API based Network ~~Automation~~ Orchestration

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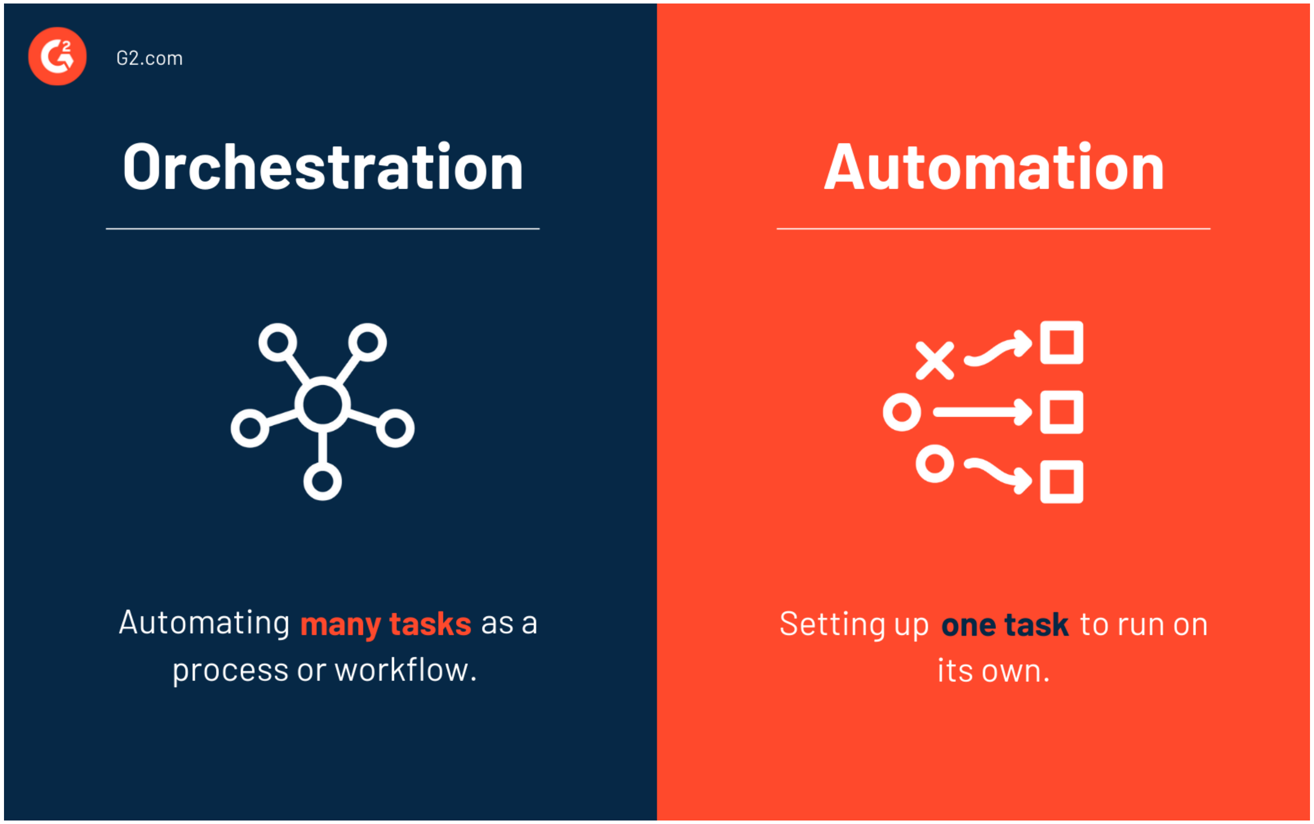
Orchestration vs Automation



G2.com

Orchestration

Automating **many tasks** as a process or workflow.

Automation

Setting up **one task** to run on its own.

Source: g2.com

Agenda

- ***Motivation***
- What are
    - NETCONF,
    - RESTCONF, and
    - YANG
- Landscape of YANG Models
- Tools
- Development Resources
- Conclusions & References

