Kausik Subramanian

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My research lies in the application of formal reasoning and programming languages techniques for verification and synthesis of networks. I am currently a Software Engineer working on datacenter routing at Google.

Education

○ **University of Wisconsin-Madison**
PhD Computer Science, CGPA: 3.868/4.00   *Aug 2015 - July 2020*
Advisors: Aditya Akella and Loris D'Antoni

○ **Indian Institute of Technology, Bombay**
BTech. Computer Science and Engineering   *June 2011 - May 2015*
Advisors: Purushottam Kulkarni and Umesh Bellur

Experience

○ **Google, Sunnyvale, USA**   *Aug 2020 - Present*
Software Engineer, Routing Engine   Manager: Leon Poutievski
  – Working on Google's data center routing platform. Responsibilities include ideation and implementation of new projects to serve different customers of Routing Engine.

○ **Facebook Menlo Park, USA**   *May 2019 - Aug 2019*
Software Engineering Intern   Mentors: Mahesh Maddikayala, Hyojeong Kim, James Zeng
  – Worked on OpenR (https://github.com/facebook/openr), Facebook's internal routing platform. Implemented the Netlink protocol for OpenR (∼3k LoC) to interface with the Linux kernel to program routes and listen to link/address/route events for protocol convergence.
Research Collaborator, Network Routing   *Nov 2019 - Jul 2020*
  – Worked on presenting Facebook's operational experience of deploying and running an in-house BGP implementation in their data centers.

○ **Microsoft Research, Cambridge, UK**   *May 2018 - Aug 2018*
Research Intern, Network Verification   Mentors: Andrey Rybalchenko and Nuno Lopes
  – Worked on developing a framework to for global MPLS tunnel path allocation for Microsoft's Wide Area Network. Using the framework, we analyse current production network allocation with the optimal allocation to make recommendations for improvements and future planning of the WAN.

○ **Barefoot Networks, Santa Clara, USA**   *May 2017 - Sep 2017*
Research Intern, Advanced Applications   Mentors: JK Lee, Robert Soule and Changhoon Kim
  – Implemented various static analysis techniques for optimizing P4 programs in the Barefoot Tofino backend compiler pertaining to table dependencies and metadata usage based on P4 developers' programming styles. Made several bug fixes to the open-source P4 compiler.

○ **Samsung Electronics, Suwon, South Korea**   *May 2014 - July 2014*
Research Intern, Software R&D Center   Mentors: Jeongshik In and Jaehoon Ko
  – Proposed four Optimizations for Hadoop's Distributed File System. Analysed and modified HDFS to find the performance bottlenecks and add features to block placement and replication policy modules.

○ **Fraunhofer ITWM, Kaiserslautern, Germany**   *May 2013 - July 2013*
Research Intern   Mentor: Mirko Rahn
  – Implemented the Chord distributed hash table protocol using Fraunhofer's communication middleware GPI, which provides synchronous and asynchronous communication methods

Patents & Publications

○ **DISTRIBUTED, PACKET-MEDIATED, PACKET ROUTING**
Loris D'Antoni, Srinivsa Akella, <u>Kausik Subramanian</u>
US Patent No: US11075835B2
  - A network switch holds a routing table and a network topology table so that when a link failure is detected at the network switch, the network switch may independently reroute a packet intended for that failed link using the network topology table. This processing can be performed in the data plane at a speed that can eliminate dropped packets.

○ **Doing more by doing less: how structured partial backpropagation improves deep learning clusters**
Adarsh Kumar, <u>Kausik Subramanian</u>, Shivaram Venkataraman, and Aditya Akella
DistributedML 2021: Proceedings of the 2nd ACM International Workshop on Distributed Machine Learning
  - In this work, we exploit the unique characteristics of deep learning workloads to propose Structured Partial Backpropagation(SPB), a technique that systematically controls the amount of backpropagation at individual workers in distributed training. This simultaneously reduces network bandwidth, compute utilization, and memory footprint while preserving model quality.

○ **D2R: Policy-Compliant Fast Reroute**
<u>Kausik Subramanian</u>, Anubhavnidhi Abhashkumar, Loris D'Antoni, and Aditya Akella
Proceedings of ACM SIGCOMM Symposium on SDN Research (SOSR) 2021
  - We take advantage of the recent advances in fast programmable switches to perform policy-compliant route computations entirely in the data plane, thus providing fast and programmable reactions to failures. D2R provides the illusion of a hierarchical network fabric that is always available and policy-compliant under failures.

