Pablo Moriano

CONTACT INFORMATION

Oak Ridge National Laboratory
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RESEARCH INTERESTS

Data Science, Machine Learning, Network Science, Cybersecurity

EDUCATION

Indiana University, Bloomington, IN

Ph.D., Informatics **May 2019**

- Dissertation: Anomaly Detection in Real-World Temporal Networks
- Committee: L. Jean Camp, Yong-Yeol Ahn, Filippo Radicchi, Raquel Hill
- Minor in Statistical Science
- GPA: 3.94/4.00

M.S., Informatics **October 2017**

- GPA: 3.88/4.00

Pontificia Universidad Javeriana, Colombia

M.S., Electrical Engineering **October 2011**

- Master thesis: Heavy-tailed distributions from local decision-making strategies
- Advisor: Jorge Finke
- *Summa cum laude*, with highest distinction
- Ranked top 1%, GPA: 4.74/5.00

B.S., Electrical Engineering **May 2008**

- *Summa cum laude*, with highest distinction
- Ranked top 1%, GPA: 4.45/5.00

HIGHLIGHTS

Selected Honors and Awards

- Laboratory Directed Research and Development (LDRD) Program Grant. PI: Next-Generation Security for Interconnected Systems, **Oak Ridge National Laboratory**, ($470,000) 2022
- Best Paper Award, Fourth ISOC NDSS International Workshop on Automotive and Autonomous Vehicle Security **(Autosec)** 2022
- IEEE Senior Member, **IEEE** (top 10%) 2021
- Research Gift. PI: Understanding Software Quality in Developer-Component Temporal Graphs, **Cisco Systems, Inc.**, ($87,000) 2018
- Best Paper Award, 9th ACM CCS International Workshop on Managing Insider Security Threats (**MIST**) 2017
- Science, Technology, and Innovation Scholar, **Minciencias** 2014
- Graduate Studies Scholarship, **Colfuturo** 2013
- Outstanding Lecturer, Department of Electrical Engineering and Computer Science, **Pontificia Universidad Javeriana** 2013
- Outstanding Young Researcher Award, **Minciencias**, ($10,000) 2010
- Dean's List, Department of Electrical Engineering and Computer Science, **Pontificia Universidad Javeriana** (top 1%) 2003–2007

PROFESSIONAL EXPERIENCE

Oak Ridge National Laboratory, Oak Ridge, TN

Research & Development Associate Staff Member **March 2020 to Present**

- Research scientist in the Computer Science and Mathematics Division working with the Systems and Decision Sciences Group. I use artificial intelligence and

machine learning for modeling, computing, and optimizing complex engineered and physical systems and their use in control and decision making. Recently my focus has been on helping ORNL to: (1) design and engineer adaptive intrusion detection systems for cyber-physical systems, (2) understand and optimize incident detection response in US highways, and (3) early detect vulnerable commits in open source codebases.

Indiana University, **Center for Security and Privacy in Informatics, Computing, and Engineering**, Bloomington, IN

Postdoctoral Research Associate **May 2019 to March 2020**

- Conducted research on analysis of BGP routing updates for early identification of man-in-the-middle (MITM) attacks using statistical analysis and machine learning.
- Characterized groups and features of developers more prone to introduce vulnerable commits using network science and machine learning methods.
- Analyzed privacy-related survey data to understand differences between samples of individuals using unsupervised learning.

Research Assistant **June 2015 to April 2019**

- Analyzed a dataset of routing anomalies using unsupervised machine learning methods to understand country-based generation of those.
- Collected a dataset of BGP routing updates for time series analysis of hijacking events.
- Conducted network analysis on BGP updates and proposed a framework of early identification of large-scale network disruptions.
- Performed statistical analysis of large-scale computer security surveys to distinguish traits between experts and non-experts security practitioners.
- Published 3 first author research articles on data-driven security applied to routing anomaly detection.
- Devised projects while teaching and mentoring 1 undergraduate and 3 graduate students.

  PI: **L. Jean Camp**

Research Assistant **September 2013 to July 2014**

- Conducted Twitter data analysis to understand how scientific publications spread online and presented results at an international conference.

  PIs: **Filippo Menczer** and **Alessandro Flammini**

Cisco Systems, Inc., Knoxville, TN

Research Intern **Summers 2016, 2017, and 2018**

- Designed and implemented an anomaly detection method based on temporal network analysis for identifying suspicious commits in Cisco's IOS codebase.
- Established collaborations to conduct experiments requiring specific techniques.
- Published a first author research article on insider threat event detection in the 9th ACM CCS International Workshop on Managing Insider Security Threats (MIST), which results in best paper award.
- Presented results at an international conference attended by more than 500 scientists.
- Participated in additional research that lead to an accepted research proposal for investigating vulnerability prediction in Cisco's codebases for over $60,000.
- Reported progress at regular meetings with the company SVP.