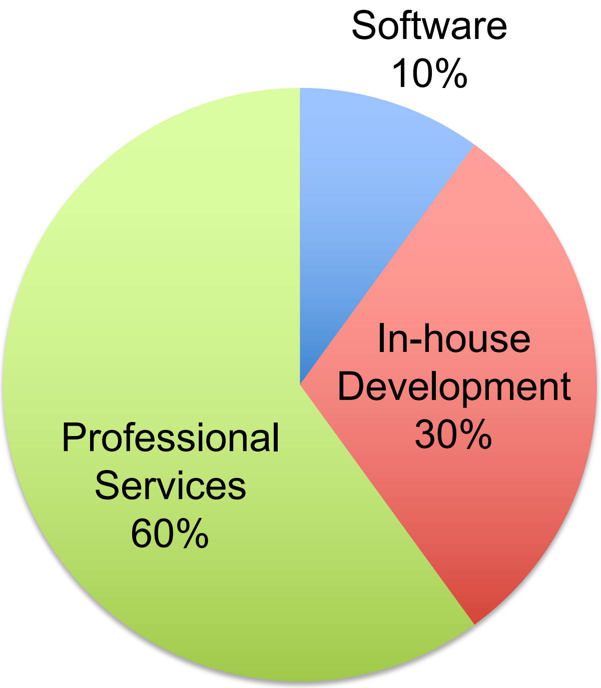
Facts

- 95% of network changes are manual
- Manual changes are error prone
- Expanding network at scale is a problem
    - 75 billion IoT devices by 2025

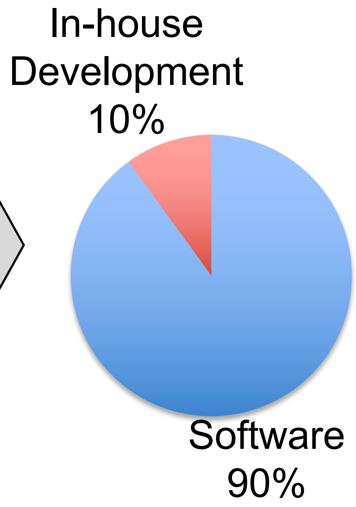
Key Drivers

- End to end management
  - Access, transport and core
- Biggest area for capex and opex reduction
  - 60 of 76 operators (survey conducted between 8/22-10/22)
- Benefits include reduction of call-centers
  - 15-20% reduction
- Agility
- Time to Market

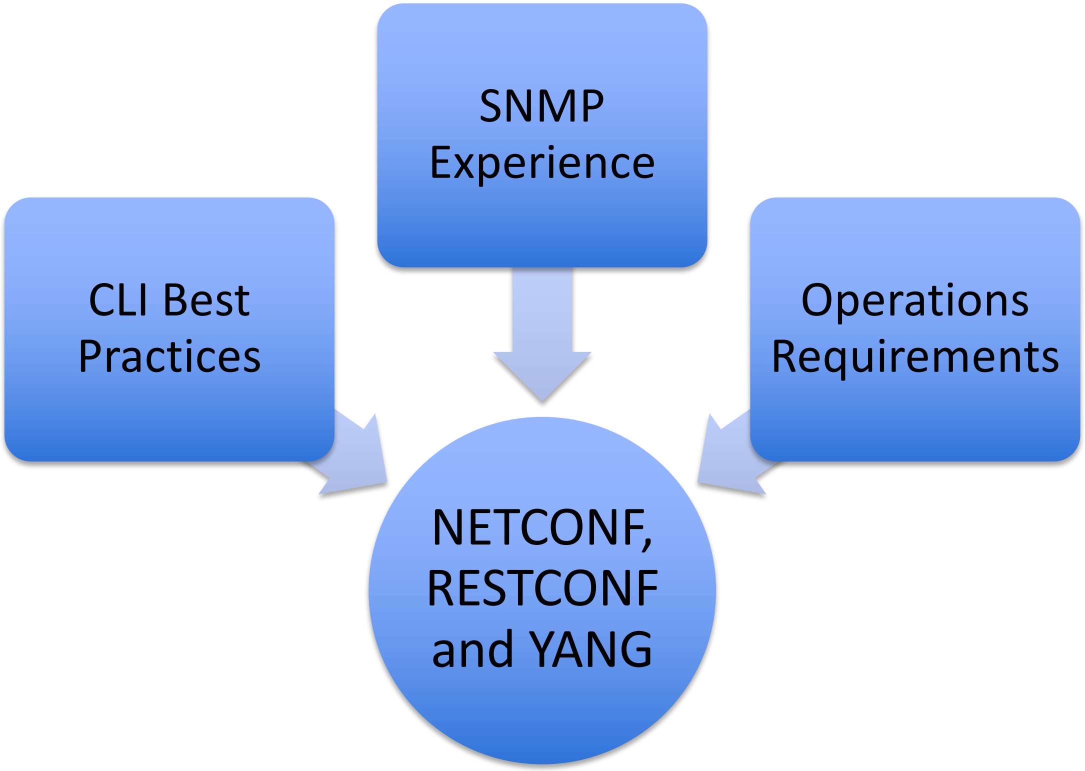
Where We Need To Go



- Networking is well known, we can build stable abstractions
- Modern software practices gives us reusability
- The competitive edge is in the applications



