Troubleshooting for Intent-based Networking

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Software-Defined Networking

- **Application Plane (SDN Apps)**
  - SDN Northbound Interfaces

- **Control Plane**
  - (OpenDaylight, ONOS, etc.)

- **Infrastructure (Data) Plane**
  - (Cloud/IT/SDN/NFV)

- **Open APIs**
- **Program Languages**
- **Abstraction**
- **Vendor specific**
- **Manual operations**
Software-Defined Networking

Application Plane (SDN Apps)

SDN Northbound Interfaces

Control Plane (OpenDaylight, ONOS, etc.)

Infrastructure (Data) Plane (Cloud/IT/SDN/NFV)

Open APIs

Program Languages

Vendor specific
Low-level specifics
Manual operations

...
Intent-based Networking

- Application Plane says “What” (doesn’t care how)
- Control Plane reasons “How” (doesn’t care why)

**Intent**
- “what”, not “how” (non-prescriptive)
- Is portable
- Is universal
- Is compose-able
- Is invariant
- Is scale-able

**Intent**
“I want my headache to stop”

**Prescription**
“Give me two aspirins”
Intent-based Networking

Examples

WEB/Gold/Working Hour

No connect/Wireless

Configure new guest WiFi
Intent-based Networking

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INVISIBLE
Intent-based Networking
Open Source Efforts

– ONF Open Source SDN Boulder
  – Define Intent North Bound Interface (NBI)
  – https://community.opensourcesdn.org/wg/IntentNBI/dashboard

– OpenDaylight NIC
  – Network Intent Composition
  – Manage and direct network services and network resources based on the given “Intent”
  – https://wiki.opendaylight.org/view/Network_Intent_Composition:Main

– ONOS Intent Framework
  – Allows applications to specify their network control desires in form of policy rather than mechanism (Intent)
  – https://wiki.onosproject.org/display/ONOS/Intent+Framework
Policy Graph Abstraction (PGA)

PGA overview
Troubleshooting for Intent-based Networking
PGA is Real
Public resources

Research Paper and Demo

Running System and Open Source Contributions

ACM SIGCOMM 2015
London, UK

OpenStack Summit
2015, 2016

OpenDaylight Summit
2015, 2016
Policy Management in Practice
Policy Graph Abstraction (PGA)

**Policy sources**
- Business Operations
- Security
- Legal
- Administrator

**Graph abstraction**
- Engg
- Ping, SSH
- Mktg
- HTTP
- LN
- Web
- SQL
- DB
- DNS
- DPI
- Normal
- Quarantined
- Remedy Service
- Campus
- FW
- BC
- Cloud

**Unified, conflict-free policy graph**
- DPI
- DNS
- HTTP
- DB
- BC
- Monitor
- SQL
- Web
- Cloud

**Deploy**
PGA Example

- Label namespace across cloud services and network, capturing overlap vs. disjoint relations between labels
PGA Example

- Label namespace across cloud services and network, capturing overlap vs. disjoint relations between labels
- 4 individual input policies

(a) Enterprise IT admin

(b) Application admin

(c) SDN app: HPE Net Protector

Label Mappings
Engg: Campus-A
Mktg: Campus-B
Application: Cloud
Empl: Net protector
PGA Example

- 4 individual input policies
- Label namespace across cloud services and network, capturing overlap vs. disjoint relations between labels
- Proactive, automatic composition
- Scalable algorithm: 13 mins to compose 20K ACL + service chain policies
PGA
Current status

### PGA implementation and impact

- PGA model, composition, deployment, and tool to convert ACL policy configuration to PGA intent specification
- PGA prototype for OpenStack (Juno ~ Newton)
- PGA Intent APIs and graph compiler contributed to ODL/NIC Beryllium release
- Troubleshooting for intent based policy management
  - Conflict detection
  - Composition correctness verification
  - Intent addition/modification/deletion
PGA Demo
Troubleshooting
With Intent-based Networking
Network debugging/troubleshooting a difficult task

Policy

Network

WEB

NO CONNECT

SNMP

tcpdump

ping

traceroute

sflow

Picture sources:
http://simplearchitectures.blogspot.com/2013/08/addressing-data-center-complexity.html
http://www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Data_Center/ServerFarmSec_2-1/ServSecDC/8_NIDS.html

