The State of the Art on Software-Defined Measurements

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Outline

- Introduction
- Background
- Survey Description
- Trends and Research Challenges
- Outlook

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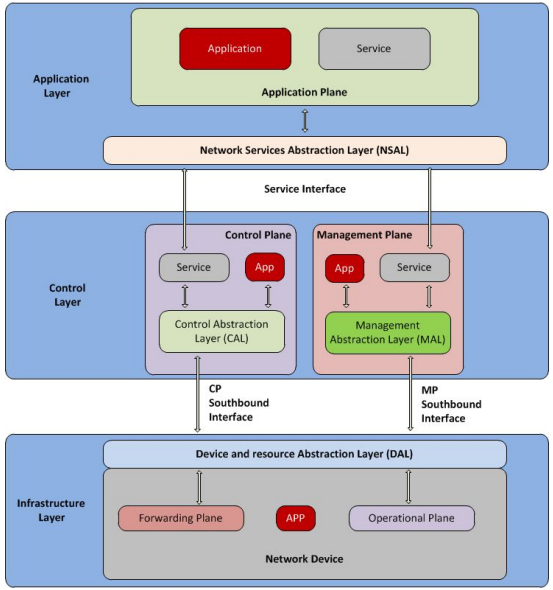
Introduction

- Software-Defined Networking (SDN) → one of the most relevant networking paradigms in the last decade
  - Separation of control/data planes
- Demands of modern networking environments
  - Cloud, Data Centers, Internet eXchange Points



SDN Layer Architecture
RFC 7426

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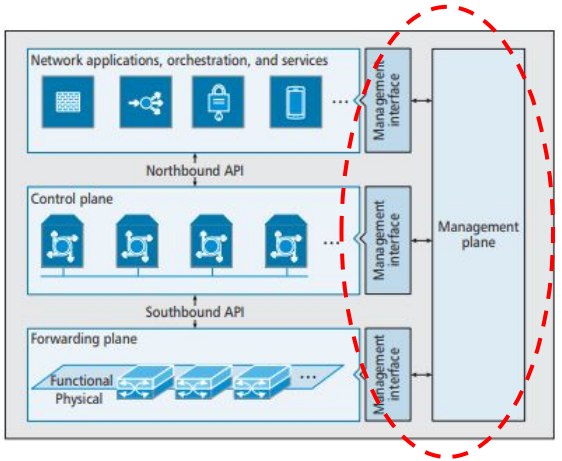
Introduction

- SDN → opportunities for network management using alternative and complementary approaches
  - Network measurements → critical network management task that can benefit from SDN innovations
    - Novel approaches emerged exploiting such innovations



High-level conceptual architecture of SDN
Wickboldt et. al, 2015

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Introduction

- SDN → developing management apps that run inside logically centralized network controllers
  - E.g., measurement applications that collect data from the network and derive metrics
    - OpenFlow protocol used to retrieve per-flow statistics to compute delay and jitter
- What is a "Software-Defined Measurement" (SDM)?
  - Use of SDN techniques to perform measurements?

Proposed Survey

- Goal → comprehensive review of the current efforts on SDM
  - Description of a set of criteria used to analyze and compare the SDM initiatives
- Our ongoing work → current landscape on network measurement solutions that exploit SDN benefits and innovations, which contributes to both network management and SDN fields

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SDM or Measurements on SDN?

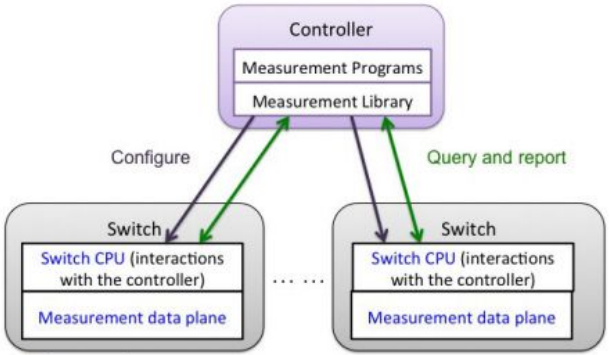
- Management of networks based on SDN paradigm imposes challenges for network operators
  - Logical part way more complex assuming that control and forwarding protocols can be redesigned
- Examples of “SDN measurement apps”
  - Flow statistics in different abstraction levels
  - Set forwarding rules in response to some events
  - Injection of packets to measure end-to-end delay

SDM or Measurements on SDN?