Best Practices Coming Together



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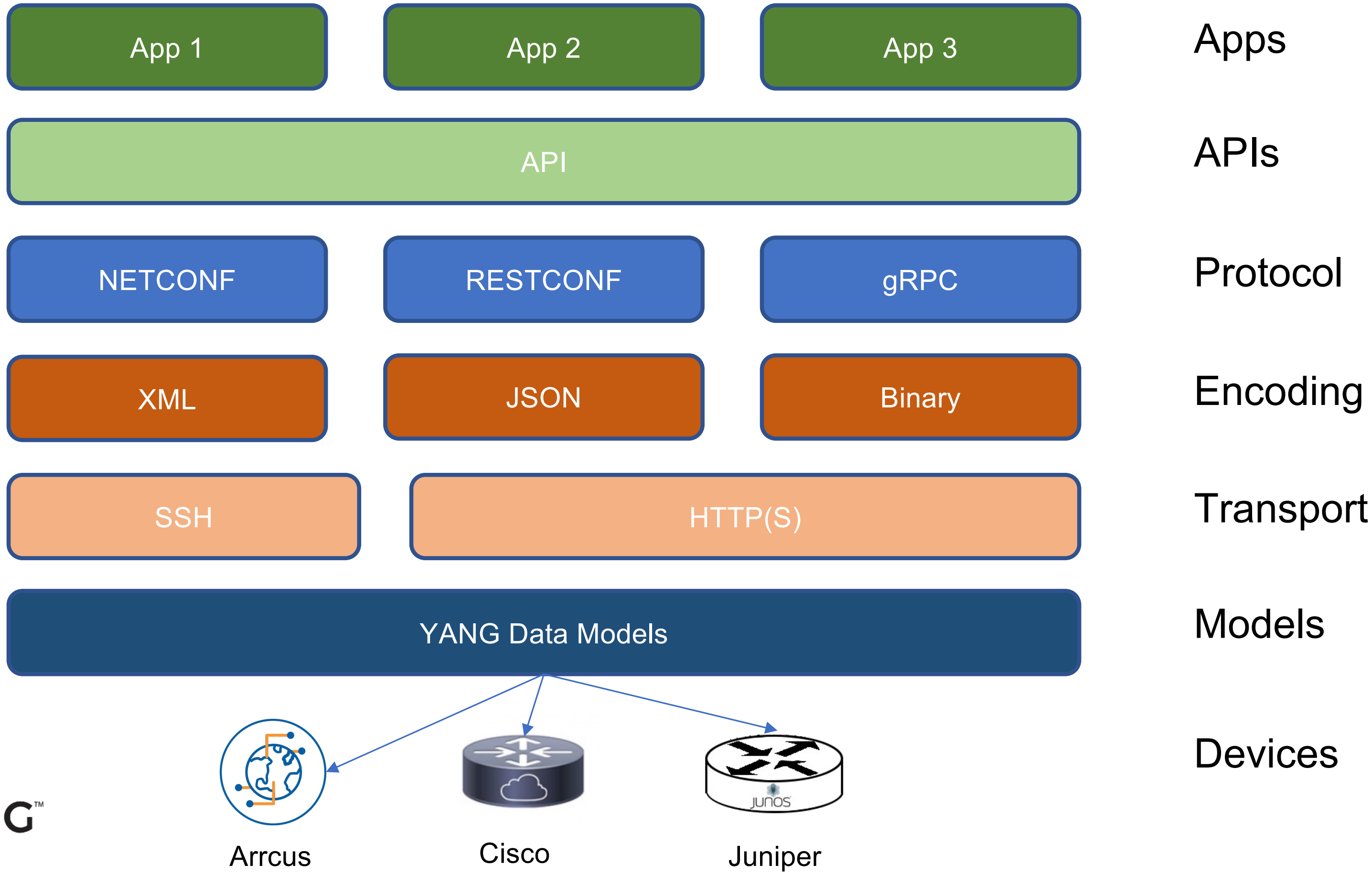
NETCONF/RESTCONF and YANG



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NETCONF Protocol (RFC 6241)

- Network Management Protocol
- Distinction between configuration and state data
- Multiple configuration data stores (candidate, running, startup, operational)
- Configuration change validations and transactions
- Selective data retrieval with filtering
- Streaming and playback of event notifications

