Software defined networking for large networks and stateful data planes
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Research context and motivation
Stateful Data Plane in Software Defined Networks

- OpenFlow
  - Stateless switches, all the states in the SDN controller
  - Limited reactivity due to the (logically) centralized approach
- OpenState, OpenPacketProcessor (OPP), P4
  - Allow some level of stateful processing (e.g., finite state machines) within switches
  - Reduced interaction with the controller
  - Allows local decisions at switches

Adopted methodologies
- Optimal state replication, finds:
  - number of copies per state
  - placement of the copies for each state
  - such that the total traffic in the network is minimized
  - total traffic = data traffic + \( A_x \times \text{sync traffic} \)
- ILP formalization using CPLEX in JAVA (not scalable)

Addressed research questions/problems
- State description
  - SNAP* as abstraction to describe a network application
  - Dependency graph to describe relation between different states
- SNAP solves state placement and traffic routing problem
  - Given a sequence of states affected by each flow:
    - Finds where to place the states
    - Routes data traffic through the states
    - Objective: minimize the total traffic in the network
  - Single copy for each state
  - All the flows affecting one state must pass through the node storing the state
    - Possible network bottleneck

Novel contributions
State Replication for Programmable Stateful Data Planes
- We allow multiple copies of each state**
  - Reduces network bottleneck
- Optimal replication of states
  - Where to place each copy of a state and how to route the flow to any copy of a state
  - Integer Linear Programming (ILP) formalization
  - Approximation algorithm
- Proof of concept in P4 and OPP

Submitted and published works
- "A. S. Muqaddas, A. Bianco, P. Giaccone and G. Maier, "Inter-controller traffic in ONOS clusters for SDN networks," IEEE ICC, Kuala Lumpur, Malaysia, May 2016"

Future work
- Improvements to approximation algorithm
- Extending to state dependency scenario
- Exploring other metrics for candidate state nodes based on inter-cluster traffic flows
- Explore if state synchronization can be implemented using strongly consistent techniques

Additional work
- Analysis of inter-controller traffic exchanged among controllers in an ONOS cluster to synchronize the shared data structures (topology store, flow store, host store)
- Utilizing time-synchronized operations in Software-defined Elastic Optical Networks for disruption time reduction in lightpath re-routing"}

List of attended classes
- "ONMRV – Computer Ethics (11-5-2016, 4 CFU/Hours)"
- "O1DTU – Free software and hardware (27-5-2016, 4 CFU/Hours)"
- "O1ORSN – Stochastic processes and queuing theory (10-6-2016, 4 CFU/Hours)"
- "O1ORSN – Optimization methods for engineering problems (10-6-2016, 6 Hours)"
- "O1ORRV – Writing Scientific Papers in English (10-6-2016, 3 CFU/Hours)"
- "O1OPC – Packet switch architectures (20-6-2016, 8 CFU/Hours)"
- "O1MLVE – Complex Networks: Models and Applications (21-6-2016, 4 CFU/Hours)"
- "O2WHY – Communication (20-9-2016, 1 CFU)"
- "O3KTRV – Project management (20-9-2016, 1 CFU)"
- "O1RISN – Public speaking (20-9-2016, 1 CFU/Hours)"