# LIANJIE CAO

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## RESEARCH INTERESTS

Computer Networks, Distributed Systems, Cloud Computing, Edge Computing, Serverless Computing, and Machine Learning.

## EDUCATION

**Purdue University** August 2011 - May 2018
*Ph.D.* in Computer Science West Lafayette, IN, United States
*Advisor: Professor Sonia Fahmy*

**George Mason University** September 2008 - August 2011
*M.S.* in Computer Engineering Fairfax, VA, United States
*Advisor: Professor Brian Mark*

**Huazhong University of Science & Technology,** September 2004 - June 2008
*B.E.* in Control Science and Engineering Wuhan, Hubei, China

## EXPERIENCE

**Hewlett Packard Labs, Research Scientist** August 2018 - Present

Work on performance optimization and resource allocation in large scale distributed systems such as network functions virtualization, edge computing, serverless computing, and distributed machine learning.

- **eCaaS: Edge Container Management as a Service**
  Developed an intent-based management framework for deploying and managing containerized applications on the edge. This work was published on ACM EdgeSys Workshop 2021.
- **Co-locating Containerized Workload Using Service Mesh Telemetry**
  Designed a solution to co-locate containerized application components based on application-level telemetry information collected by service mesh for reducing the negative impact of dynamic network status and improving the application performance. This work was published on ACM CoNEXT 2021.

**Purdue University, Research Assistant** August 2011 - May 2018

- **Ph.D. Dissertation: Data-driven Resource Allocation in Virtualized Environments**
  This dissertation explored and addressed performance challenges in virtualized environments by characterizing and modeling application performance for resource allocation in two application scenarios: distributed network emulation and network functions virtualization (NFV).
- **High Fidelity Network Emulation Project**
  Designed a plug-in system to improve experimental fidelity of network emulation by quantifying network processing ability of physical machines, and developing "Waterfall" algorithm (based on METIS) to separate and map a network emulation experiment onto a heterogeneous cluster. This work was published on IEEE ICCCN 2017.
- **Phishing and Malware Attacks Analysis Project**
  Analyzed over 1 billion HTTP requests/responses on the campus network of Purdue University collected by our monitoring system to understand behavior patterns of attackers and victims, and proposed several suggestions to protect users from phishing and malware attacks. This work was published on PAM 2013.

**Hewlett Packard Labs, Research Associate Intern** May 2014 - May 2017

- **Elastic Resource Allocation for NFV Project**
  Designed a framework to automatically detect VNF scaling events using neural network models, and make resource flexing plans by leveraging chaining relations of SFCs. This work was published on USENIX HotCloud 2017 and ACM ANCS 2018.
- **Performance Study of VNF Containerization Project**
  Studied and compared performance of three VNFs running in VMs and containers, and reported guidelines for building an elastic microservice architecture for NFV deployments. This work was published and selected as **best paper runner-up** on IEEE NFV-SDN 2016.

· **VNF Performance Characterization Project**
Developed a framework to systematically characterize VNF performance by monitoring resource utilization and exploring performance impact of virtualization choices, and provided corresponding deployment suggestions to meet user requirements. This work was granted the **best paper award** on IEEE NFV-SDN 2015, incorporated into HPE VNF Partner Onboarding platform, demonstrated at Mobile World Congress (MWC) Shanghai 2016 and covered by SDxCentral.

**Hewlett Packard Enterprise, SDN Engineering Intern** May 2013 - December 2013

· Simulated OpenStack network nodes and compute nodes to test the scalability of HPE data center networking solutions.

**George Mason University, Research Assistant** September 2008 - August 2010

· **Master Thesis: A Rate-based Congestion Control Overlay System**
Developed a new congestion control mechanism based on single-trip delay and fuzzy logic rules for overlay system using *Click modular router*, and evaluated the system on *Emulab*.

## AWARDS

- Best Paper Runner-up, IEEE NFV-SDN 2016
- Best Paper Award, IEEE NFV-SDN 2015
- Outstanding Bachelor Thesis of Hubei, China 2008

## PATENTS

• **Lianjie Cao**, Puneet Sharma, Faraz Ahmed, "Machine Learning-based Approaches for Service Function Chain Selection," US Patent Application 17/503,232.

• **Lianjie Cao**, Puneet Sharma, Faraz Ahmed, Ali Tariq, "Network-aware Resource Allocation," US Patent Application 17/468,517.

• **Lianjie Cao**, Puneet Sharma, Faraz Ahmed, Anu Mercian, Diman Zad Tootaghaj, "Management Framework of Edge Container as a Service for Edge Applications," US Patent Application 17/236,884.

• **Lianjie Cao**, Puneet Sharma, Faraz Ahmed, Ali Tariq, "Systems and Methods of Resource Configuration Optimization for Machine Learning Workloads - II," US Patent Application 17/199,294.

• **Lianjie Cao**, Puneet Sharma, Faraz Ahmed, "Systems and Methods of Resource Configuration Optimization for Machine Learning Workloads - I," US Patent Application 16/874,479.