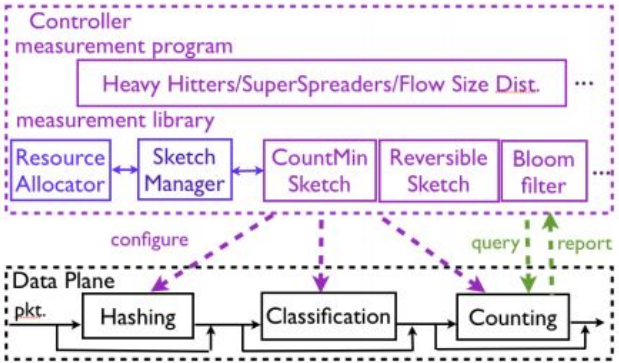
- Although SDN measurement apps achieve relevant measurement data → majority still based on embedded SW to perform a predefined set of measurements tasks
  - Similar to solutions in traditional networks
- Our position → fully SDM techniques go beyond, providing a certain level of programmability of the measurement task for the operator
  - API or language that control measurement tasks

Example - OpenSketch

- Yu et al., 2013
  - SDM architecture considering data and control planes



Software defined traffic measurement
Yu et al., 2013



OpenSketch Architecture
Yu et al., 2013

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Example - OpenSketch

- Programming measurement tasks
  - "Sketches" → traffic statistics, flow identification, etc
    - Additional sketches can be implemented
  - Measurement programs → integration of sketches

Superspreader/DDoS	A *k*-superspreader is a host that contacts more than *k* unique destinations during a time interval. A DDoS victim is a host that is contacted by more than k unique sources.	*Count-Min sketch* to estimate counts for different sources, *bitmap* to count distinct destinations for each *Count-Min sketch* counter, *reversible sketch* to identify sources in *Count-Min sketch* with heavy distinct counts

Implementing measurement tasks using the OpenSketch library
Yu et al., 2013

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Survey Summary

- Initial set: ~300 papers
- Exclusion criteria
  - Not SDN related
  - No evaluation
  - No programmability
- Final set: ~15 papers

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Proposed Classification

- Intrusiveness level
  - Classification based on the RFC 7799
    - Passive, active, or hybrid (type I or II)
- Distribution paradigm
  - Control and data plane
    - Centralized, distributed

	Single Stream of Interest	Multiple Simultaneous Streams of Interest from Different Methods
Single Fundamental Method	Active or Passive	
Synthesis of Fundamental Methods	Hybrid Type I	
Multiple Methods	Spatial Metrics [RFC5644]	Hybrid Type II

Categorization of methods
RFC 7799

Proposed Classification

- Network metrics
  - Traditional ones
    - E.g., latency, jitter
  - SDN specifics
    - E.g., flow-specific, controller-specific
- Instrumentation requirement
  - Different degrees of instrumentation
    - Data collection ↔ modifications in SDN environment

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Proposed Classification

- Functional areas
  - Based on ISO/OSI FCAPS categories
    - Fault, Configuration, Accounting, Performance, and Security)
  - Several proposals address more than one area

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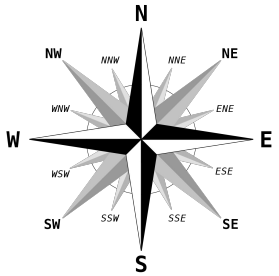
Trends and Research Challenges

- Substantial interest on SDM → research areas that could potentially attract more attention in the following years
  - East-West Application Programming Interfaces (APIs)
  - Architecture and relationship of test and control protocols
  - Measurement dependability

Trends and Research Challenges



- East-West APIs
  - Network-wide SDMs → ability to provide comprehensive metrics for network infrastructures
    - Multi-controller environment → interactions among different controllers potentially required
      - Measurement federations and large-scale measurements
  - Standard API for controllers communication missing
    - As for general SDN OAM

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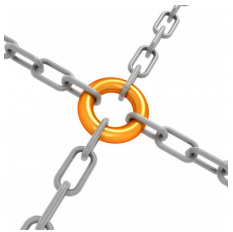
Trends and Research Challenges

- Architecture and relationship of test and control protocols
  - Measurement roles
    - Roles dependent of the measurement architecture
    - Measurement roles potentially deployed in different nodes regarding a SDN infrastructure
  - Separation on SDM protocols paired with SDN planes
    - Interfaces from SDN and SDM could be connected to perform integrated measurements

Trends and Research Challenges



- Measurement dependability
  - Disconnection between the forwarding and control planes can lead to resilience issues in SDM
    - Specially when the control of the measurement is hosted within a single node
  - Isolation among different measurement sessions
  - Protection/restriction regarding the use of network and computing resources

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Concluding Remarks

- The SDN paradigm enabled opportunities to make network infrastructures more flexible, dynamic, and customizable
- The SDM concept incorporates into measurements SDN features
  - … and more importantly **programmability**
- Particularly important considering the increasing complexity of computer networks

Thanks.

Questions?

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