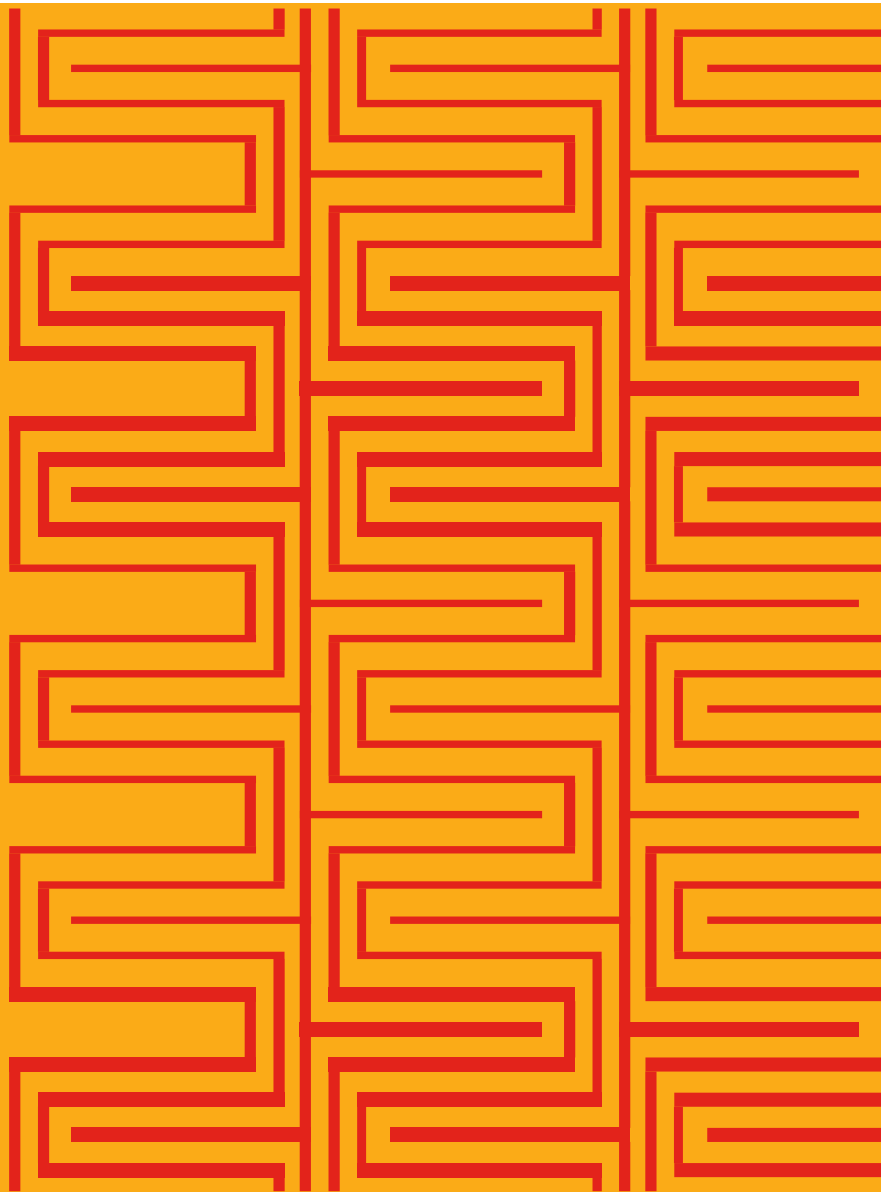
Introduction to Software-Defined Networking (SDN) and Network Programmability

By Minh Dang

Agenda

- Let’s define SDN
- Key Concepts and Technologies
  - APIs
  - RESTCONF, NETCONF & YANG
  - Model Driven Telemetry
  - NFV

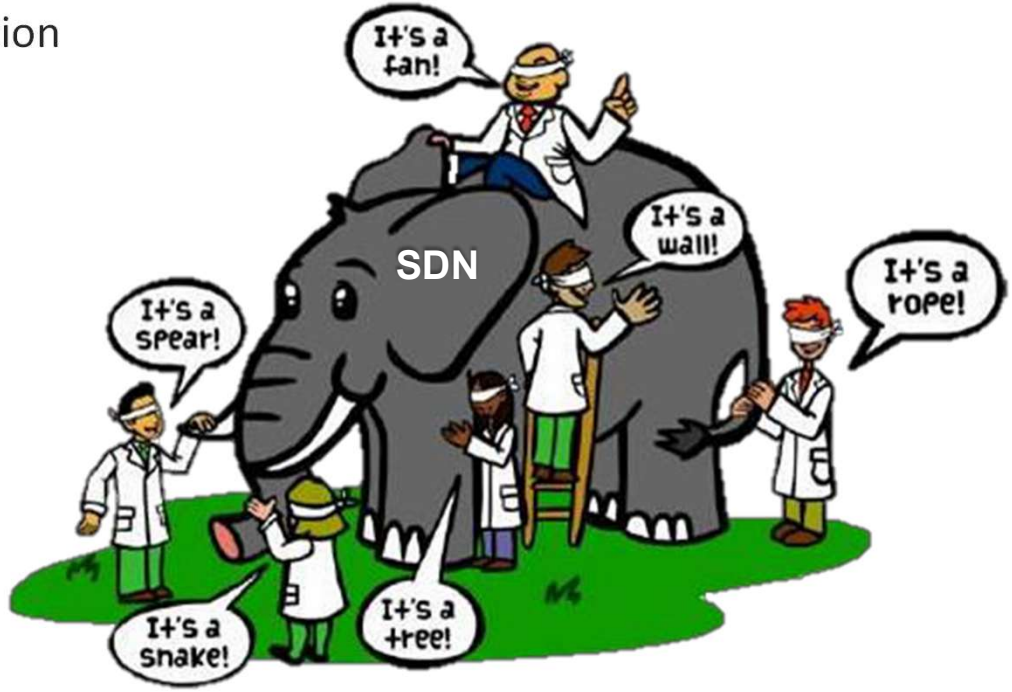
Let’s Define Software-Defined Networking (SDN)



What is Software-Defined Networking?

- What is SDN about? Automation/Simplification
- Why? Savings!

- SDN is not a protocol
- SDN is not single industry standard
- SDN is an approach



Developers & Infrastructure Engineers Must Collaborate

Network APIs

DevOps

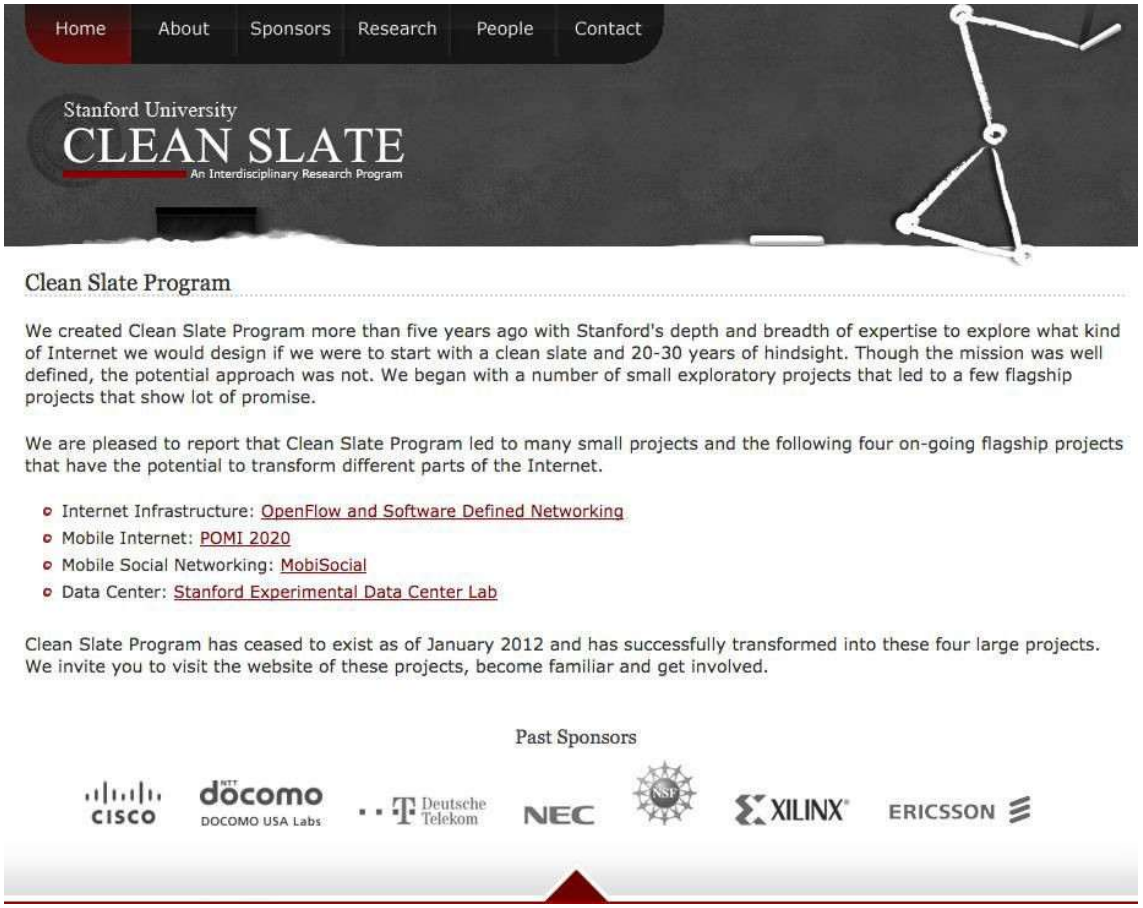
Infrastructure Management

Applications

Network Requirements

Security

Where Did It All Begin?