• **Lianjie Cao**, Puneet Sharma, "Assignment of Microservices," US Patent 10,827,020.

• **Lianjie Cao**, Puneet Sharma, Vinay Saxena, "Virtual Network Function Resource Allocation," US Patent 11,010,205.

• **Lianjie Cao**, Puneet Sharma, Vinay Saxena, Vasu Sankhavaram, Badrinath Natarajan, "Determining Virtual Network Function Configurations," US Patent 10,489,180.

## PUBLICATIONS

• Junguk Cho, Diman Zad Tootaghaj, **Lianjie Cao**, Puneet Sharma, "SLA-Driven ML Inference Framework For Clouds With Heterogeneous Accelerators," In Proceedings of Machine Learning and Systems (MLSys), August 2022.

• Arun Raghuramu, **Lianjie Cao**, Puneet Sharma, Mario Sanchez, Joon-Myung Kang, Chen-Nee Chuah, David Lee, Vinay Saxena, "Metered Boot: Trusted Framework for Application Usage Rights Management in Virtualized Ecosystems," In IEEE Transactions on Network and Service Management (TNSM), 2022.

• **Lianjie Cao**, Puneet Sharma, "Co-locating Containerized Workload Using Service Mesh Telemetry," In Proceedings of the ACM International Conference on emerging Networking EXperiments and Technologies (CoNEXT), December 2021.

• **Lianjie Cao**, Anu Mercian, Diman Zad Tootaghaj, Faraz Ahmed, Puneet Sharma, Vinay Saxena, "eCaaS: A Management Framework of Edge Container as a Service for Business Workload," In Proceedings of the ACM International Workshop on Edge Systems, Analytics and Networking (EdgeSys), April 2021.

• Amit Sheoran, Sonia Fahmy, **Lianjie Cao**, Puneet Sharma, "AI-Driven Provisioning in the 5G Core," In IEEE Internet Computing, vol. 25, no. 2, pp. 18-25, 1 March-April 2021.

• **Lianjie Cao**, Sonia Fahmy, Puneet Sharma, "Data-driven Resource Allocation in Virtualized Environments," In Proceedings of the IFIP/IEEE International Symposium on Integrated Network Management (IM), April 2019. Dissertation Paper.

• **Lianjie Cao**, Sonia Fahmy, Puneet Sharma, Shandian Zhe, "Data-driven Resource Flexing for Network Functions Virtualization," In Proceedings of the ACM/IEEE Symposium on Architectures for Networking and Communications Systems (ANCS), July 2018.

• **Lianjie Cao**, Xiangyu Bu, Sonia Fahmy, Siyuan Cao, "Towards High Fidelity Network Emulation," In Proceedings of IEEE the International Conference on Computer Communications and Networks (ICCCN), July 2017.

• **Lianjie Cao**, Puneet Sharma, Sonia Fahmy, Vinay Saxena, "ENVI: Elastic resource flexing for Network function VIrtualization," In Proceedings of the USENIX Workshop on Hot Topics in Cloud Computing (HotCloud), July 2017.

• Amit Sheoran, Xiangyu Bu, **Lianjie Cao**, Puneet Sharma, and Sonia Fahmy, "An Empirical Case for Container-driven Fine-grained VNF Resource Flexing," In Proceedings of the IEEE Conference on Network Function Virtualization & Software Defined Networks (NFV-SDN), November 2016. **Best Paper Runner-up**

• **Lianjie Cao**, Puneet Sharma, Sonia Fahmy, and Vinay Saxena, "NFV-VITAL: A Framework for Characterizing the Performance of Virtual Network Function," In Proceedings of the IEEE Conference on Network Function Virtualization & Software Defined Networks (NFV-SDN), November 2015. **Best Paper Award**

• **Lianjie Cao**, Thibaut Provost, and Ramana Kompella, "PhishLive: A View of Phishing and Malware Attacks from an Edge Router," In Proceedings of the International Conference on Passive and Active Measurement (PAM), March 2013.

## PROFESSIONAL SERVICE

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|---|---|
| **Technical Program Committee:** | PAM 2022 |
| | IEEE/IFIP NOMS 2022 2023 |
| | IFIP/IEEE IM 2021 |
| | IFIP Networking 2019, 2020 |
| | IARIA INTERNET 2017, 2018, 2019, 2020, 2021 |
| | IARIA AFIN 2017, 2018, 2019, 2020, 2021 |
| **Reviewer:** | IEEE TNSM |
| | IEEE Sensors Journal |
| | IEEE Networking Letters |
| **External Reviewer:** | ACM SOSR, ACM CoNEXT, IEEE INFOCOM |

## TECHNICAL SKILLS

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|---|---|
| **Programing Languages:** | C/C++, Pyhon, Bash, Golang Java, Matlab, R, NS2, LaTeX, HTML |
| **Tools:** | Kubernetes, Docker, OpenStack, Open vSwtich, Mininet, Emulab |