  Mentor: **Steven Rich**

Pontificia Universidad Javeriana, Colombia

Research Assistant **February 2009 to July 2013**

- Developed software for constructing models of networks that have both heavy-tail degree distributions and high degrees of clustering.
- Participated in additional research that lead to an accepted research proposal with Colombian's National Science Department for investigating methods for anomaly detection in networks for $10,000.
- Published 3 first author research articles on mechanisms of network formation.
- Presented results at 3 international conferences in control systems.
  PI: **Jorge Finke**

Teaching Experience

Indiana University, Bloomington, IN

Associate Instructor **August 2014 to May 2015**

- Assisted in teaching 2 undergraduate courses ranging in size from 20-80 students on topics including: Discrete mathematics, programming in Python, and statistics.
- Led weekly laboratory and/or problem-solving and discussion sections for groups of 5-10 students.
- Supervised students in final projects, graded exams and weekly homework.

Pontificia Universidad Javeriana, Colombia

Lecturer **July 2011 to July 2013**

- Recognized as an outstanding lecturer while teaching an undergraduate introduction to programming class of about 30 students.
- Prepared course material including laboratory experiments, lectures, exams, homework, and practice problems.

Publications

(†: equal contribution)

Peer Reviewed Journals

[J10] J. Bryan† and **P. Moriano† Graph-Based Machine Learning Improves Just-in-Time Defect Prediction**. *Submitted*, 2022. arXiv: 2110.05371 [cs.SE].

[J9] M. E. Verma, M. D. Iannacone, R. A. Bridges, S. C. Hollifield, **P. Moriano**, B. Kay, and F. L. Combs. **Addressing the Lack of Comparability & Testing in CAN Intrusion Detection Research: A Comprehensive Guide to CAN IDS Data & Introduction of the ROAD Dataset**. *Submitted*, 2021. arXiv: 2012.14600 [cs.CR].

[J8] **P. Moriano**, R. Hill, and L. J. Camp. **Using bursty announcements for detecting BGP routing anomalies**. *Computer Networks*, vol. 188, p. 107835, 2021.

[J7] **P. Moriano**, J. Finke, and Y.-Y. Ahn. **Community-Based Event Detection in Temporal Networks**. *Scientific Reports*, vol. 9, no. 1, p. 4358, 2019.

[J6] **P. Moriano**, J. Pendleton, S. Rich, and L. J. Camp. **Stopping the Insider at the Gates: Protecting Organizational Assets Through Graph Mining**. *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*, vol. 9, no. 1, pp. 4–29, 2018.

[J5] **P. Moriano**, S. Achar, and L. J. Camp. **Incompetents, criminals, or spies: Macroeconomic analysis of routing anomalies**. *Computers & Security*, vol. 70,

pp. 319–334, 2017.

[J4] P. Rajivan, **P. Moriano**, T. Kelley, and L. J. Camp. **Factors in an end user security expertise instrument**. *Information and Computer Security*, vol. 25, no. 2, pp. 190–205, 2017.

[J3] **P. Moriano** and J. Finke. **On the formation of structure in growing networks**. *Journal of Statistical Mechanics: Theory and Experiment*, 2013 (06), P06010.

[J2] **P. Moriano** and J. Finke. **Power-law weighted networks from local attachments**. *Europhysics Letters*, vol. 99, no. 1, p.18002(6), 2012.

[J1] **P. Moriano** and F. Naranjo. **Modelado y control de un nuevo sistema bola viga con levitación magnética**. *Revista Iberoamericana de Automática e Informática Industrial*, vol. 9, no. 3, pp. 249–258, 2012.

Peer Reviewed Conferences

[C7] Md. H. Shahriar, Y. Xiao, **P. Moriano**, W. Lou, and Y. T. Hou. **CANShield: Signal-based Intrusion Detection for Controller Area Networks**. In Proceedings of the *Embedded Security in Cars Conference (ESCAR) USA*, pp. 1–15, Detroit, MI, USA, June 2022.

[C6] J. Dev, **P. Moriano**, and L. J. Camp. **Lessons Learnt from Comparing WhatsApp Privacy Concerns Across Saudi and Indian Populations**. In Proceedings of the *Sixteenth USENIX Symposium on Usable Privacy and Security (SOUPS)*, pp. 81–97, Virtual Conference, August 2020.