OPEN NETWORKING FOUNDATION

Dynamically apply state and control to network infrastructure using globally aware **software controls**

Decoupled control and **data planes** and **centralised** intelligence

Abstraction of underlying **network infrastructure**

SDN is…

…a new approach at network transformation

…impacting the networking industry

…providing new methods to interact with equipment/services via **controllers**, **APIs**

…enabling high-scale, rapid network and service provisioning/management

…generating a LOT of attention

…**providing a catalyst for traditional Route/Switch engineers to branch-out**

SDN is not…

…an easy button

…an end-state

…narrowly defined

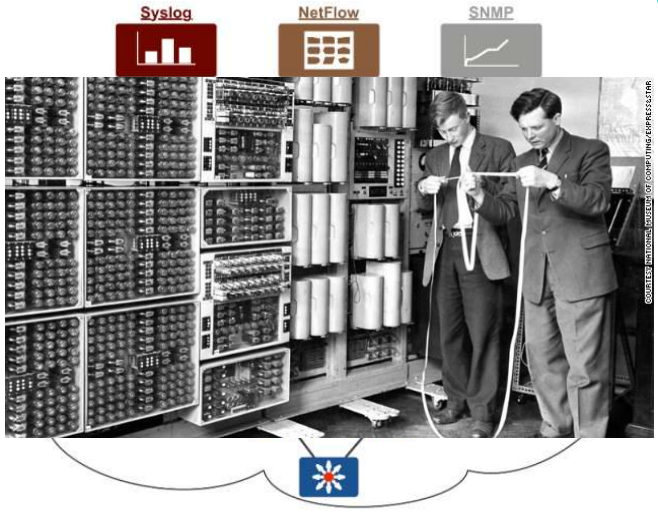
…meaning the death of network engineers

…a mandate for all network engineers to become programmers

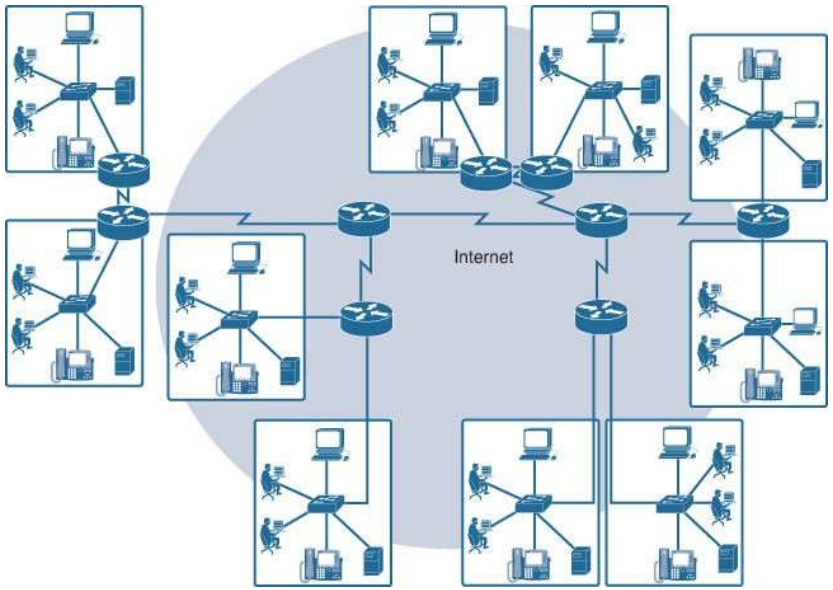
…a new attempt at network evolution

Evolution of Network Configuration

1990s

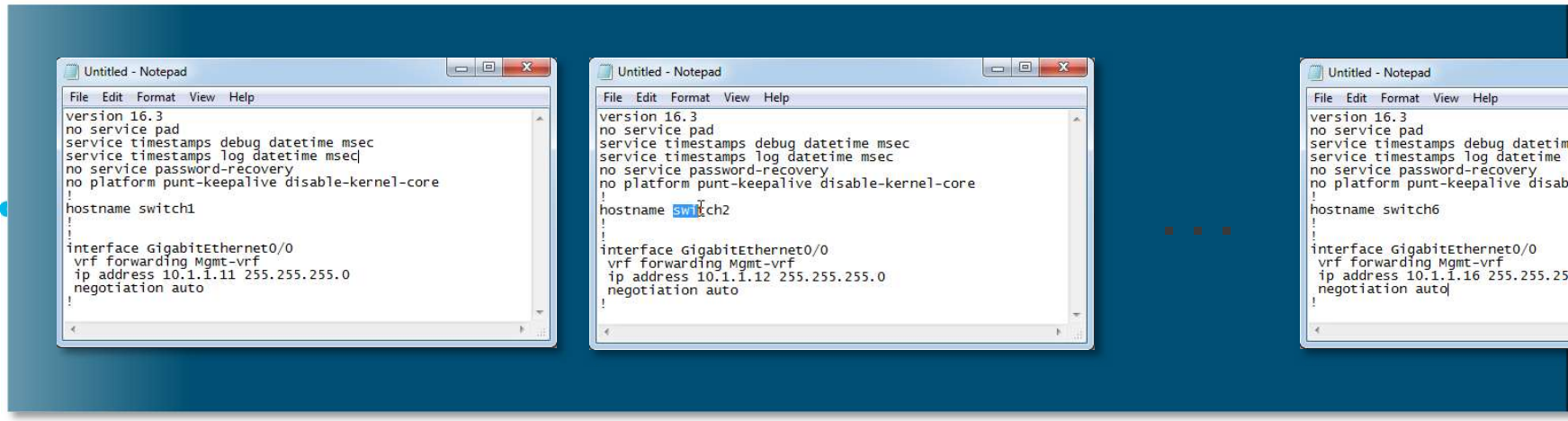


Today

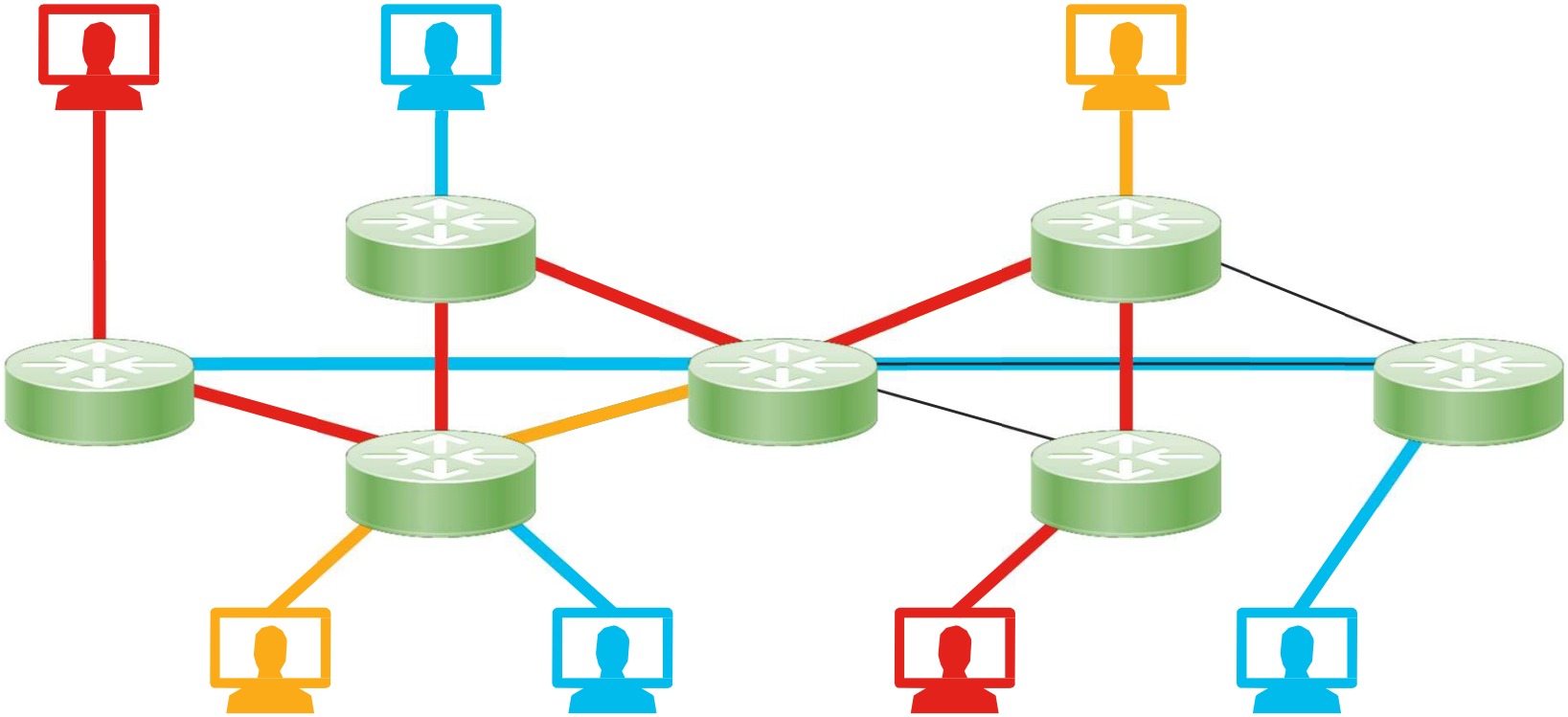


What is the most used automation tool for network engineers?