Why you should care:

NETCONF provides fundamental programming features for comfortable and robust orchestration of network services

NETCONF Transactions

Transaction Definition: the “ACID test”

- Atomicity: all-or-nothing, great for error handling
- Consistency: all-at-once, great for integrity
- Independence: no-crosstalk, great for many concurrent clients
- Durability: done-is-done, great for reliability

Introduction of transactions + SQL caused a DB industry boom in the 80’s. Applications got reliable. Could run against many different DBMS’

NETCONF makes the network a distributed database

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RESTCONF Protocol (RFC 8040)

- Network Management Protocol
- Not intended to replace NETCONF, but rather provide an additional simplified REST interface
- Defines HTTP-based Create, Retrieve, Update, Delete (CRUD) operations
- Configuration data and state data exposed as resources
- Operations defined with YANG rpc invoked with the POST method
- Simplified transaction model

Why you should care:

RESTCONF provides a lighter-weight interface to NETCONF data stores leveraging the well known combination of HTTP and JSON/XML/CBOR

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The YANG 1.1 Language (RFC 7950)

A Data Modeling Language for Networking

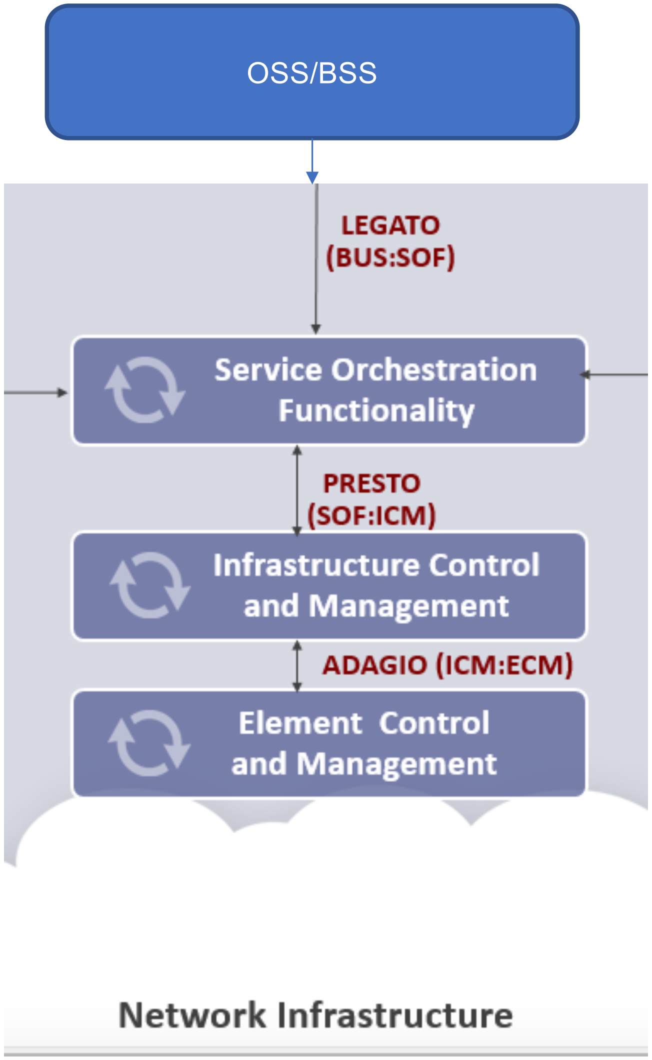
- Human readable and easy to learn
- Hierarchical configuration/state data models
- Reusable types and groupings (structured types)
- Extensibility through augmentation
- Formal constraints for configuration validation
- Data modularity through modules and sub-modules
- Well defined versioning rules

Why you should care:

YANG is a full, formal contract language with rich syntax and semantics to build applications on

Service vs Infra vs Device Level Models

- Services Level Models
  - End-to-End Services
  - E-Line, E-LAN, E-Tree (MEF 58)
  - Legato
- Infra Level Models
  - Topology Models
  - Presto
- Device Level Models
  - Device Specific
  - Adagio
- https://github.com/MEF-GIT/


OSS/BSS
LEGATO (BUS:SOF)
Service Orchestration Functionality
PRESTO (SOF:ICM)
Infrastructure Control and Management
ADAGIO (ICM:ECM)
Element Control and Management
Network Infrastructure

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YANG Tsunami in the industry

IETF®
MEF
OPEN DAYLIGHT
sysrepo
ITU
broadband forum
IEEE
Advancing Technology for Humanity
CableLabs®
OPENCONFIG
ETSI