[C5] P. Rajivan, **P. Moriano**, T. Kelley, and L. J. Camp. **What Can Johnny Do? – Factors in an End-User Expertise Instrument**. In Proceedings of the *Tenth International Symposium on Human Aspects of Information Security & Assurance (HAISA)*, pp. 199–208, Frankfurt, Germany, July 2016.

[C4] **P. Moriano** and J. Finke. **Model-based fraud detection in growing networks**. In Proceedings of the *IEEE Conference on Decision and Control (CDC)*, pp. 6068–6073, Los Angeles, CA, USA, December 2014.

[C3] **P. Moriano** and J. Finke. **Characterizing the relationship between degree distributions and community structures**. In Proceedings of the *American Control Conference (ACC)*, pp. 2383–2388, Portland, OR, USA, June 2014.

[C2] **P. Moriano** and J. Finke. **Structure of growing networks with no preferential attachment**. In Proceedings of the *American Control Conference (ACC)*, pp. 1088–1093, Washington, DC, USA, June 2013.

[C1] **P. Moriano** and J. Finke. **Heavy-tailed weighted networks from local attachment strategies**. In Proceedings of the *50th IEEE Conference on Decision and Control and European Control Conference (CDC-ECC)*, pp. 5211–5216, Orlando, FL, USA, December 2011.

Referred Workshops

[W5] **P. Moriano**, R. A. Bridges, and M. D. Iannacone. **Detecting CAN Masquerade Attacks with Signal Clustering Similarity**. In Proceedings of the *Fourth ISOC NDSS International Workshop on Automative and Autonomous Vehicle Security Workshop (Autosec)*, 2022. arXiv: 2201.02665 [cs.CR] (**Best paper award**).

[W4] D. H. Blevins†, **P. Moriano**†, R. A. Bridges, M. E. Verma, M. D. Iannacone and S. C. Hollifield. **Time-Based CAN Intrusion Detection Benchmark**. In Proceedings of the *Third ISOC NDSS International Workshop on Automative and Autonomous Vehicle Security Workshop (Autosec)*, 2021. arXiv: 2101.05781 [cs.CR].

[W3] **P. Moriano**, J. Pendleton, S. Rich, and L. J. Camp. **Insider Threat Event Detection in User-System Interactions**. In Proceedings of the *9th ACM CCS International Workshop on Managing Insider Security Threats (MIST)*, pp. 1–12, Dallas, TX, USA, October 2017 (**Best paper award**).

[W2] **P. Moriano**, E. Ferrara, A. Flammini, and F. Menczer. **Dissemination of scholarly literature in social media**. In Proceedings of the *ACM Web of Science Conference Workshop Altmetrics*, Bloomington, IN, USA, June 2014.

[W1] **P. Moriano** and F. Naranjo. **Modelado de un nuevo sistema bola viga con levitación magnética**. In Proceedings of the *4th IEEE Colombian Workshop on Robotics and Automation*, Cali, Colombia, August 2008.

Referred Abstracts & **Posters**

[A6] M. Tian and **P. Moriano**. **How Robust are Communities in Temporal Networks? A Comparative Analysis Using Community Detection Algorithms**. In *SIAM Workshop on Network Science*, Virtual, September 2022.

[A7] S. C. Hollifield, M. D. Iannacone, **P. Moriano**, and M. Boozer. **Developing and Deploying Security Applications for In-Vehicle Networks**. *Submitted*, 2021.

[A5] **P. Moriano**, J. Finke, and Y.-Y. Ahn. **Community-Based Event Detection in Temporal Networks**. In *LatinX in AI Workshop at ICML*, Long Beach, CA, USA, June 2019.

[A4] **P. Moriano**, R. Hill, and L. J. Camp. **Hijacking Network Traffic: Temporal Analysis of Adverse Changes in the Internet Topology**. In *Conference on Complex Systems (CCS)*, Thessaloniki, Greece, September 2018.

[A3] C. McElroy, **P. Moriano**, and L. J. Camp. **On Predicting BGP Anomalous Incidents: A Bayesian Approach**. In *Network and Distributed Security Symposium (NDSS)*, San Diego, CA, USA, February 2018 (**Honorable mention**).

[A2] **P. Moriano**, J. Finke, and Y.-Y. Ahn. **Community-based anomalous event detection in temporal networks**. In *Conference on Complex Systems (CCS)*, Cancún, Mexico, September 2017.