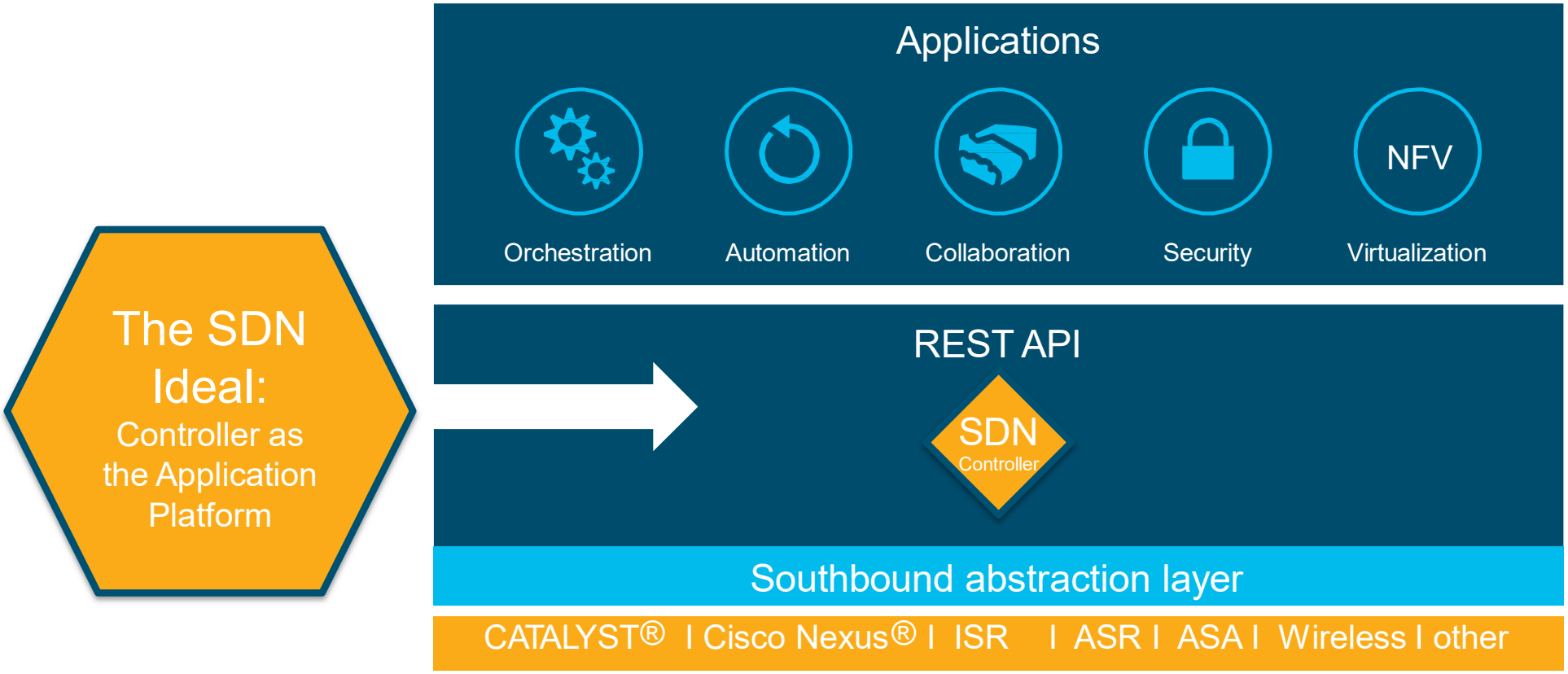
Notepad



Need More than Centralised Management



Network-Wide Abstractions Simplify the Network



Automation Makes Life Easier & Prettier!

You 1:35 pm

dnac show networkDevices

dnac 1:35 pm

```
DNAC>asr1001-x.abc.inc(ASR1001-X: ip 10.10.22.74: serial FXS1932Q1SE:  version 16.6.1: statu
cat_9k_1.abc.inc(C9300-24UX: ip 10.10.22.66: serial FCW2136L0AK:  version 16.6.1: status Mar
cat_9k_2.abc.inc(C9300-24UX: ip 10.10.22.70: serial FCW2140L039:  version 16.6.1: status Mar
cs3850.abc.inc(WS-C3850-48U-E: ip 10.10.22.69: serial FOC1833X0AR:  version 16.6.2s: status
```

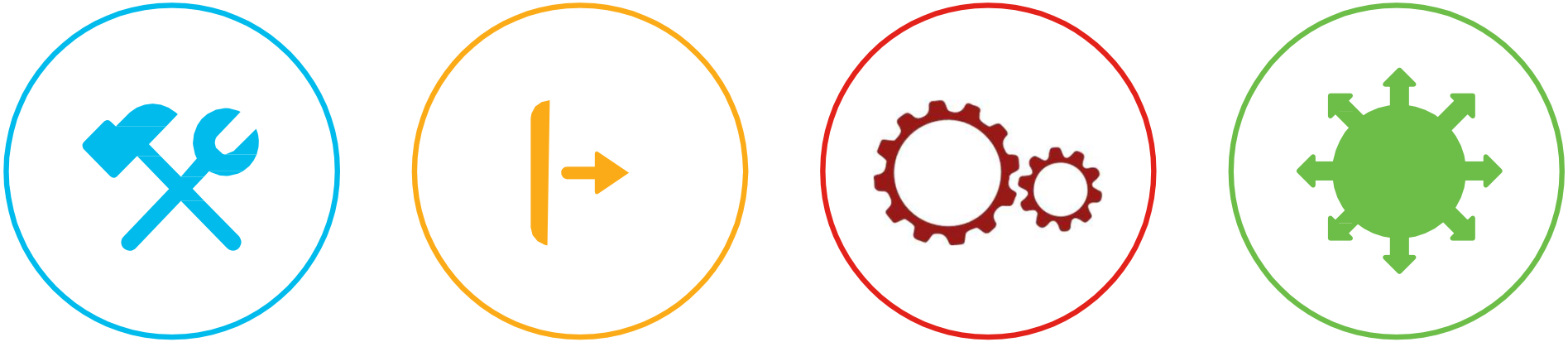
You Yesterday, 11:47 am

dnac find host 10.10.22.114

dnac Yesterday, 11:47 am

```
DNAC>Found HOST 10.10.22.114:00:1e:13:a5:b9:40(wired) on ->
DEVICE:10.10.22.70|TenGigabitEthernet1/0/24 vlan:1
```

SDN Use Cases



Network Abstraction

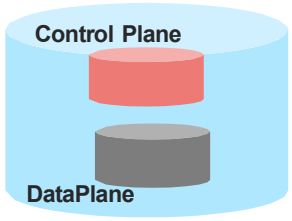
Service Deployment

Traffic Engineering

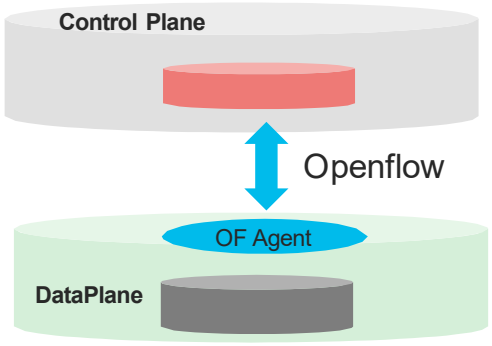
Network Function Virtualisation

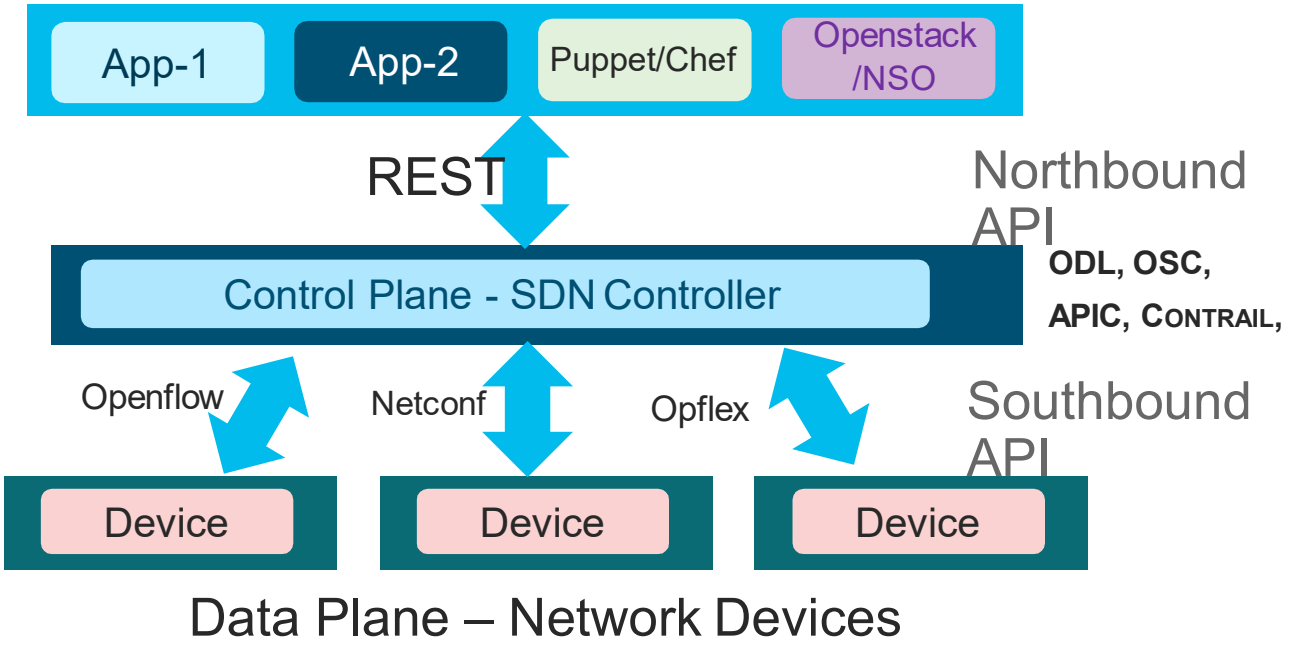
Software Defined Networking

SDN Definition (ONF): The physical separation of the network control plane from the forwarding plane, and where a control plane controls several devices.