Standards Body Models

- IETF YANG models
  - ~1500 YANG Models
  - GitHub (https://github.com/YangModels/yang)
- BBF, IEEE, ETSI, IANA, MEF

OPENCONFIG

www.openconfig.net

- Operators-led YANG models
  - Google, AT&T, British Telecom, Microsoft, Facebook, Comcast, Verizon, Level3, Cox Communications, Yahoo!, Apple, Jive Communications, Deutsche Telekom / TeraStream, Bell Canada
  - (https://github.com/openconfig/public)
- YANG models not aligned with other SDO, e.g. IETF

VENDOR SPECIFIC MODELS

- Augmentation of Standard ***or*** OpenConfig YANG models
- Vendor Specific Features
  - Missing capabilities
  - Support existing CLI
- Not compatible with other vendor models

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Validating YANG models

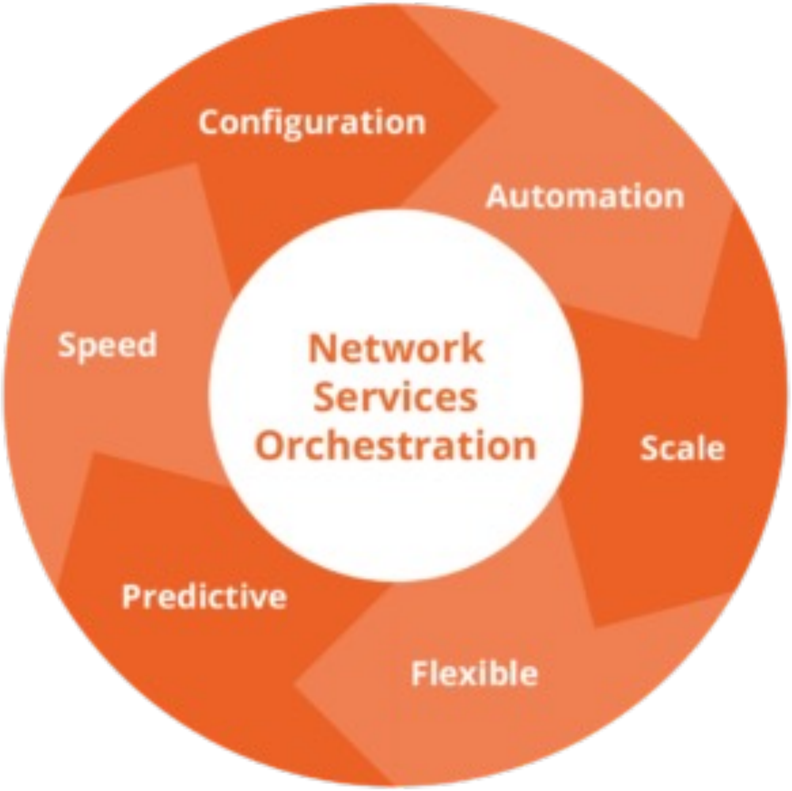
- pyang
  - An extensible YANG validator written in Python. (Video trainining: pyang)
  - Can be used standalone as a validator of YANG modules, or to generate YIN, YANG, DSDL and XSD from YANG and YIN.
  - https://github.com/mbj4668/pyang
- libyang
  - yanglint – tool to validate YANG models and examples
  - https://github.com/CESNET/libyang

Client tools

- Interacting with servers (NETCONF and RESTCONF)
  - netconf-client - A NETCONF client for Python 3.6+.
  - ncclient - Python library for NETCONF clients (ncclient.org)
  - curl - command line tool and library for transferring data with URLs (curl.haxx.se)
  - Python requests - the only Non-GMO HTTP library for Python (python-requests.org)
  - Postman – REST(conf) requests

Orchestrators

- OpenDaylight
  - Enables auto-generation of RESTconf APIs from YANG models, with NETCONF client support
  - APIdocs feature provides a way to explore both local and mounted YANG models
- Network System Orchestrator (NSO)
- Others



