PayLess: A Low Cost Network Monitoring Framework for Software Defined Networks

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This work has been supported by NSERC discovery grant and SAVI research network

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Typical SDN Scenario

- **Data Plane**
- **Control Plane (NOX/POX/FloodLight/Beacon etc.)**
- **Northbound API (non-standard)**
- **Southbound API (e.g., OpenFlow)**
Application Development over SDN: Current Scenario

Management Plane

Monitoring Application (e.g., Link Utilization Monitor, User Billing)

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Northbound API

Control Plane (NOX/POX/FloodLight/Beacon etc.)

Southbound API

Data Plane
Application Development over SDN: Current Scenario (contd…)

Control Plane (NOX/POX/FloodLight/Beacon etc.)

- Monitoring Application (e.g., Link Utilization Monitor, User Billing)
- Non-standard, Controller Dependent

Controller API

Applications become “part” of the controller

Data Plane
Application Development over SDN: Proposal

- **User Billing**
- **IDS**
- **Usage Monitor**

- **RESTful API**
- **Northbound API**
- **Southbound API - OpenFlow**

- **Network Monitoring Framework**

- **Control Plane (NOX/POX/FloodLight/Beacon etc.)**

- **Data Plane**

- **Monitoring Applications**
Application Development over SDN: Proposal

User Billing  
IDS  
...  
Usage Monitor

Monitoring Applications

RESTful API

PayLess

Network Monitoring Framework

Northbound API

Control Plane (NOX/POX/FloodLight/Beacon etc.)

Southbound API - OpenFlow

Data Plane
PayLess Architecture

- User Billing
- IDS
- Scheduler
- Switch Selector
- Aggregator
- Data Store

Monitoring Applications

PayLess RESTful API

Controller Driver and Plug-in
PayLess Architecture (contd...)

- Each component has well-defined interface
  - Can be easily replaced by a custom implementation
    - i.e., data aggregation level, sampling algorithm etc. can be customized
PayLess Architecture (contd…)

- Determines **what** to monitor by translating monitoring requests from the applications
  - Requests are sent in JSON format
    - May contain:
      - Type (performance, security, fault etc.)
      - Monitoring metric (what to measure)
      - Entity (which network entity to monitor)
      - Aggregation level (per switch/user/flow etc.)
      - Priority (real-time, medium, low)
      - Logging (format of the log)
PayLess Architecture (contd...)

- Determines *when* to collect statistics from the network.
  - Periodic
  - At specific events
  - Adaptive sampling
  - etc.
PayLess Architecture (contd…)

- Determines *which* subset of network elements should be probed for statistics.
  - Only the ingress and egress switches
  - Switches with maximum connectivity
  - etc.
PayLess Architecture (contd...)

- Aggregates the raw monitoring data as per application requirement
  - Per link aggregation
  - Per user aggregation
  - Per switch aggregation
  - etc.
PayLess Architecture (contd…)

- RESTful API for developing monitoring applications
  - Applications can be oblivious of control plane technology
  - Applications can be written in any Language
  - Despite of the control plane technology, applications have the same set of services available
Implementation

- Application
  - Adaptive Link Usage Monitoring

- Scheduler
  - We propose an adaptive sampling algorithm
    - Adjust the monitoring frequency according to network load.
    - Assign a monitoring time out to each flow
    - Query the switch(es) for flow statistics when timeout expires
    - If no significant traffic change ($\leq \alpha$), increase the timeout (up to $T_{max}$)
    - If change in traffic is significant ($\geq \beta$), decrease the timeout (up to $T_{min}$)

- Switch selector:
  - Query all the switches

- Aggregator
  - Aggregate data per link
Evaluation: Setup

- Simulation using Mininet and Floodlight controller
- Topology
  - Hierarchical topology to emulate behavior of a scaled down data center
  - $\alpha = \beta = 100\text{MB}; T_{\text{max}} = 5\text{s}, T_{\text{min}} = 500\text{ms}$
  - Monitor the usage of Sw-0 – Sw-1 link over time
Evaluation: Utilization

- Comparison with FlowSense*, and Periodic polling (every 500ms)

Evaluation: Overhead

Overhead is measured by the number of monitoring queries.

PayLess can reduce the messaging overhead **up to 50%** compared to periodic polling.
Conclusion

Summary
- State-of-the art controllers offer different northbound APIs. We need an uniform API for network applications
- Payless is a step to provide unified API for monitoring application development

Future Works
- Full fledged implementation
- Develop a QoS policy enforcement application* over PayLess

Questions?
Evaluation: Effect of $T_{min}$

- $T_{min}$ is the minimum polling timeout.
- $T_{min}$ is varied (250ms – 2s) to observe its effect on accuracy and overhead.
  - Accuracy was measured as rms error between PayLess and periodic polling over 250ms interval.
Related Works

- **OpenTM (PAM ‘10)**
  - Heuristics on *which* OpenFlow switches to query for measuring traffic matrix

- **FlowSense (PAM ‘13)**
  - Event based link utilization monitoring in SDN.
  - No additional measurement overhead.

- **OpenSketch (NSDI ‘13)**
  - Clean slate redesign of data plane to support monitoring in SDN