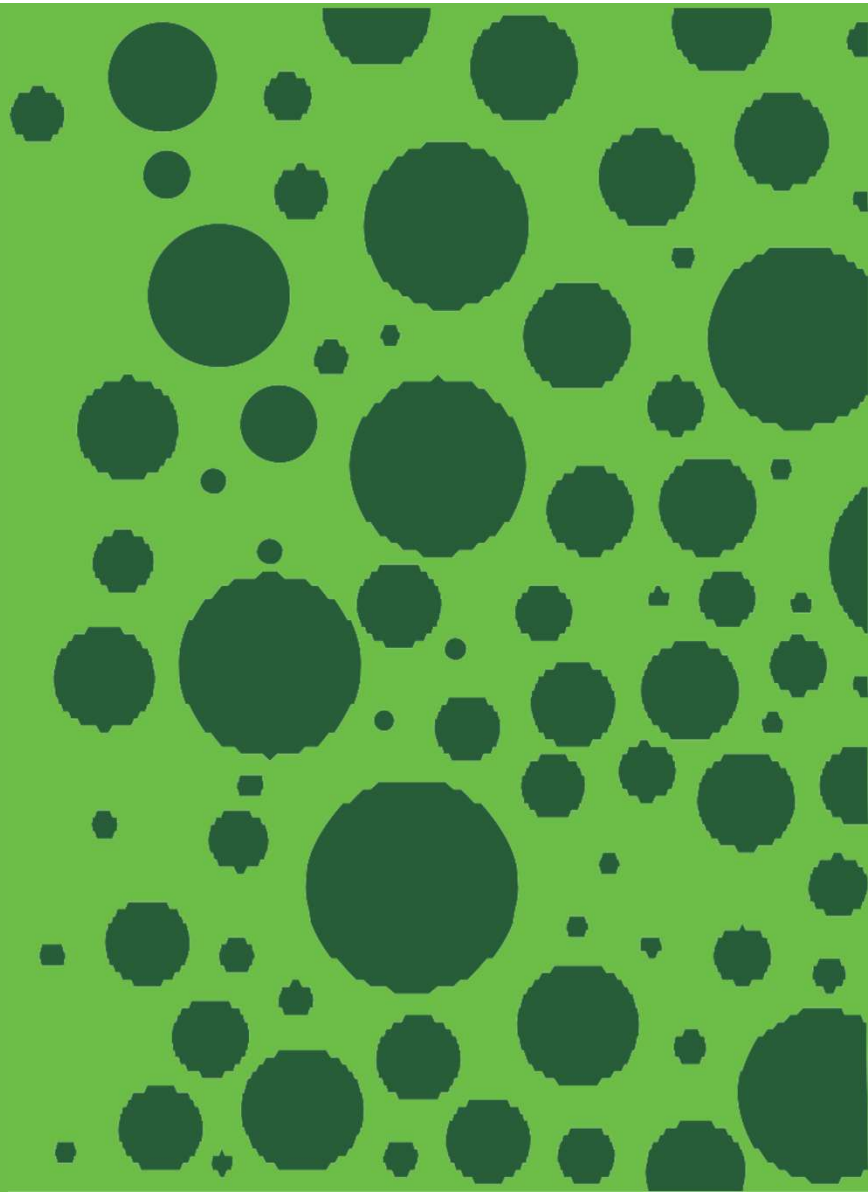


In SDN, Not All Processing Happens Inside Device



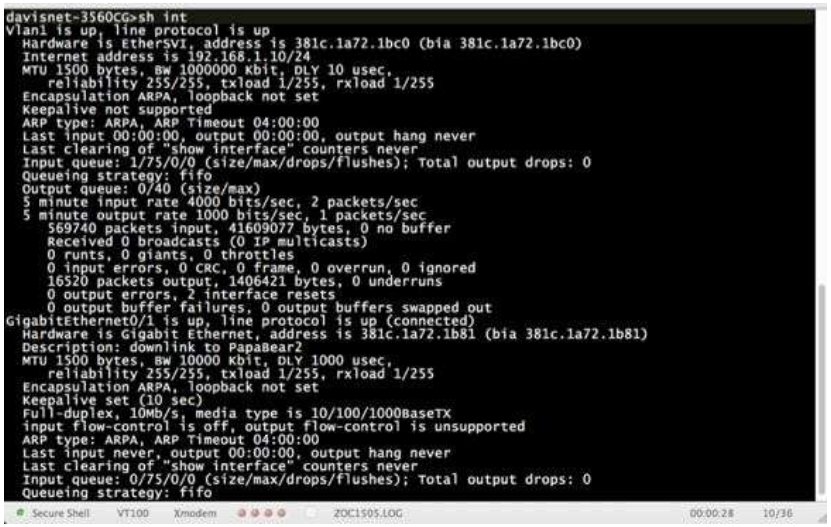


API



CLI to API

- Familiar Manual, CLI-driven, device-by-device approach is inefficient
- Increased need for programmatic interfaces which allow faster and automated execution of processes and workflows with reduced errors
- Need for programmatically readable data structures



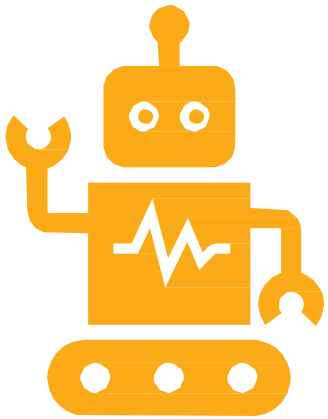
```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="4" xmlns="urn:ietf:params:netconf:base:1.0">
    <data>
        <xml-config-data> Building configuration...
            <Device-Configuration>
                <interface>
                    <Param>GigabitEthernet0/0</Param>
                    <ConfigIf-Configuration>
                        <ip>
                            <address><dhcp/></address>
                        </ip>
                        <duplex><auto/></duplex>
                        <speed><auto/></speed>
                    </ConfigIf-Configuration>
                </interface>
                <end></end>
            </Device-Configuration>
        </xml-config-data>
    </data>
</rpc-reply>]]>]]>
```

Application Programming Interface (API)

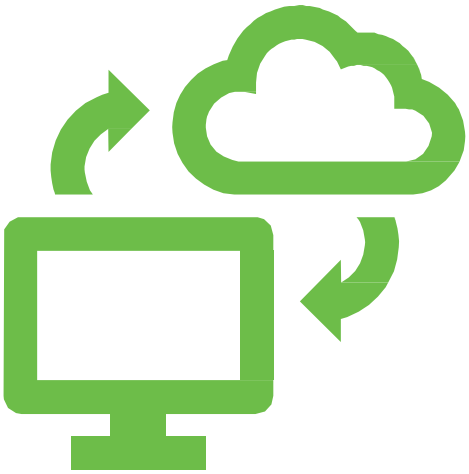
APIs expose pieces of an application to the outside world

APIs are used to connect pieces of software together

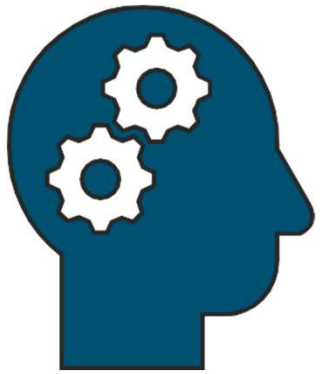
Why APIs?