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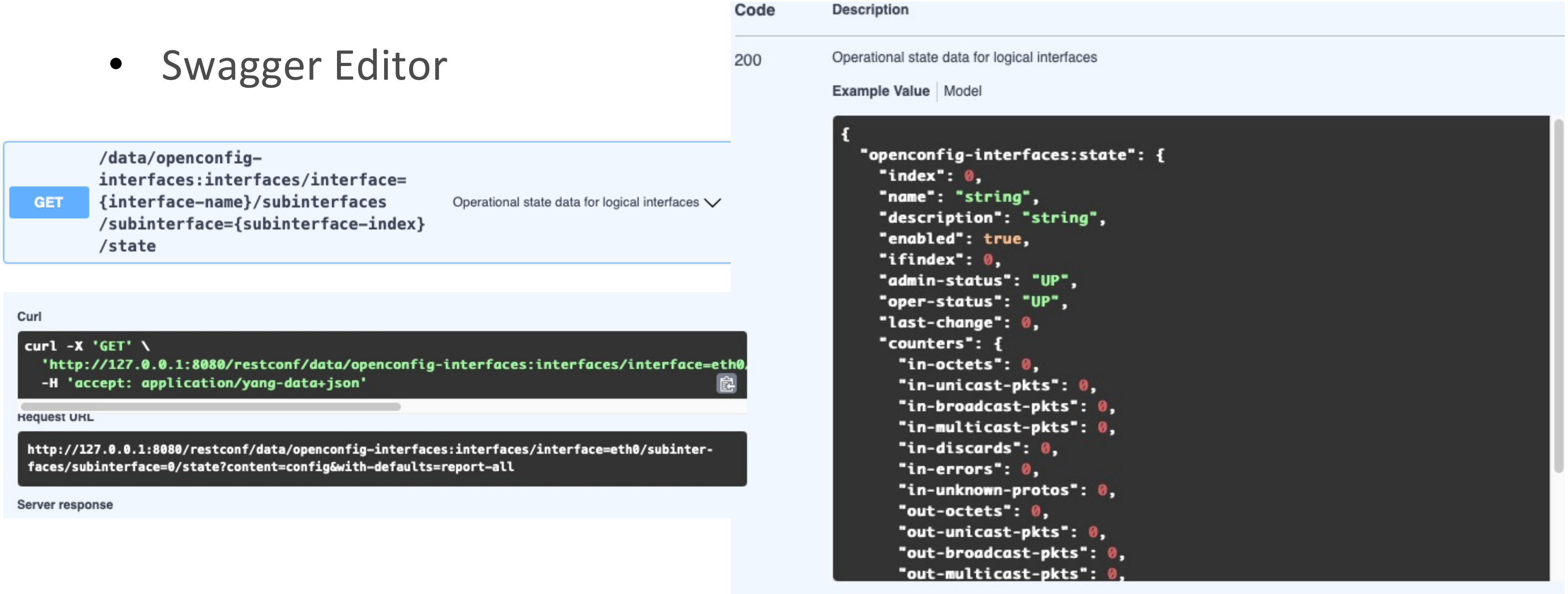
NAPALM

- Network Automation and Programmability Abstraction Layer with Multivendor support
- Python 3 library
- Support for multiple vendors including Arrcus
- Template based
  - Replace - device.load_replace_candidate(filename='new_good.conf')
  - Merge - device.load_merge_candidate(filename='new_good.conf’)
  - Commit - device.commit_config()
  - Rollback - device.rollback()

API documentation

- Swagger Editor



```
/data/openconfig-
interfaces:interfaces/interface=
{interface-name}/subinterfaces
/subinterface={subinterface-index}
/state
```

Operational state data for logical interfaces

Curl

```
curl -X 'GET' \
  'http://127.0.0.1:8080/restconf/data/openconfig-interfaces:interfaces/interface=eth0
  -H 'accept: application/yang-data+json'
```

Request URL

```
http://127.0.0.1:8080/restconf/data/openconfig-interfaces:interfaces/interface=eth0/subinter-
faces/subinterface=0/state?content=config&with-defaults=report-all
```

Server response

Code	Description
200	Operational state data for logical interfaces

```
{
  "openconfig-interfaces:state": {
    "index": 0,
    "name": "string",
    "description": "string",
    "enabled": true,
    "ifindex": 0,
    "admin-status": "UP",
    "oper-status": "UP",
    "last-change": 0,
    "counters": {
      "in-octets": 0,
      "in-unicast-pkts": 0,
      "in-broadcast-pkts": 0,
      "in-multicast-pkts": 0,
      "in-discards": 0,
      "in-errors": 0,
      "in-unknown-protos": 0,
      "out-octets": 0,
      "out-unicast-pkts": 0,
      "out-broadcast-pkts": 0,
      "out-multicast-pkts": 0,
```

Programming Resources

- libyang-cpp – C++ bindings for YANG
- libyang-python – Python bindings for YANG

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Conclusions

- Critical mass of models available
- Model first
  - Consistent interface between CLI and API
- Network orchestration is where dB was 30 years ago
- Services to be deployed in minutes instead of days

