Shouxu Lin

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Education

Cornell University 2023 – 2028 (Expected)
Ph.D. in Computer Science

Carnegie Mellon University 2021 – 2022
M.S. in Information Networking

Australian National University 2016 – 2019
B.S. in Software Engineering, with Honours

Wuhan University 2015 – 2016
B.S. in Computer Science

Selected Projects

Efficient device scheduling for multi-job federated learning
Advisors: Prof. Carlee Joe-Wong, Prof. Pei Zhang, and Prof. Haeyoung Noh *Pittsburgh, United States*

- Aimed to design an efficient device scheduler for multiple federated learning (FL) jobs to improve the overall time-to-accuracy performance in model training.
- Developed a multi-job FL framework to efficiently evaluate the performance of different scheduling algorithms on various workloads and settings, based on FedScale [ICML '22], an existing single-job FL framework.

Heterogeneity-aware multidimensional planner for DNN parallelization
Advisors: Prof. Greg Ganger and Prof. Zhihao Jia *Pittsburgh, United States*

- Aimed to automate the parallel training of DNNs on heterogeneous devices that unifies data, operator, and pipeline parallelism.
- Quantified the performance characteristic of different DNN operators on different device types.
- Developed an algorithm to slice DNN computation graphs into pipeline stages and map different stages to heterogeneous devices with the aim to minimize the end-to-end pipeline execution latency, based on dynamic programming.
- Designed experiments to evaluate the cost-efficiency improvements of using heterogeneous devices to parallelize Wide-ResNet, Transformer, and Mixture-of-Experts models.

Heterogeneity-aware ML-cluster scheduling
Advisors: Prof. Greg Ganger and Prof. Zhihao Jia *Pittsburgh, United States*

- Aimed to design an ML-cluster scheduler which considers both device heterogeneity and job elasticity.
- Implemented a discrete-time heterogeneous cluster simulator which accurately models job progress over time for multiple device types to efficiently evaluate a broad set of workloads and settings.
- Profiled and analyzed the performance of different DNNs on different device types to demonstrate the necessity of considering device heterogeneity to facilitate scheduling decisions.
- Collaborated on designing a scheduling policy with the aim to maximize the overall Goodput, a metric that combines sample-processing throughput and statistical efficiency.
- Developed a mechanism to accommodate jobs with DNNs that cannot be parallelized using data parallelism, by finding the optimal pipeline model parallel execution plan for every job on every subset of heterogeneous devices.
- Implemented and evaluated existing schedulers in our simulator, including Gavel [OSDI '20], Allox [EuroSys '20], Pollux [OSDI '21], and Shockwave [NSDI '23].
- Discovered several serious mistakes in Shockwave's original implementation and evaluation (confirmed with the Shockwave authors), which refuted the argument that Shockwave can improve job fairness.
- Reduced JCT by 27-80%, makespan by 40-85%, and GPU hours by 20-30% compared with existing schedulers.

A neural-based bandit approach to resource allocation
Advisors: Prof. Carlee Joe-Wong, Prof. Pei Zhang, and Prof. Haeyoung Noh *Pittsburgh, United States*

- Aimed to address the resource allocation problem with unknown utilities by learning the unknown utility of an arbitrary allocation via Multi-Armed Bandit (MAB) frameworks.

- Designed a scalable DNN architecture called ScaleNet that can take dynamic input sizes with carefully specified connections between the neurons to efficiently learn the total utility of allocating a dynamic number of resources.
- Devised a novel training algorithm for ScaleNet by adapting the classic backpropagation algorithm to address the problem that the parameters corresponding to different numbers of resources would be trained asynchronously.
- Proposed an online learning algorithm for ScaleNet to balance exploration and exploitation of dynamic input sizes by adapting the Upper-Confidence-Bound type algorithms.
- Showed a 50% reduction in regret compared to state-of-the-art MAB algorithms, such as ACC-UCB [AISTATS '20] and MuFasa [KDD '21].

Reliable virtualized network functions provisioning

Advisor: Prof. Weifa Liang *Canberra, Australia*

- Aimed to maximize the number of admitted requests whose reliability requirements can be satisfied by co-optimizing the number and the placement of redundancies for every requested function in every request, subject to the cloudlets' capacity.
- Proved that the defined problem was NP-hard by showing that it can be reduced from the Generalized Assignment Problem, a well-known NP-hard problem.
- Devised a randomized algorithm with a provable lower bound of the number of admitted requests and an upper bound of the constraint violations.
- Designed a heuristic algorithm without constraint violations, based on Maximum Bipartite Matching.
- Achieved $> 90\%$ of the number of admitted requests with $< 10\%$ constraint violations compared to the optimal solution.

Other Projects

- Implemented a distributed model training module of ACAI, an end-to-end cloud-based platform that manages the entire lifecycle of the machine learning model development process, using Ray and Kubernetes.
- Built a cloud-backed local file system with block-level deduplication, taking/restoring snapshots, and local caching for cloud-backed data.
- Built a flash translation layer for an emulated SSD with garbage collection, trim, and wear leveling scheme.
- Designed an auto-scaling mechanism for an image classification application using a customized AWS auto-scaling controller and AWS Lambda.
- Developed a distributed ETL processing program and model training program using Spark.
- Built a fault-tolerant distributed file system with a dynamic master selection mechanism based on the Raft algorithm.
- Designed a hardware circuit for Unum Arithmetic using Vivado high-level synthesis.

Publications

- FLAMMABLE: A Multi-Model Federated Learning Framework with Multi-Model Engagement and Adaptive Batch Sizes
  Shouxu Lin, Zimeng Pan, Yuhang Yao, Pei Zhang, Hae Young Hoh, Carlee Joe-Wong
  7th Conference on Machine Learning and Systems (MLSys), 2024 (under review)
- Sia: Heterogeneity-aware, goodput-optimized ML-cluster scheduling
  Suhas Subramanya, Daiyaan Arfeen, **Shouxu Lin**, Aurick Qiao, Yonghao Zhuang, Xupeng Miao, Amar Phanishayee, Zhihao Jia, Greg Ganger
  17th USENIX Symposium on Operating Systems Design and Implementation (OSDI), 2023 (under review)
- A Neural-Based Bandit Approach to Mobile Crowdsourcing
  Shouxu Lin, Yuhang Yao, Pei Zhang, Hae Young Hoh, Carlee Joe-Wong
  23rd Annual International Workshop on Mobile Computing Systems and Applications (HotMobile), 2022
- Reliability-Aware Service Function Chain Provisioning in Mobile Edge-Cloud Networks
  Shouxu Lin, Weifa Liang, Jing Li
  29th International Conference on Computer Communications and Networks (ICCCN), 2020
- Emotion Recognition Through Observer's Physiological Signals
  Yang Liu, Tom Gedeon, Sabrina Caldwell, **Shouxu Lin**, Zi Jin
  arXiv preprint arXiv:2002.08034, 2020

Honors & Awards

- Cornell University Fellowship 2023
- Carnegie Mellon University INI Outstanding Research Assistant Reward 2023
- Carnegie Mellon University INI Scholarship 2021
- Australian National University Distinguished Research Scholarship. 2019
- 'Top 5 award' in the InnovationACT entrepreneurship competition with an $8,750 grant. 2018
- 'Startup of the year' in the digital Canberra iAwards. 2018
- Chinese Patent - Smart Door Lock 2015