Automation



Integration



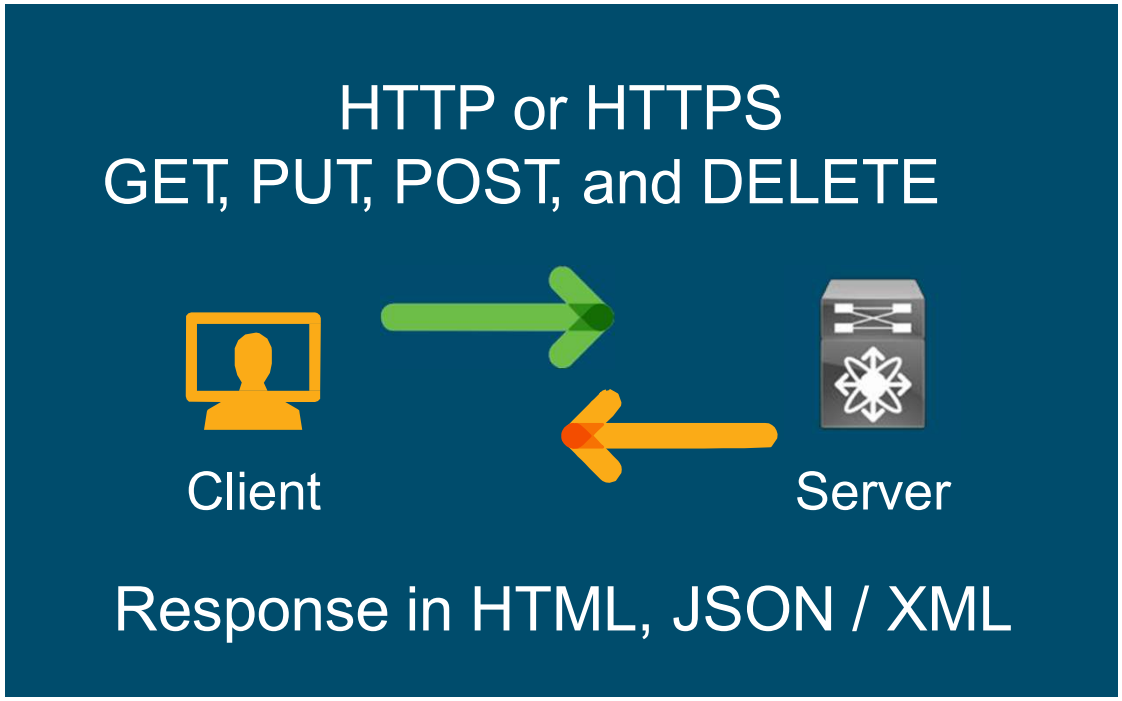
Innovation

RESTful APIs

Well Understood

Easy to Develop Against

Versioned



JSON/XML

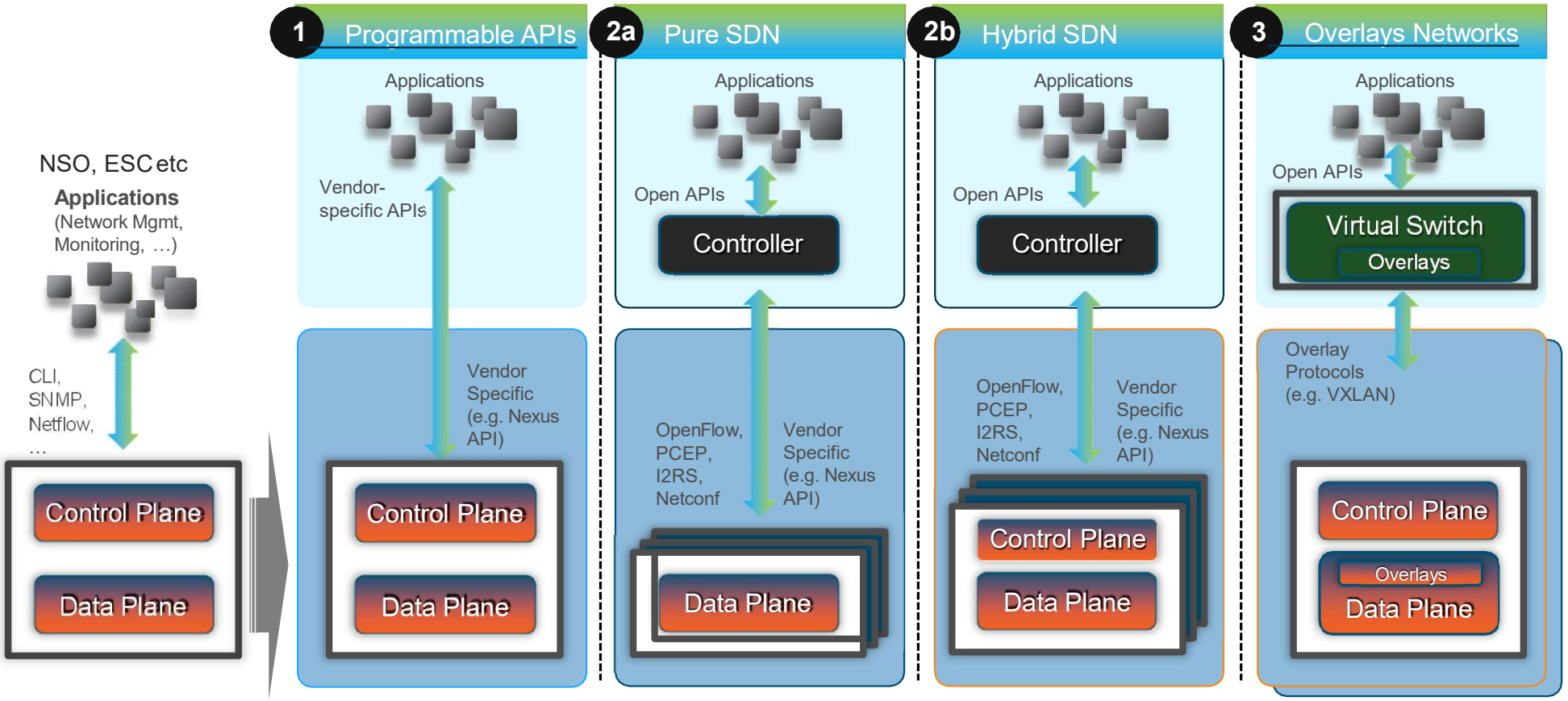
JSON

```
{
    "ipv4Address": "172.16.11.11",
    "ipv4Mask": "255.255.255.0",
    "portName": "GigabitEthernet1",
    "description": " TO_vSWITCH0",
}
```

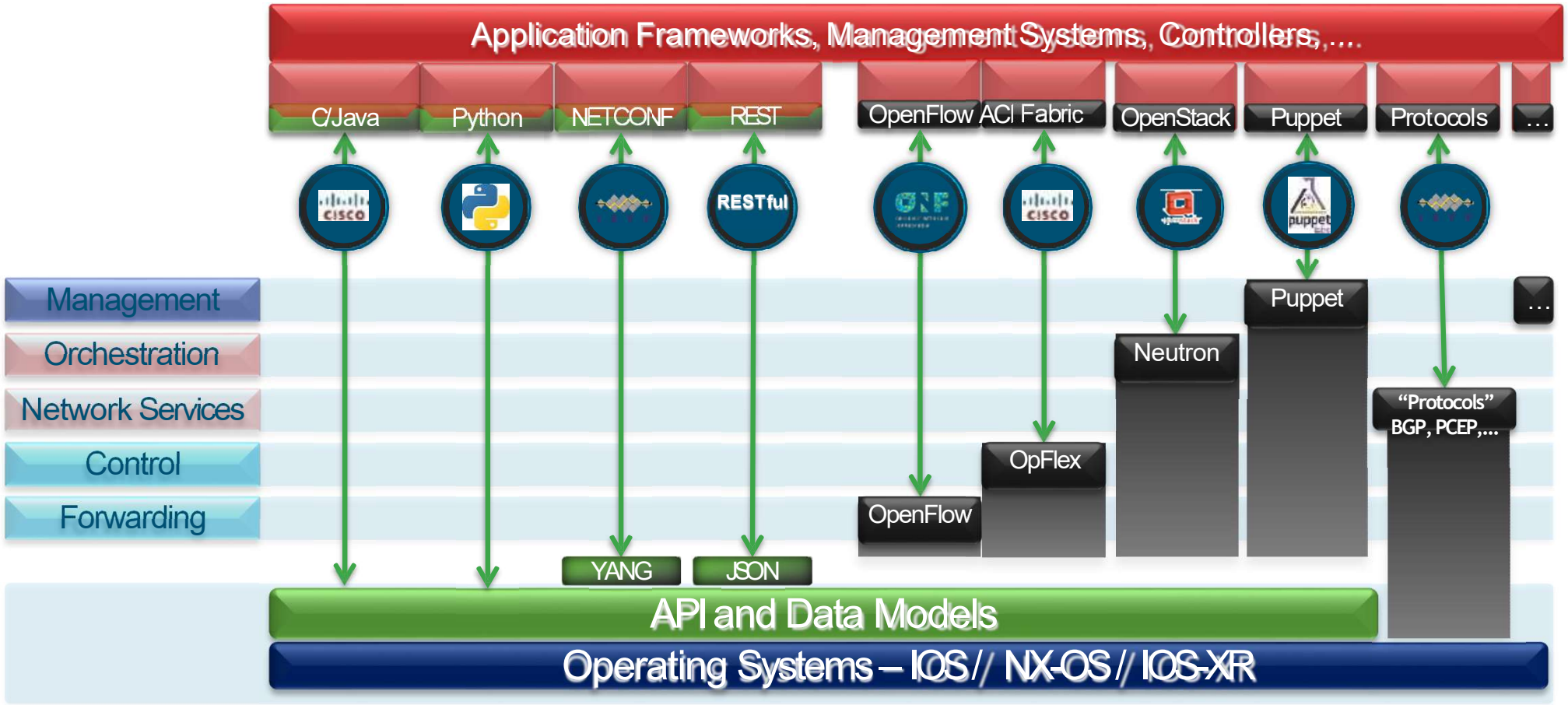
XML


```
{
    <interface>
        <name>GigabitEthernet1</name>
        <description>TO_vSWITCH0</description>
            <address>
                <ip>172.16.11.11</ip>
                <netmask>255.255.255.0</netmask>
            </address>
    </interface>
}
```

