ABOR) for funding of AI-empowered emergency management. https://www.azregents.edu/news-releases/abor-regents-grant-boosts-ai-powered-disaster-response-efforts-help-keep-arizona
- Feb. 2024: Wall Street Journal https://www.wsj.com/tech/ai/ai-is-tutoring-students-but-still-struggles-with-basic-math-694e76d3 (quoted on the topic of ChatGPT's ability to solve math word problems)
- Nov. 2023: Daily Independent https://www.yourvalley.net/stories/inaugural-asu-artificial-intelligence-day-scheduled-for-tempe,460271 (quoted on SCAI's AI day)
- Oct. 2023: ZDNet https://www.zdnet.com/article/using-chatgpt-for-accounting-you-may-want-to-think-again/ (quoted on work relating to evaluation of LLMs on math problems)
- Oct. 2023: ASU News https://news.asu.edu/20231020-government-calling-tech-leaders-help-crafting-artificial-intelligence-legislation
- Aug. 2023: ASU Full Circle https://fullcircle.asu.edu/fulton-schools/asu-researchers-bridge-security-and-ai/ (regarding participation in DARPA AI Forward)
- Jul. 2023: AI Magazine https://onlinelibrary-wiley-com.ezproxy1.lib.asu.edu/doi/full/10.1002/aaai.12094 (regarding work on LLM performance on math problems)
- Feb. 2023: ASU News https://news.asu.edu/20230221-discoveries-do-math-chatgpt-sometimes-cant-expert-says
- Mar. 2022: CYR3CON acquisition by CSW covered in HelpNetSecurity and New Mexico Inno
- Aug. 2018: Pathogenic social media research featured in the Wall Street Journal
- May 2017: Coverage in Slate, The Economist, quoted by CNN and interviewed on CBC.
- Aug. 2016: Darkweb scraping technology featured on Forbes, Cisco Continuum, and MIT Technology Review.

- Jan. 2016: Featured in the print edition of The Economist.
- Nov. 2015: Featured in Business Insider as part of a Veteran's day series. The major Chinese news outlet Sohu published a similar article.
- Sep./Oct., 2015: Our work on information cascades featured in TechCrunch, ExtremeTech, and the Irish Times.
- Aug., 2015: My KDD-2015 paper on causal learning to understand Islamic State military actions was featured as BBC Technology's lead story and also featured in the Huffington Post, Business Insider (with a follow-up) and Australian news media.
- Jan. 2014: *MIT Technology Review* included my research on viral marketing (as published in the paper A Scalable Heuristic for Viral Marketing Under the Tipping Model) as one of the "Best of 2013." Also, in the same month, my work on protecting the power grid was featured in Foreign Policy's Complex Blog.
- Jan. 2014: My ORCA software package was featured in the print edition of *Popular Science.* The story was also carried by Focus.it – a major Italian technology blog/magazine.
- 6 Dec. 2012: *WIRED* (online) featured my research on attacking robust terror networks.
- 21 Apr. 2012: *The Economist* featured my work on the SCARE counter-IED software

Predictive Artificial Intelligence

Fast time-to-value -

Frictionless trial -

Designed for integration -

Eliminate analyst -

Mining of malicious hacker discussions

- Automated

- Platform-centric

- Mature API

- Multi-sourced (darkweb, deepweb, social media, open)

CYR3CON: Artificial intelligence + threat data = Predictive cyber

Peer-Reviewed

IEEE ISI, ACM CSS, IEEE ICDIS, Cambridge University Press, CyCon-US, IEEE SocialCom

Provisional Patents

U.S.: 62/581,123, 62/703,110, 62/668,871, 62/753,019
PCT: US2018/057812

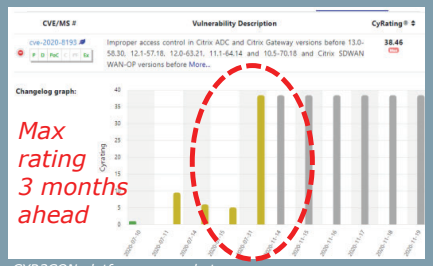
Award Winning

Defense Innovation Award, PwC Cybersecurity Finalist, IEEE ICDIS Best Paper

Predicting Chinese Government Hacks during the Pandemic

Example Head-to-Head

CYR3CON



CYR3CON platform screenshot

Incumbent

(ranked medium in both V2 and V3 of CVSS)

CYR3CON predictions led NSA's advisory by 3-12+ months.

CYR3CON predicts hacker use of vulnerabilities

NSA publishes advisory on **Chinese government hacker activity** during the pandemic

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.

62/859,940 (June 11, 2019) *System and Method for Identifying Whether Software Vulnerabilities will be Discussed by Hacking Actors*

PCT/US2018/057812 (Oct. 26, 2018)
Systems and Methods for Predicting which Software Vulnerabilities will be Exploited by Malicious Hackers to Prioritize for Patching

62/832,219 (April 10, 2019) *Systems and Method for Aggregating, Ranking, and Minimizing Threat to Computer Systems Based on External Vulnerability Intelligence*

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cyr3con be in the know, now.

Science-Based Approach

Multiple Peer-Reviewed Case Studies

M. Almukaynizi, A. Grimm, E. Nunes, J. Shakarian, P. Shakarian, Predicting Cyber Threats through Hacker Social Networks in Darkweb and Deepweb Forums, *ACM Computational Social Science* (CSS-2017) (Oct. 2017).

M. Almukaynizi, E. Nunes, K. Dharaiya, M. Senguttuvan, J. Shakarian, P. Shakarian, Proactive Identification of Exploits in the Wild Through Vulnerability Mentions Online, *2017 International Conference on Cyber Conflict* (CyCon-US) (Nov. 2017).
Video: https://www.youtube.com/watch?v=cYZXk8ejbks&index=18&list=PLtUuPz3a0Gz8dihTzZ-eAuLMHMlmprrpt
Media: https://www.defenseone.com/technology/2017/11/which-bugs-will-hackers-exploit-first-machine-learning-promises-better-guess/142621/?oref=d-channeltop

N. Tavabi, P. Goyal, M. Almukaynizi, P. Shakarian, K. Lerman, DarkEmbed: Exploit Prediction with Neural Language Models, *30th Innovative Applications of Artificial Intelligence* (IAAI-18) (Feb. 2018).

Filed Provisional Patent

62/581,123 (Nov. 3, 2017) Dark/deepweb based model for the prediction of exploited software vulnerabilities

Research Award

Winner, Defense Innovation Challenge

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