Picture source:
http://www.ntstn.com/category/troubleshooting/network-troubleshooting
Systematic troubleshooting

– Know intent of the operator
– Check network behavior against operator intent

Intent-based networking

– Policy is a first-class citizen
– Intent explicitly expressed at policy layer
– Forwarding semantics explicitly defined
– Code compiles policy description into lower-level configuration

Difficult to achieve in legacy networks

Opportunity to rethink network debugging
Intent-based Networking

- **Application Plane**
  - (SDN Apps)

- **Controller Plane**
  - (OpenDaylight, ONOS, etc.)

- **Infrastructure Control Interfaces**

- **Infrastructure (Data) Plane**
  - (Cloud/IT/SDN/NFV)

- **INTENT North Bound Interface**

- **Control Apps**
  - Specify routing/access control policies

- **Logical view**
  - Simplified/abstract representation of network

- **Physical view**
  - One-to-one correspondence with the physical network

- **Controller’s job to configure the network devices**
  - (OpenFlow)
Intent-based Networking

- Each layer performs one piece of translation process
- Every layer should correctly map to every other layer
- Most errors in SDN are mistranslations between layers
Checking network behavior against intent

– Early debugging tools for OpenFlow-enabled networks
  – Ndb, OFRewind, NetSight, netwatch, netshark, nprof…
  – Easier to discover the source of network problems
    [Faulty device firmware, inconsistent flow rules, faulty routing…]

– **Testing** and **verification** complement network troubleshooting and debugging
  [Loop freedom, black holes, performance of OpenFlow switches…]

Too low level!
Knowing the operator’s intent

Does the Actual Network Behavior Match the Policy?

– If NO…
  Match the symptoms to responsible system component

– If YES…
  The policy itself is the problem, a human must resolve the discrepancy

– If unwanted behavior persists & all state layers are equivalent:
  – The configured policy must not match the operator’s intent
Troubleshooting System

User/App₁ → User intents → Query → Results → Troubleshooting System → PGA → Metadata → Composed graph → Infrastructure Controllers

Query Examples
- Reachability/Connectivity checking
  - Can A talk to B?
- Security vulnerability or Risk assessment
- Addition/removal/edition correctness
Troubleshooting Examples

Reachability

– Can A talk to B?
  – What EPG do nodes belong to?
  – Is there an edge connecting both EPGs?
  – What security groups should be checked?
  – What middleboxes should be checked?
Troubleshooting example
Troubleshooting network connectivity (reachability)

(a) Enterprise IT admin
Engg, Ping, SSH → Mktg
(b) Application admin
Engg, HTTP → Empl, LB → Web, SQL → DB

(c) SDN app: HP Net Protector
DPI → DNS
Normal DNS
Quarantine

(d) Cloud operator
Campus → FW → BC → Cloud

Label Namespace

Label Mappings
Engg: Campus-A
Mktg: Campus-B
Application: Cloud
Empl: Net protector
Troubleshooting example
Intent addition/modification/removal

(a) Enterprise IT admin

(b) Application admin

(c) SDN app: HP Net Protector

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Troubleshooting example

Risk Assessment

What if a host from “Web&Cloud” is compromised?

What EPGs might be able to reach host ‘x’ (through intermediate host compromise)?

Indicator may be composed using different data points:
e.g. # of compromised hops; # of network functions traversed, etc.
Troubleshooting Demo

Connectivity Problem

Marketing Employee

10.10.20.1

Intent edition

Campus Admin

Remote desktop connection
PGA and Troubleshooting Demo
Summary

Intent-based Networking is beneficial to simplify network control & management.
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- Intent-level troubleshooting can help to easily do troubleshooting network problems
Summary

– Intent-based Networking is beneficial to simplify network control & management
– Policy Graph Abstraction (PGA) is one of the well-defined intent-based management framework and we presented possible troubleshooting examples
– Intent-level troubleshooting can help to easily identify network problems

– What’s next
  – More More More practical experiences from network operators/administrators/developers…
Thank you

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