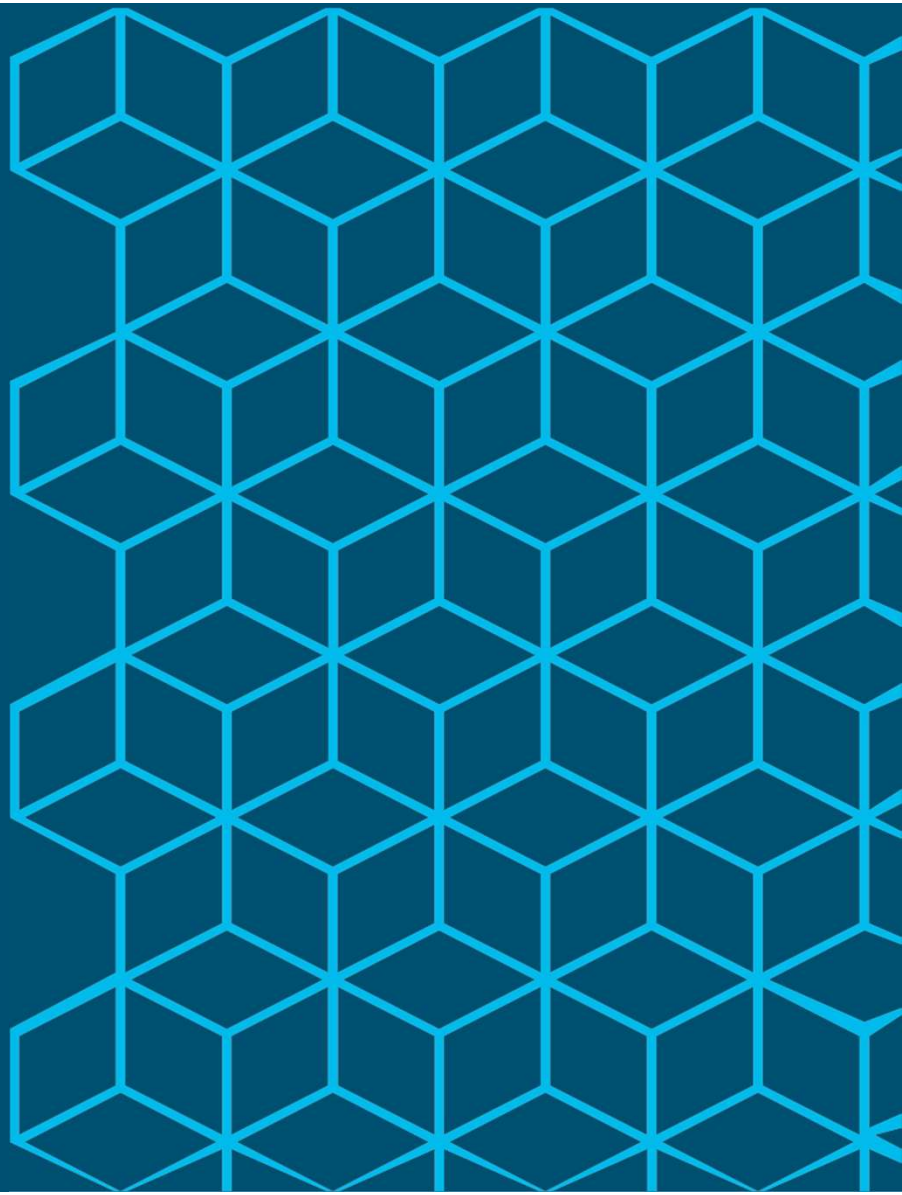
Network Programmability Options



Device Programmability Options – No Single Answer!



Key Concepts and Technologies



Good Old SNMP

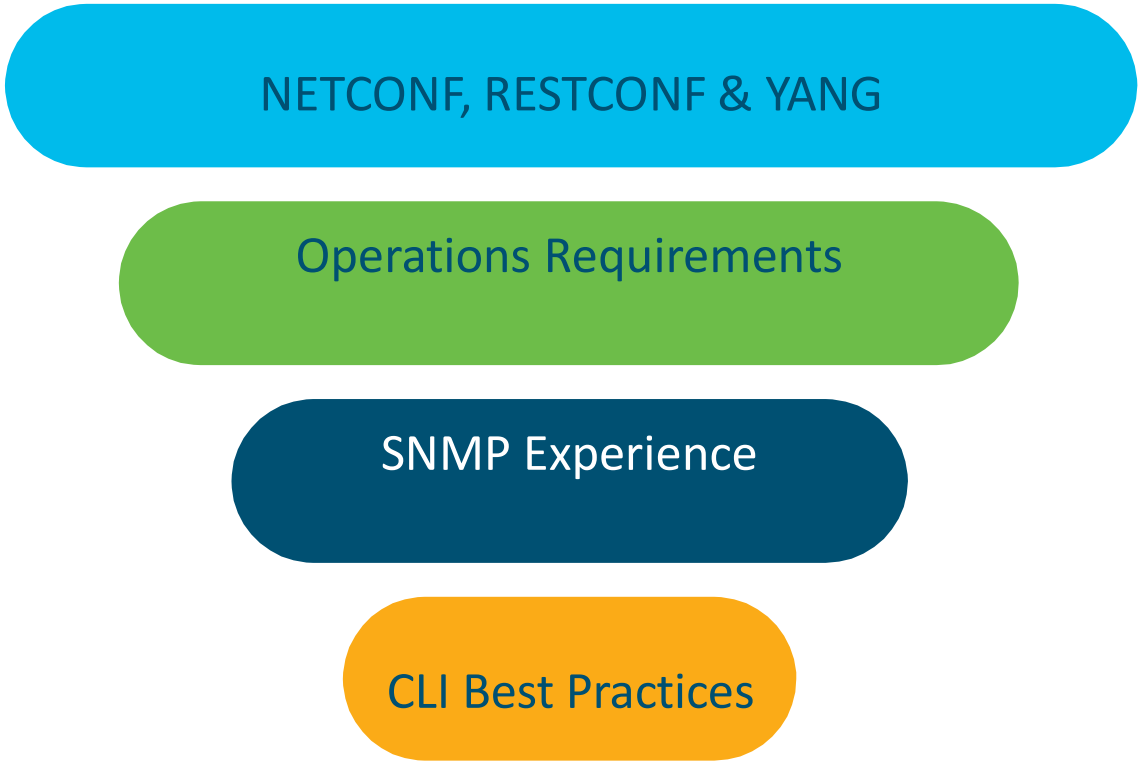
SNMP works "reasonably well for device monitoring"

- Typical config: SNMPv2 read-only community strings
- Typical usage: interface statistics queries and traps
- Empirical Observation: SNMP is not used for configuration
  - Lack of Writeable MIBs
  - Security Concerns
  - Difficult to Replay/Rollback
  - Special Applications

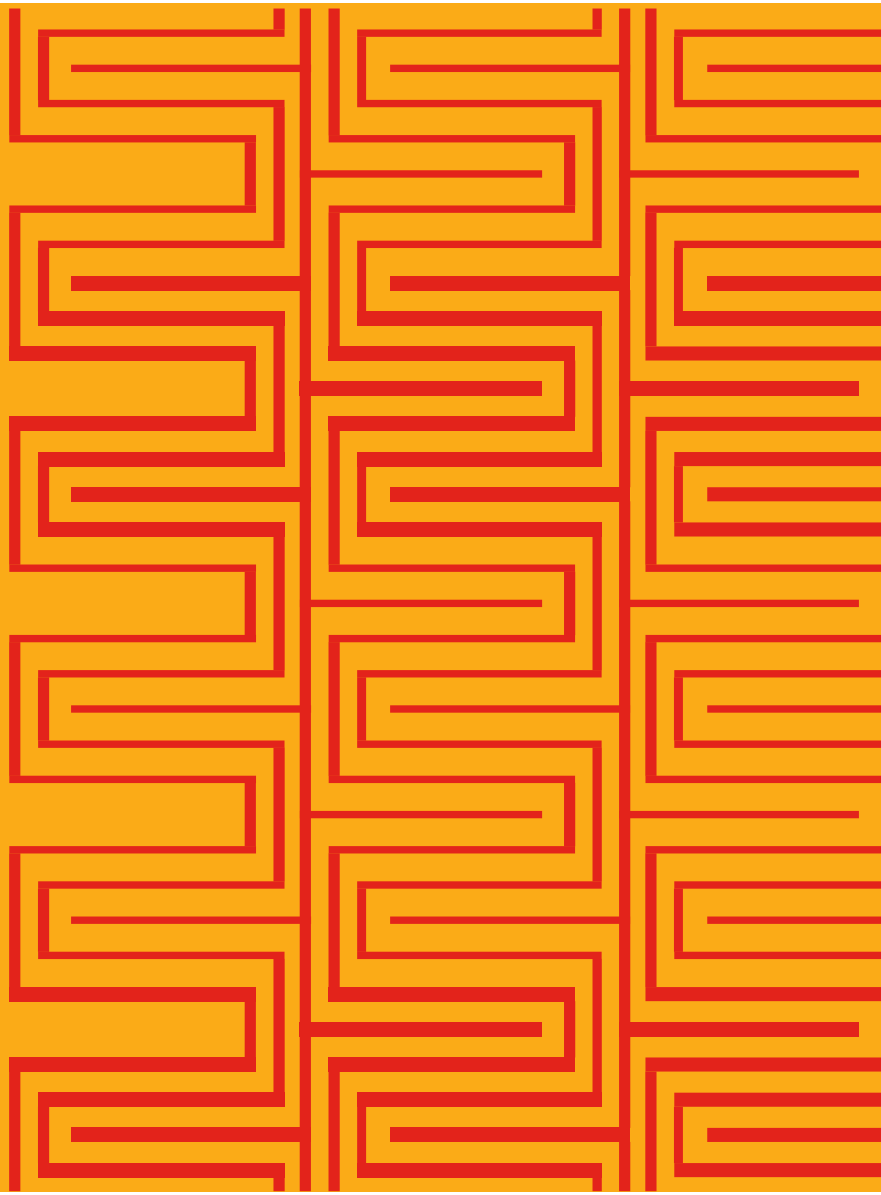
What is needed?