References

- YANG Catalog
  https://yangcatalog.org

Thank you

13-June-2023

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Backup Slides

01-JAN-2020

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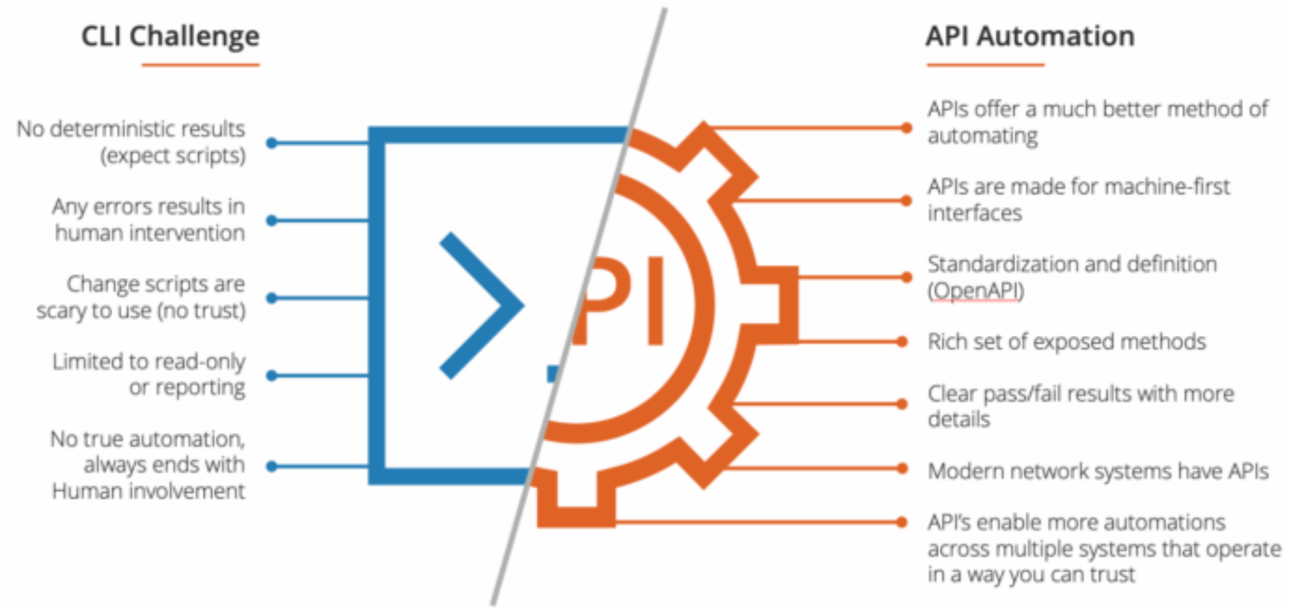
CLI to API



CLI Challenge

- No deterministic results (expect scripts)
- Any errors results in human intervention
- Change scripts are scary to use (no trust)
- Limited to read-only or reporting
- No true automation, always ends with Human involvement

API Automation

- APIs offer a much better method of automating
- APIs are made for machine-first interfaces
- Standardization and definition (OpenAPI)
- Rich set of exposed methods
- Clear pass/fail results with more details
- Modern network systems have APIs
- API's enable more automations across multiple systems that operate in a way you can trust

Source: itential.com

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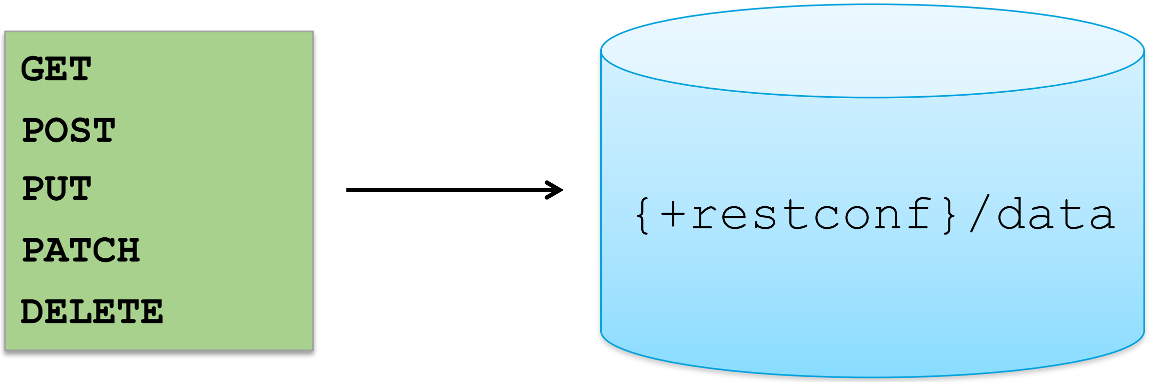
RESTCONF Datastores (before NMDA)



GET

POST

PUT

PATCH

DELETE

{+restconf}/data

Complete and active configuration and operational data

Beware Confusion on Information vs Data Models

Information Models

- Conceptual models
- Independent of implementations or protocols

Data Models

- Precise models
- Include protocol-specific constructs.

