Decision-making System driven by Big Data Telemetry for SDN and Traditional Networks

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*MEF acting as main Project Customer. POC TBD.*

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1.0 Problem or Need

In the early, to mid-1990s the Internet’s growth changed the rules and due process in the daily lives of users all around the globe. What started as email for scientists and early file transfer systems, is now what moves every fiber of society regardless of culture, expertise or even direct exposure to connectivity.

As Internet traffic increased over the years, it was soon evident that traditional IP network management practices fall short when it comes to areas such as control over paths used to route traffic. In [1], traffic-engineering capabilities under traditional networks, even in the early 2000s, are characterized by the following statement: “The means for performing traffic engineering using conventional routing protocols were primitive at best.” Researchers foresaw the need to transition to a more programmable networking practice and the foundation for Software Defined Networks (SDN) was established.

The concept of SDN revolutionized the way network engineers approach to traffic engineering by allowing a high level of abstraction in comparison with traditional networks. A typical intent-based approach allows a user or application to only specify the intent such as the requirement of low latency path between two nodes, bandwidth reservation, and real-time monitoring for the re-evaluation of selected paths [2]. In theory, this characteristic alone should be a “blanket” solution for efficient routing decisions.

However, SDN adoption has been challenging. Only in recent years, the industry has finally entered a transition stage from traditional networking practices. The global SDN and Network Functions Visualization (SDN/NFV) market is expected to grow from $3.68 billion in 2017 to $54.41 billion by 2022, at a Compound Annual Growth Rate (CAGR) of 71.4% [3]. While some telecom providers such as AT&T and Verizon have already started implementing an SDN based architecture [4], many other providers are relying on mixed and hybrid models moving forward. When a network is designed to work with both traditional and SDN elements, it impairs the ability of the network manager to use some of the core benefits of SDN, such as making intelligent, global decisions for the network driven by the controller.

Making this moment an ideal setting to introduce a game-changing strategy for traffic engineering in a transitional era:

What if the mechanics of SDN’s intent based networking can be leveraged to model an intelligent decision-making process compatible with traditional, mixed, hybrid and SDN to enable comprehensive analysis and traffic engineering?
2.0 Previous Work

SDN and Big Data tools such as the Platform for Network Data Analytics (PNDA), which is specifically designed for network data analytics, have been the source of continuous application development as the Industry seeks innovation to provide end customers the best and most profitable experience in the network.

New methodologies that have emerged recently have served as key drivers to SDN based solutions. One example of a case where an innovative approach was merged with an SDN solution was a capstone conducted by Interdisciplinary Telecom Program (ITP) Masters’ candidates titled “A Practical Framework for the Automation of Traditional and SDN Devices using a DevOps Approach” [5]. For their investigation, the group leveraged an innovative approach to software development called Development and Operations (DevOps) to push forward a system to automate network management practices in Traditional and SDN networks.

In “SDN-PANDA: Software-Defined Network Platform for Anomaly Detection” [6], the authors were able to develop, as described in their documentation, a “pluggable” software platform that aims to provide centralized administration and experimentation for anomaly detection techniques in Software Defined Data Centers (SDDCs).

While the scope of both projects has a level of overlap with our objectives, the innovation of our solution relies on developing a python framework that acts as a “Network Agnostic” (SDN vs Traditional) tool to make global, intelligent networking decisions based on telemetry data collected from the underlying network configuration. This project will lead to better user experience, higher uptime, faster recovery and prevention of suboptimal routing.

3.0 Specific Objectives

**Level 1:**

**Objective:** Create a Python-based framework, which can efficiently perform telemetry data collection from both an SDN controller and traditional network devices.

**Requirements:** Data collection has to be fault tolerant, reliable, and scalable. Once the data is collected, it must be sent to PNDA for storage, processing, and general trends analysis. Additionally, all steps of the process should be accessible for monitoring via a web-based Graphical User Interface (GUI) interface with a limited control over the process.

**Business/Policy:** Document industry tendencies and trends regarding SDN penetration and traditional vs mixed vs hybrid vs fully SDN. Study the policy case implications of data collection in the main telecommunications markets around the globe to determine if it would affect a widespread implementation of a data collection and analysis system.
Level 2:

Objective: In addition to fulfilling all Level 1 requirements, the system will progress to analyze data in order to predict basic networking decisions such as best path routing based on multiple criteria.

Requirements: In order to do this, it must discern data relevant for each type of networking decision. The data analyzed will depend on what objective will be the key driver to traffic decisions such as CPU utilization, load balancing, or traffic engineering. The web-based GUI should offer the option to navigate between types of networking decisions.