- A programmatic interface for device configuration
- Separation of Configuration and State Data
- Ability to configure "services" NOT "devices"
- Integrated error checking and recovery

Best Practices Coming Together



RESTCONF, NETCONF, YANG



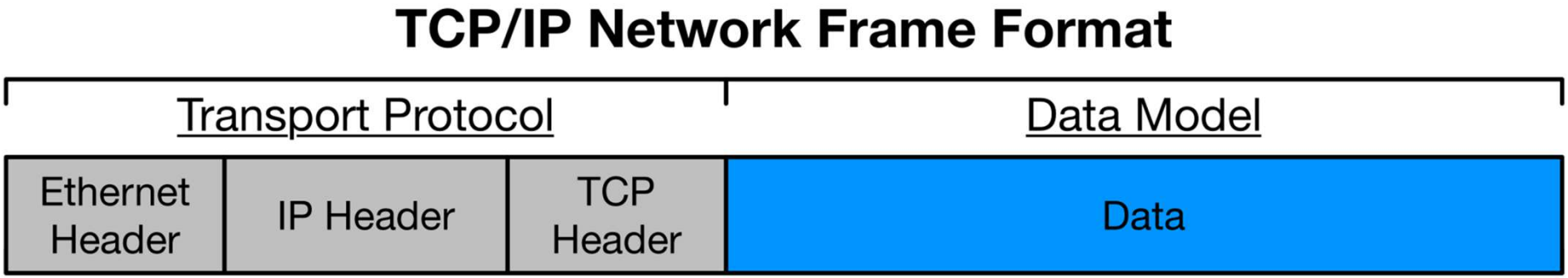
Data Model vs. Network Management Protocol

Data Model

- Defines the structure, syntax, and semantics of data
- Consistent and complete

Protocol

- Remote primitives to view and manipulate data
- Encoding of the data



- NETCONF
- RESTCONF

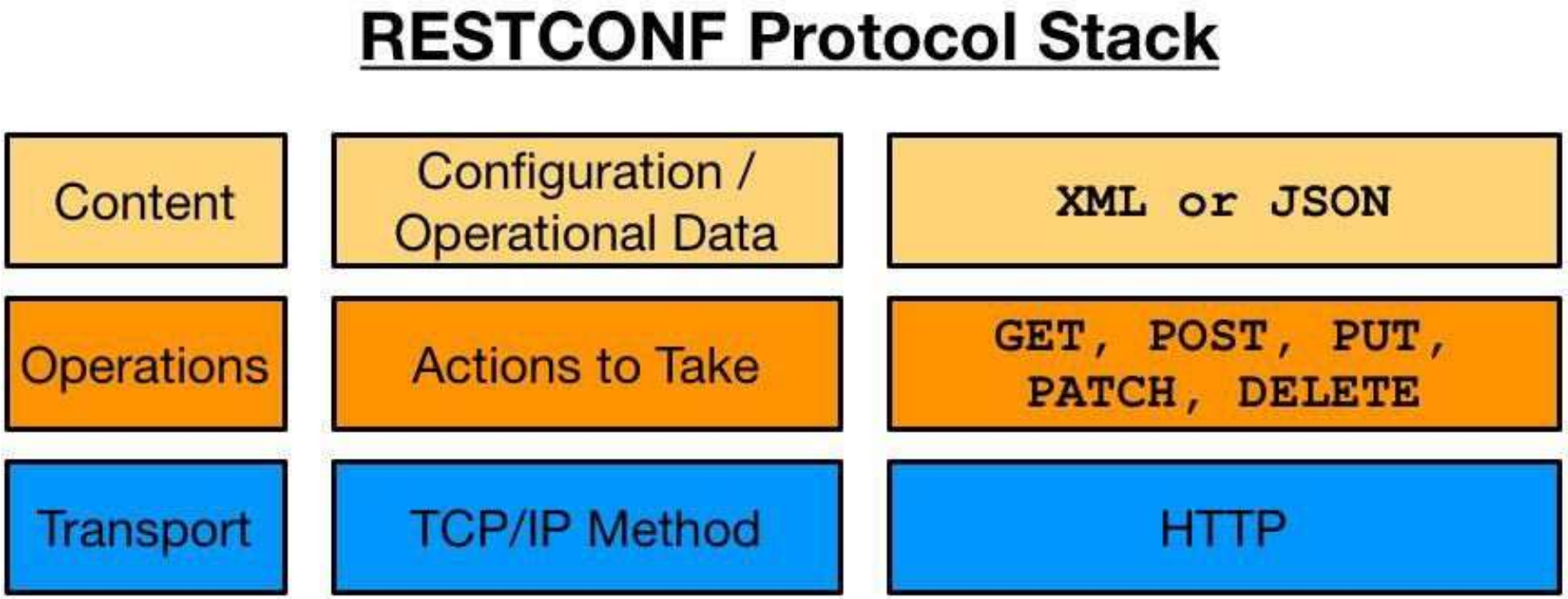
- YANG

RESTCONF

"an HTTPS-based protocol that provides a programmatic interface for accessing data defined in YANG…"

- Uses HTTP(S) for transport
- Tightly coupled to the YANG data model definitions
- Provides JSON or XML data formats

RESTCONF Protocol Stack & Transport

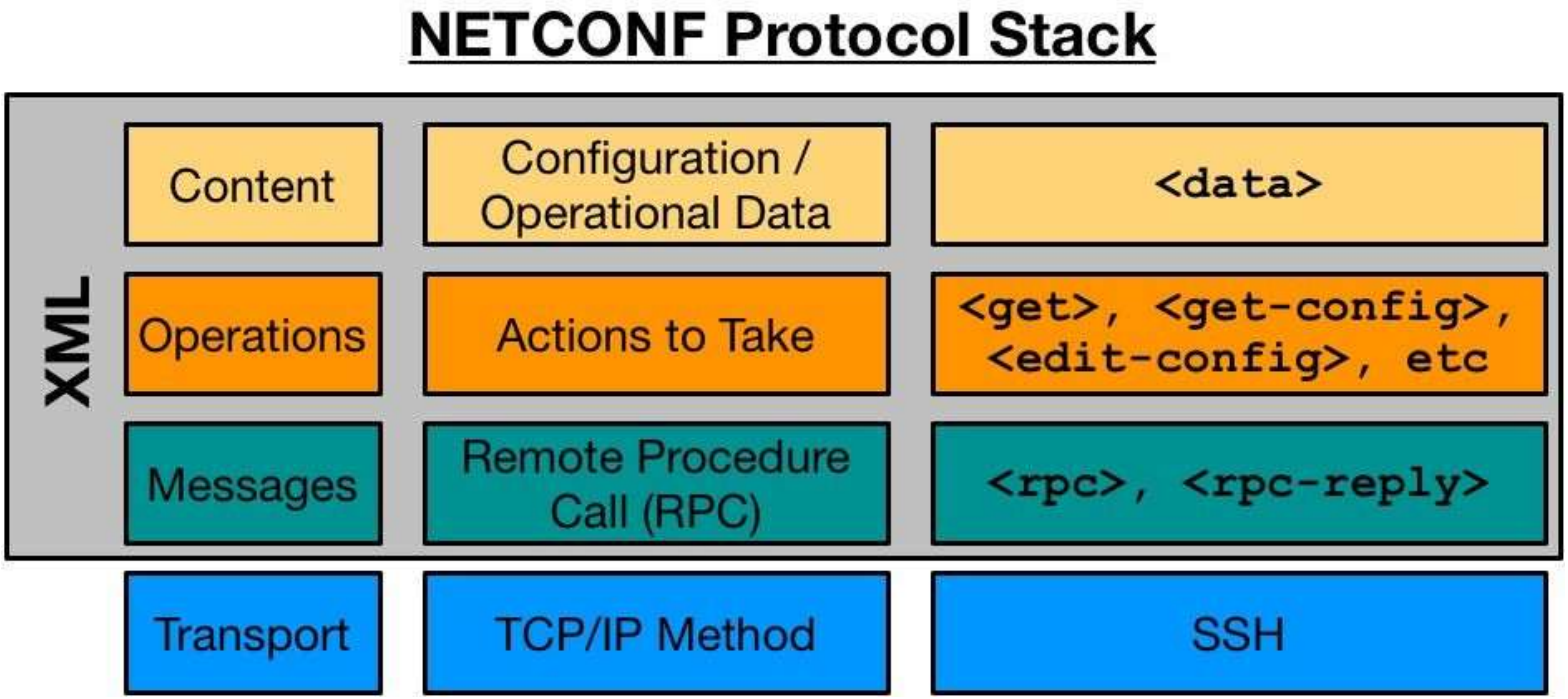


NETCONF

"The Network Configuration Protocol (NETCONF) is a SSH-based network management protocol developed and standardised by the IETF…"

- Uses SSH for transport
- Tightly coupled to XML
- Its operations are realised on top of a simple remote procedure call (RPC) layer

