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**
M.S Computer Science, CGPA: 3.868/4.00   *Fall 2015–Fall 2017*
PhD Computer Science, Advisors: Aditya Akella and Loris D'Antoni   *Fall 2017–Summer 2020*

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

Experience

○ **Google, Sunnyvale, USA**   *08/31/2020-Present*
Software Engineer, Routing Engine   Manager: Rob Adams
  - 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**   *05/20/2019 - 08/09/2019*
Software Engineering Intern   Mentors: Mahesh Maddikayala, Hyojeong Kim, James Zeng
  - Worked on OpenR (https://github.com/facebook/openr), Facebook's internal routing platform. I 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   *11/04/2019-07/01/2020*
  - Worked on presenting Facebook's operational experience of deploying and running an in-house BGP implementation in their data centers.

○ **Microsoft Research, Cambridge, UK**   *05/15/2018-08/03/2018*
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**   *05/29/2017 - 09/01/2017*
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 (https://github.com/p4lang/p4c).

Publications

○ **Detecting Network Load Violations for Distributed Control Planes**
Kausik Subramanian, 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
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
Proceedings of the ACM on Measurement and Analysis of Computing Systems (SIGMETRICS 2018), Irvine, California, USA
  - – 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
44th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2017), Paris, France, (23% acceptance rate)
  - – 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

- ○ **D2R: Dataplane-Only Policy-Compliant Hierarchical Routing**
<u>Kausik Subramanian</u>, Anubhavnidhi Abhashkumar, Loris D'Antoni, and Aditya Akella
Under submission
  - – We design a network architecture where routing (computing active network paths) is done completely in the data plane using programmable P4 switches. Packets carry failure information and each switch can performs hierarchical graph traversal algorithms completely in the data planes at near line rates, and thus, avoiding losses incurred due to slow control planes.

Talks and Posters

- ○ 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

o Awarded the UW-Madison CS Summer Research Assistantship, 2016 (awarded to 6 people).
o Awarded Student Grants to attend SIGCOMM 2016, POPL 2017 and SIGMETRICS 2018.
o Secured All India Rank 87 in IIT-JEE 2011 out of 485,000 students.
o Secured All India Rank 3 in 10th CBSE Board Examination, 2009. Was invited by the PM's Office to witness the Republic Day Parade from the Prime Minister Box in New Delhi in 2010

Technical and Personal skills

o Proficient in Python, C++, Java, Z3, Gurobi, LaTeX, P4
o Familiar with Android, Hadoop, POX

Courses

o *Networks/Systems*: Advanced Networking, Big Data Systems
o *Programming Languages*: Program Verification and Synthesis, Theory of Programming Languages, Advanced Compilation
o *Pedagogy*: Teaching in the College Classroom, Effective Teaching in Internationally Diverse College Classroom
o *Miscellaneous*: Topics in Databases, Advanced Algorithms, Computational Complexity Theory, Management and Marketing, and Accounting and Finance for non-Business majors

Positions of Responsibility

o Mentor, Institute Student Mentorship Programme   2014-15
  Mentoring a group of 12 freshmen and easing their transition to the academic and social aspects of institute life. Also serving as a Department Academic Mentor to 12 sophomores, guiding them about CS academic aspects.
o Internship Coordinator, Placement Cell   2013-14
  Involved in the communication and scheduling of various companies as well as universities and assisting them in the process of recruiting of students for internships. Awarded Certificate of Appreciation by Dean, Academic Affairs for exemplary work during the tenure.