[A1] **P. Moriano**, S. Achar, and L. J. Camp. **Macroeconomic Analysis of Routing Anomalies**. In *Telecommunications Policy Research Conference (TPRC)*, Arlington, VA, USA, October 2016 (**Honorable mention**).

Other Publications

[O2] **P. Moriano** and K. Perumalla. **On the Robustness of Network Community Structure Under Addition of Edges**. ORNL Report, 2020.

[O1] **P. Moriano**. **Anomaly Detection in Real-World Temporal Networks**. Ph.D. Dissertation, Indiana University, 2019.

Patents

[P2] **P. Moriano** and J. Bryan. **A Graph Machine Learning Framework For Improving Just-in-Time Software Defect Prediction**. To be filed by October 11, 2022.

[P1] R. A. Bridges, K. A. Verma, M. D. Iannacone, Samuel C. Hollifield, **P. Moriano**, and J. Sosnowski. **Universally Applicable Signal-Based Controller Area Network (CAN) Intrusion Detection System**. U.S. Patent Application, Serial No. 17/725,774.

Software Releases

[S1] **P. Moriano** and D. H. Blevins. **Time-Based CAN IDS Paper Results Code**. **DOE CODE**, January 2022.

Grants, Gifts, and Awards

Grents

- PI: Next-Generation Security for Interconnected Systems, **Oak Ridge National Laboratory**, ($470,000) 2022

Gifts

- PI: Understanding Software Quality in Developer-Component Temporal Graphs, **Cisco Systems, Inc.**, ($87,000) 2018

Minciencias, Colombia

- Science, Technology, and Innovation Scholar 2014
- Outstanding Young Researcher Award ($10,000) 2010

Colfuturo, Colombia

- Graduate Studies Scholarship 2013

Pontificia Universidad Javeriana, Colombia

- Outstanding Lecturer 2013
- Outstanding Master Thesis 2011
- M.S. Research Scholarship 2009–2011
- Outstanding Undergraduate Thesis 2008
- Dean's List 2003–2007

Travel Grants ($10,100 in total)

- USENIX Enigma (Virtual) ($250) 2021
- International Conference for High Performance Computing, Networking, Storage and Analysis (SC) Early Career Workshop (Virtual) 2020
- CMD-IT Academic Careers Workshop (Virtual) 2020
- ACM Architectural Support for Programming Languages and Operating Systems (ASPLOS) ($1,600) 2020
- ACM-IMS Interdisciplinary Summit on the Foundations of Data Science ($1,100) 2019
- International Conference in Machine Learning (ICML) ($1,250) 2019
- CRA Grad Cohort Workshop for URMD ($1,500) 2019

- Tapia Conference Doctoral Consortium ($1,500) 2018
- IU Graduate and Professional Student Government ($500) 2017
- IEEE Symposium on Security and Privacy (IEEE S&P) ($900) 2017
- GREPSEC III Workshop ($700) 2017
- American Control Conference (ACC) ($800) 2014

Best Paper Awards

- Fourth ISOC NDSS International Workshop on Automotive and Autonomous Vehicle Security **(Autosec)** 2022
- 9th ACM CCS International Workshop on Managing Insider Security Threats **(MIST)** 2017

Talks and events

Invited Talks

- **Cyber Threats to Transportation and Innovative Technological Solutions**. Caribbean, Central America, and Mexico Regional Transport Security Series, Virtual 2022

- **Using Graphs for Improving Machine Learning: Methods and Applications**. Network Science for Fluid Dynamics Seminar Series, Virtual 2022

- **Cyber Threats to Transportation and Innovative Technological Solutions**. South American Regional Transport Security Series, Virtual 2021

- **Next Generation Anomaly Detection**. United States Army Research Laboratory 2019

- **Data and Network Science Methods for Detecting Anomalies in Time-Varying Networked Systems**. Oak Ridge National Laboratory 2019

- **Next Generation Anomaly Detection**. Information Sciences Institute. University of Southern California 2019

- **Macroeconomic analysis of routing anomalies**. Cisco Systems Research Summit. University of Pennsylvania 2016

- **Anomaly detection in temporal social networks**. Cisco Systems Research Summit. University of Pennsylvania 2016

Contributed Talks

- **Vehicle Cyber Protection**. Experience National Security Sciences event, Oak Ridge National Laboratory, 2022

- **Detecting CAN Masquerade Attacks with Signal Clustering Similarity**. The Fourth International Workshop on Automative and Autonomous Vehicle Security Workshop (Autosec), Virtual 2022