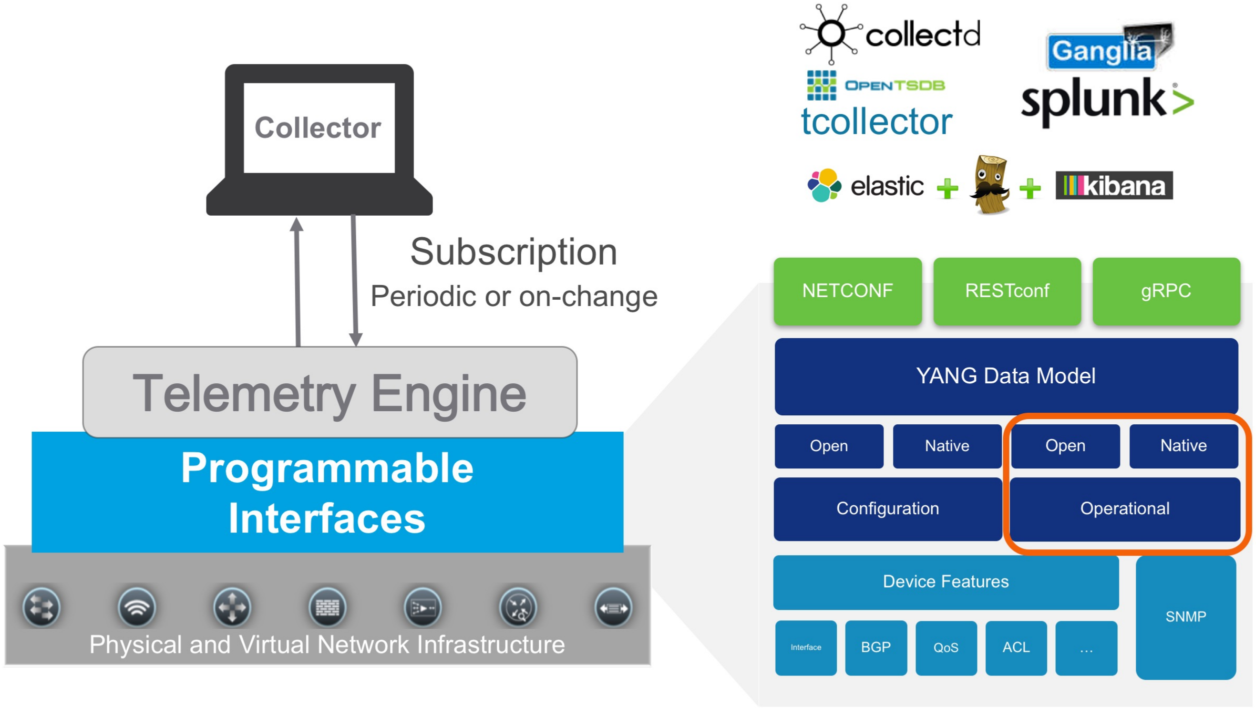
RFC3444 On the Difference between Information Models and Data Models

Management

- Do not forget monitoring

	SNMP	Telemetry
How it works	Polling (Pull)	Push
Protocol	UDP	UDP or TCP
Use Cases	Static data, inventory	Performance, high speed data
Benefits	Simple, widely supported	Higher rate, selective
Challenges	Pull	Can overwhelm the server

Model Driven Telemetry



Collector

Subscription

Periodic or on-change

Telemetry Engine

Programmable Interfaces

Physical and Virtual Network Infrastructure

NETCONF

RESTconf

gRPC

YANG Data Model

Open

Native

Open

Native

Configuration

Operational

Device Features

SNMP

Interface

BGP

QoS

ACL

…

Exploring and using YANG

- Editor plug-ins
  - emacs (yang-mode.el)
  - vim (yang.vim)
  - sublime text (sublime-yang-syntax)
- libsmi
  - A library allowing the generation of YANG models from SMI/SMIv2 compliant MIBs