Business/Policy: Develop a business analysis for the scalability of the project. Including financial implications of handling larger amounts of traffic derived from aspects such as processing power and server storage capacity. Determine barriers for agreements with Internet Service Providers (ISPs) to subject their traffic to a centralized analysis alongside other providers.

Level 3:

Objective: After testing and ensuring the success of Level 2 technical requirements and completing non-technical objectives, it will be necessary to reinforce and test security within the system.

Requirements: Incorporate traffic encryption as it is retrieved from the underlying network and sent to the central repository of information. Once all traffic handling is secure, start aggregating functionalities to the Python framework such as detection and prevention of common threats to networks. Test a self-healing proposal for the handling of top common failures in networking systems such as errors in configuration of devices bringing down sectors of the network.

Business/Policy: Develop a financial study on benefits of making routing decisions based on non-traditional criteria with a large sample of ISPs. Moreover, define a common policy framework that would be applicable to the top telecommunications markets in order for the project to be applicable to a large sample of global Internet traffic.
4.0 Functional Requirements

Figure 1. Overview of the System

Figure 2. Concept of Operations (CONOPS) diagram
The general overview of the system can be seen in Figure 1, which aligns with the technical requirements described in section 3.0.

Now, considering a scenario where Host A in one network wishes to communicate with Host B in another network, Figure 2 shows an example of analyzing the interaction going through the data collection and best path routing system:

1. The Python based software is actively collecting data from all networks regardless of their configuration and sending information to PNDA for storage and analysis.

2. When Hosts A communicates with Host B, when defined by the operator via the GUI, the Python framework queries PNDA’s database for the best networking decision.

3. PNDA sends back the information necessary to decide on the best path the traffic could take when different routing criteria are applied.

4. The Python software will be the decision maker, based on the user’s request, on what solution to send back as a command for the system, considering relevant factors such as latency and throughput depending on the type of traffic. I.e. when handling a video upload request, the script would prioritize throughput as opposed to a file download where latency could be prioritized when making the decision.

5. Once a decision is made, the Python script relays it to the networking devices via an API or socket.

5.0 Critical Project Elements

**Technical**

**CPE 1.1 Python framework driving the collection of data from both SDN and traditional networks.** The Python framework will act as an automated telemetry collection system running as software on a server. It must have simultaneous connectivity to both SDN and traditional networks in order to pull necessary networking data. As the software acquires this data, its algorithm must also orchestrate the transmission of the metrics to PNDA for storage, monitoring, analysis. As the project evolves and moves up the levels described in section 3.0, this Python based software will be the core where every targeted networking decision function originates.

**CPE 1.2 PNDA acting as the preferred database for data collection and network data analytics.** PNDA will be running on a separate server, acting as the central repository for network data collection and analysis. With the Python based software acting as the link between the underlying network and PNDA, it is crucial to have a fault tolerant and reliable system that can handle large volumes
of traffic. Since PNDA is an open source big data analytics platform, its implementation will enhance the scalability of the project while keeping economic impact at minimum.

CPE 1.3 Intuitive customer facing interface. A web-based front end GUI will be developed to offer the customer an intuitive management interface for the overall system. The user will be able to access the server with all collected data with the option for customizable web dashboards to reflect the telemetry analysis.

Logistical

CPE 2.1 Access to CU Boulder’s ITP telecommunications laboratory and equipment. In order to complete the proof of concept, access to the on campus facilities with the proper networking devices and resources is sine qua non for the success of the project.

Non-technical

CPE 3.1 Policy and business strategy experience and research: In order to develop the proposed policy and business analysis, experience and access to research will be necessary to make the proper financial forecasts and policy implications analyses.

Financial

Open source software and original Python framework result in no critical financial elements to develop a proof of concept.

6.0 Team Skills and Interests

Ankur Jain: Ankur interned at Juniper Networks, Herndon on this past summer (Summer 2017) and has four years of work experience in the networking industry. He has worked on many technologies, such as MPLS, RSVP, OSPF and SDN. During the course of his internship, he worked on NorthStar, a proprietary SDN solution. There, he developed and implemented a virtualized environment on UBUNTU server that is leveraged to demonstrate the features and use cases of NorthStar.

Arohi Gupta: Arohi is skilled in both networking and systems; she is experienced at effectively implementing features, which are efficient, reliable and fault-tolerant. She believes in having solid relationships within the team on all levels. Her primary goal will always be to win as a team and drive change in technology through persistent efforts and innovation.

Ashutosh Gupta: Ashutosh is currently an Edge Operations intern at Google Inc. His primary task at Google is to troubleshoot and manage Edge Network (CDN). He is skilled in Python and networking. He also has a number of projects in network automation and
SDN/NFV. Finally, he is a good team player and has good networking/programming skills that are valuable and indispensable for the completion of this project.