- **Using Graphs for Improving Machine Learning: Models and Applications**. CCSD Science Research Monthly Meeting Series. Oak Ridge National Laboratory, Virtual 2021

- **Time-Based CAN Intrusion Detection Benchmark**. The Third International Workshop on Automative and Autonomous Vehicle Security Workshop (Autosec), Virtual 2021

- **Protecting the Routing Cyberinfrastructure Through Machine Learning and Statistical Analysis**. NSF Cybersecurity Summit for Large Facilities and Cyberinfrastructure, Virtual 2020

- **COVID-relevant Scalable Computational Research Directions and Tools**. Information Exchange Seminar. Discrete Computing Systems Group. Oak Ridge National Laboratory, Virtual 2020

- **Hijacking Network Traffic: Temporal Analysis of Adverse Changes in the Internet Topology**. Conference on Complex Systems (CCS), Thessaloniki, Greece 2018

- **Community-based anomalous event detection in temporal networks**. Conference on Complex Systems (CCS), Cancun, Mexico 2017

- **Insider Threat Event Detection in User-System Interactions**. 9th ACM CCS International Workshop on Managing Insider Security Threats (MIST), Dallas, TX, USA 2017

- **Characterizing the relationship between degree distributions and community structures**. American Control Conference (ACC), Portland, OR, USA 2014

- **Dissemination of scholarly literature in social media**. ACM Web of Science Conference Workshop Altmetrics, Bloomington, IN, USA 2014

- **Structure of growing networks with no preferential attachment**. American Control Conference (ACC), Washington, DC, USA 2013

- **Heavy-tailed weighted networks from local attachment strategies**. 50th IEEE Conference on Decision and Control and European Control Conference (CDC-ECC), Orlando, FL, USA 2011

Community service

Memberships

- Institute of Electrical and Electronics Engineering (IEEE) senior member
- Association for Computing Machinery (ACM) member
- Society for Industrial and Applied Mathematics (SIAM) member
- Complex Systems Society (CSS) member
- Federation of Automatic Control (IFAC) technical committee member for Technology, Culture, and International Stability

Mentoring and Advising

- Moyi Tian, Ph.D. in Applied Mathematics, Brown University 2022–
- Jonathan Bryan, B.S. in Computer Science, University of Tennessee Knoxville 2021–2022
- DongInn Kim, Ph.D. in Computer Science, Indiana University 2020
- Jayati Dev, Ph.D. in Informatics, Indiana University 2019–2020
- Clint McElroy, B.S. in Informatics, Indiana University 2017–2018
- Srivatsan Iyer, M.S. in Computer Science, Indiana University 2015–2017
- Soumya Achar, M.S. in Computer Science, Indiana University 2015–2016

Master Thesis Committee

- Juan Camilo Campos, M.S. in Electrical Engineering, Pontificia Universidad Javeriana, Colombia 2018

Ph.D. Thesis Committee

- Katerine Guerrero, Ph.D. in Engineering, Universidad del Valle, Colombia 2021

Reviewing

Journal Referee

- Intelligent Systems with Applications
- International Journal of Wireless Information Networks
- Computer Networks
- Chaos: An Interdisciplinary Journal of Nonlinear Science
- Recent Advances in Computer Science and Communications
- Computers & Security
- PLOS One
- IEEE Transactions on Knowledge and Data Engineering
- IEEE Access
- ACM Transactions on Information and System Security (TISSEC)

Technical Program Committees

- The International Conference for High Performance Computing, Networking, Storage, and Analysis (SC) 2021
- Society for Advancement of Chicanos/Hispanics & Native Americans in Science (SACNAS) Conference 2019
- ICML Latin in AI Workshop 2019
- ACM Internet Measurement Conference (Shadow PC 2017)

Grant Proposal Reviewer

- DOE/ASCR Continuation of Solicitation for the Office of Science Financial Assistance Program, 2022
- Internal Reviewer for DOE Grant Proposals, 2020

Skills

Programming Languages

- Frequent user of Python for data analysis using NumPy, Pandas, Scikit-learn, Matplotlib, seaborn, Keras
- Experience with TensorFlow, PyTorch, R, MATLAB, Mathematica, C/C++
- Familiar with HTML, CSS, JS for frontend
- Used SQLite, NoSQL (MongoDB)

Spoken Langauges

- English (fluent), Spanish (native)

Extracurricular Activities

- Tennis, travel, hiking

CV updated on September 23, 2022