○ **Running BGP in Data Centers at Scale**
Anubhavnidhi Abhashkumar*, Kausik Subramanian*, Alexey Andreyev, Hyojeong Kim, Nanda Kishore Salem, Jingyi Yang, Petr Lapukhov, Aditya Akella, and Hongyi Zeng
Proceedings of 18th USENIX Symposium on Networked Systems Design and Implementation (NSDI '21)
  - We present Facebook's BGP-based data center routing design and how it marries data center's stringent requirements with BGP's functionality, design and implementation of an in-house BGP stack and operational experience of running BGP at scale.
  - *Both authors contributed equally to this work.

○ **Detecting Network Load Violations for Distributed Control Planes**
<u>Kausik Subramanian</u>, Anubhavnidhi Abhashkumar, Loris D'Antoni, and Aditya Akella
Proceedings of 41st ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI 2020), London, UK, (22% acceptance rate)
  - By using an abstract representation of the control plane (ARC), we formulate a multi-node Mixed-Integer Linear Program which can be used to verify across machines if network links are overloaded (utilization exceeds capacity) under different failure scenarios. QARC models different routing protocols like OSPF and BGP and distributed load balancing strategies like ECMP/WCMP.

○ **Liveness Verification of Stateful Network Functions**
Farnaz Yousefi, Anubhavnidhi Abhashkumar, <u>Kausik Subramanian</u>, Kartik Hans, Soudeh Ghorbani, and Aditya Akella
Conference: Proceedings of 17th USENIX Symposium on Networked Systems Design and Implementation (NSDI 2020), Santa Clara, California, USA, (18% acceptance rate)
  - Liveness properties are important for stateful network function verification. In this work, we provide a

compositional programming abstraction that decouples reachability from stateful network functions and model the behavior of the programs expressed in this abstraction using compact Boolean formulas. We provide a compiler that translates the programs written using our abstraction to P4 programs.

○ **Synthesis of Fault-Tolerant Distributed Router Configurations**
<u>Kausik Subramanian</u>, Loris D'Antoni, and Aditya Akella
Conference: Proceedings of the ACM on Measurement and Analysis of Computing Systems (SIGMETRICS 2018), Irvine, California, USA
Journal: Proceedings of the ACM on Measurement and Analysis of Computing Systems Volume 2 Issue 1 March 2018 Article No.: 22 pp 1–26 (https://doi.org/10.1145/3179425)
  - A two phase synthesis algorithm for generating policy-compliant OSPF and BGP configurations which comply with high-level policies, even under failures. First, we use Genesis to synthesize a policy-compliant data plane, and then Zeppelin uses ILP solvers to generate OSPF and BGP configurations which converge to the policy-compliant data plane.

○ **Genesis: Synthesizing Forwarding Tables in Multi-tenant Networks**
<u>Kausik Subramanian</u>, Loris D'Antoni, and Aditya Akella
Conference: 44th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2017), Paris, France, (23% acceptance rate)
Journal: ACM SIGPLAN Notices Volume 52 Issue 1 January 2017 pp 572–585 (https://doi.org/10.1145/3093333.3009845)
  - A general and extensible approach to synthesize policy-compliant SDN forwarding tables for multi-tenant cloud settings using SMT solvers. Can support complex policies like reachability, waypoint traversal, path isolation and traffic engineering

Professional Service

○ Technical Program Committee - ACM SIGCOMM Symposium of SDN Research (SOSR) 2022
○ External Reviewer - ACM SIGCOMM 2021

Talks and Posters

○ D2R: Detecting Network Load Violations for Distributed Control Planes
  Talk at SOSR 2021 (Virtual)
○ QARC: Detecting Network Load Violations for Distributed Control Planes
  Talk at PLDI'20 (Virtual)
○ Zeppelin: Synthesis of Fault-Tolerant Distributed Router Configurations
  Talk at SIGMETRICS'18, Irvine, California, USA
○ Genesis: Synthesizing Forwarding Tables in Multi-tenant Networks
  Talk at POPL'17, Paris, France
  Talk at VMWare Research Group, August 2017
○ Synthesizing Data and Control Planes for Multi-tenant Networks
  Poster at Google Networking Research Summit 2017
  Poster at NSF workshop on Programmable Networks, NYU, 2018

Academic Honors

○ Awarded the UW-Madison CS Summer Research Assistantship, 2016.
○ Awarded Student Grants to attend SIGCOMM 2016, POPL 2017 and SIGMETRICS 2018.
○ Secured All India Rank 87 in IIT-JEE 2011 out of 485,000 students.
○ Secured All India Rank 3 in 10th CBSE Board Examination, 2009. Invited by the Prime Minister's Office to witness the Republic Day Parade from the Prime Minister Box in New Delhi in 2010