**Sanjay Murthy:** Sanjay has a three-year work experience as a software engineer in Cisco Systems. He also recently interned with Juniper networks as a Systems Engineer where he developed a Python framework to automate the virtual IP fabric spin up with BGP/EVPN triggered by an IOS application to make it Zero touch. Hence, he has the right background and experience to understand and contribute greatly to the project. He is a proven team player with interest in Network Engineering-DevOps.

**Leidy Pérez:** Leidy is currently a Project Manager for Zayo Group. While she comes from a Telecommunications Engineering background reinforced by the ITP Masters at CU Boulder, she has also dedicated the last two years to develop strong telecommunications policy knowledge and business strategy. These abilities, combined with the solid technical experience, allowed her to be the right candidate for a Global Partner Enablement project in the Tranzact Department at Zayo. After developing an on-boarding strategy for new partners to join Zayo’s marketplace, she now oversees partner relations as the POC between potential partners from all around the globe to be brought into Zayo’s homegrown market platform. Leidy is interested in developing her front end GUI developing capabilities, strengthening her SDN and traditional networks management abilities and keep enriching the policy and business strategy field.

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<tr>
<th>Critical Project Elements</th>
<th>Team member(s) and associated skills/interests</th>
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| **1.1 - Python framework driving the collection of data from both SDN and Traditional networks.** | Ankur (Experience with MPLS/BGP)  
Arohi (Expertise in reliable and fault tolerant networks)  
Ashutosh (Experience in SDN and Traditional Networking)  
Sanjay (Background and experience in Network Automation)  
Leidy (Network Management background and interest)  
*All team members are skilled with Python.* |

| **1.3 - Intuitive customer facing interface.** | Ankur (Experience with virtualized testing and proof of concept environments)  
Arohi (Passion for implementation of innovative features and the technical skills to bring them to completion)  
Sanjay (Experience with features triggered by front end applications)  
Leidy (Interest in development of web-based interfaces intuitive to customers).  
*All team members have experience with Python resources such as Flask to develop interfaces.* |
3.1 Policy and Business Strategy experience and research

Leidy (Member of the Policy Track and experience in business strategy, carrier relations and research).

All Team Members have a good policy and strategy education.

7.0 Resources

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<td>2.1 - Access to CU Boulder’s ITP telecommunications laboratory and equipment</td>
<td>ITP Masters Faculty and Staff.</td>
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8.0 References


8.0 Appendix

List of Requirements

Level 1:

- Develop a Python based framework as software on a server, able to perform effectively telemetry data collection from both an SDN controller and traditional network devices.
- Design the data collection process to be fault tolerant, reliable, and scalable.
- Process the collected data by sending it to PNDA running on a separate server for storage, processing, and general trends analysis.
- Scheme a web-based Graphical User Interface (GUI) interface where the user is able to monitor the steps of the process.
- Document industry tendencies and trends regarding SDN penetration and traditional vs mixed vs hybrid vs fully SDN.
- Research the policy case implications of data collection in the main telecommunications markets around the globe to determine if it would affect a widespread implementation of a data collection and analysis system.

Level 2:

- Analyze data in order to predict basic networking decisions such as best path routing based on multiple criteria.
- Discern data relevant for each type of networking decision.
- Aggregate the functionality to the web-based GUI of user selection of types of networking decisions to be executed.
- Develop a business analysis for the scalability of the project.
- Include financial implications of handling larger amounts of traffic derived from aspects such as processing power and server storage capacity.
- Determine barriers for agreements with Internet Service Providers (ISPs) to subject their traffic to a centralized analysis alongside other providers.

Level 3:

- Reinforce and test security within the system.
- Incorporate traffic encryption as it is retrieved from the underlying network and sent to the central repository of information.
- Aggregate feasible functionalities to the Python framework such as detection and prevention of common threats to networks.
- Test a self-healing proposal for the handling of top common failures in networking systems such as errors in configuration of devices bringing down sectors of the network.
- Develop a financial study on benefits of making networking decisions based on non-traditional criteria with a large sample of ISPs.
- Define a common policy framework that would be applicable to the top telecommunications markets in order for the project to be applicable to a large sample of global Internet traffic.
Design Drivers:

As developed for the CPEs section of this PDD, the key design requirements that will drive the feasibility and potential solutions for the project will be:

− **Python** based framework to be used for software design.
− **PNDA** acting as the preferred database for data collection and network data analytics.
− **Web-based** customer facing interface (GUI).