NETCONF Protocol Stack



YANG

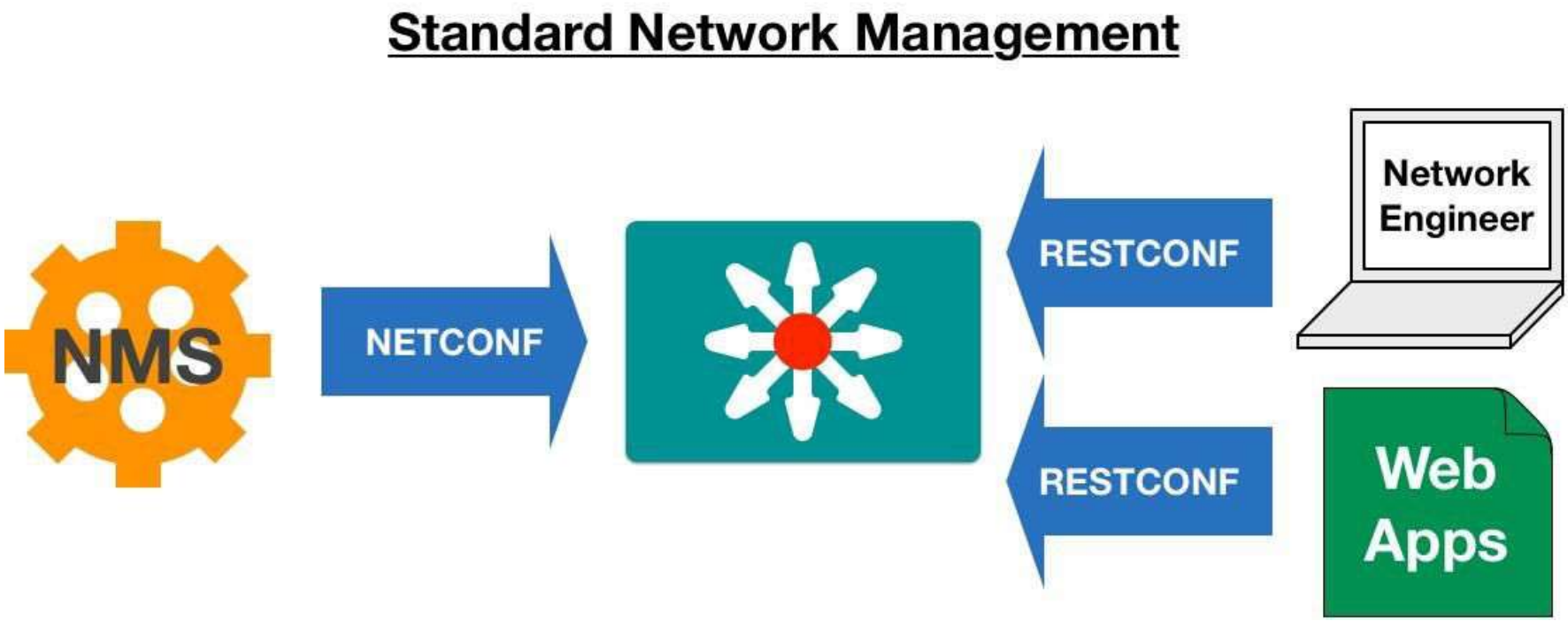
```
DevNet$ pyang -f tree ietf-interfaces.yang

module: ietf-interfaces
   +--rw interfaces
   |  +--rw interface* [name]
   |     +--rw name                        string
   |     +--rw description?                string
   |     +--rw type                        identityref
   |     +--rw enabled?                    boolean
   |     +--rw link-up-down-trap-enable?   enumeration {if-mib}?
```

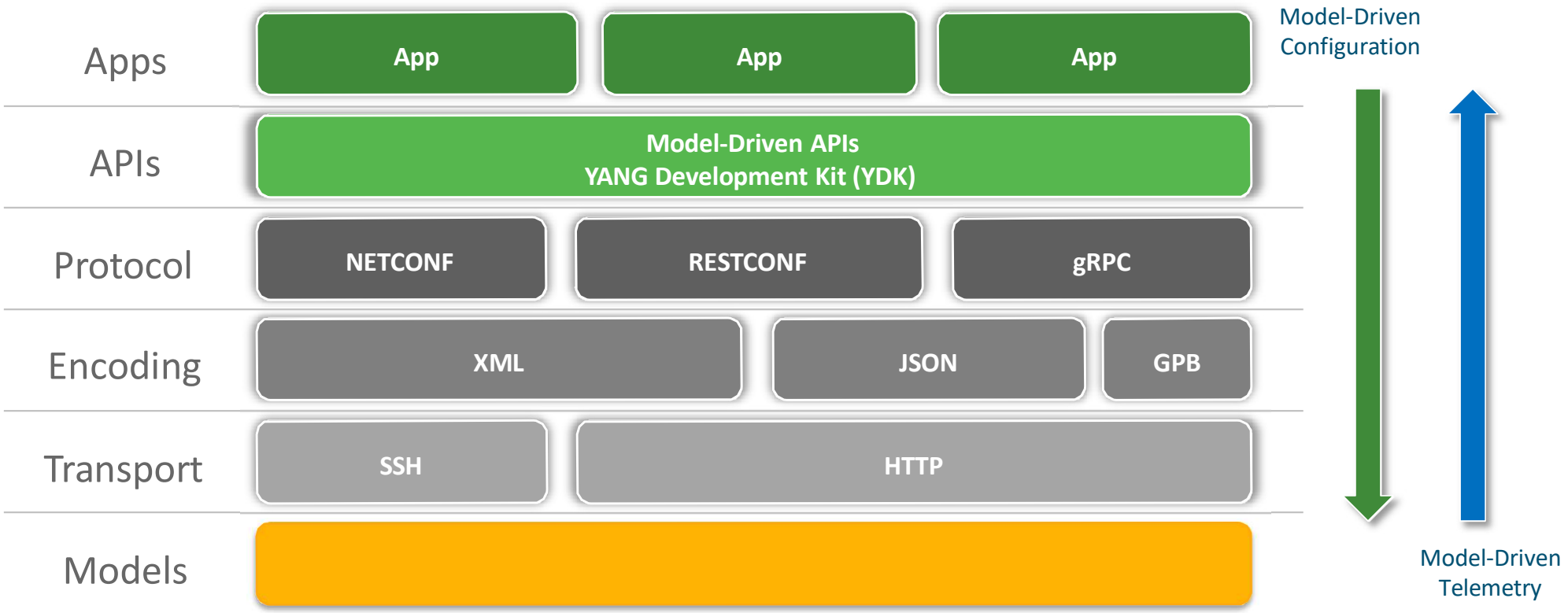
Protocol vs Data Model Considerations

- NETCONF was described and standardised as a transport protocol **several years before YANG** was defined.
- In the time before YANG models existed, NETCONF leveraged **vendor specific data models**.
- Going forward YANG based data models are the primary network data model format used by vendors, but you **may still find devices that offer non-YANG data**
- YANG data models can be leveraged without NETCONF. **RESTCONF** is a great example of this.

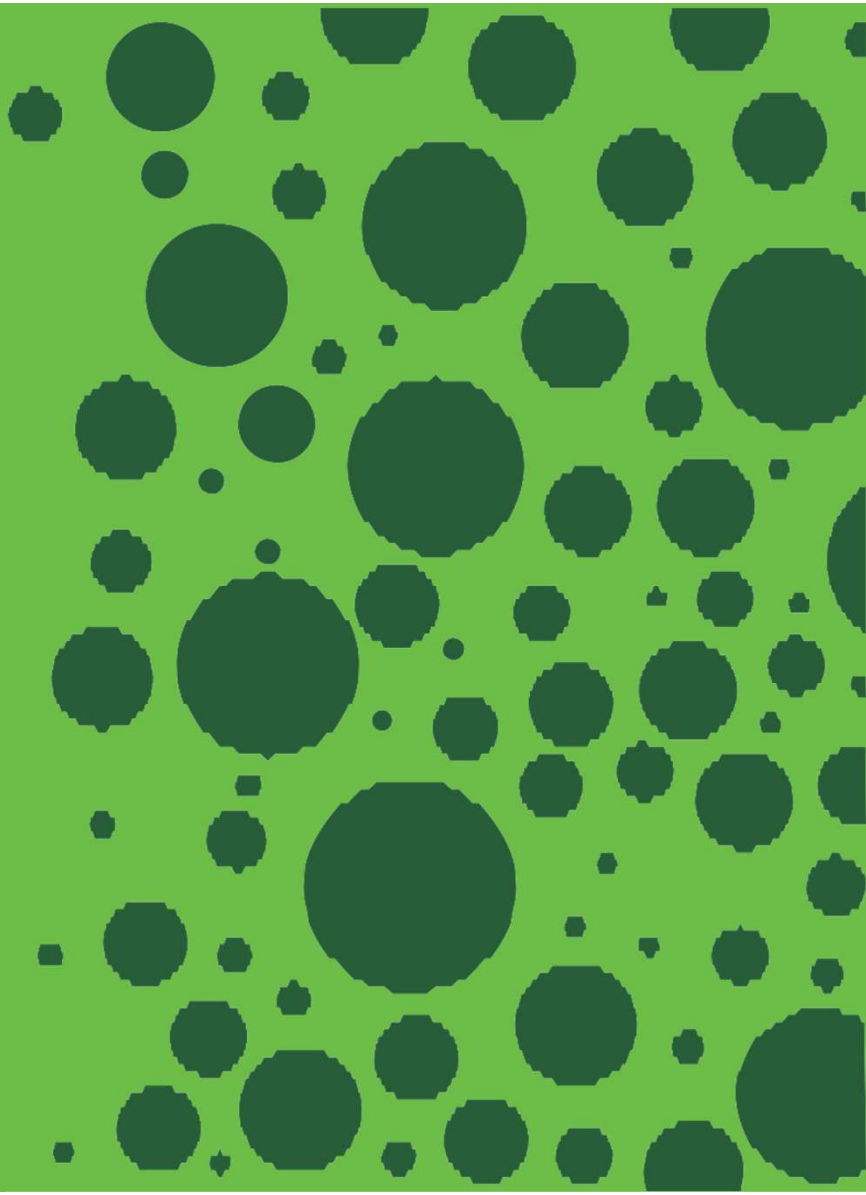
RESTCONF And NETCONF?



Model-Driven Programmability Stack



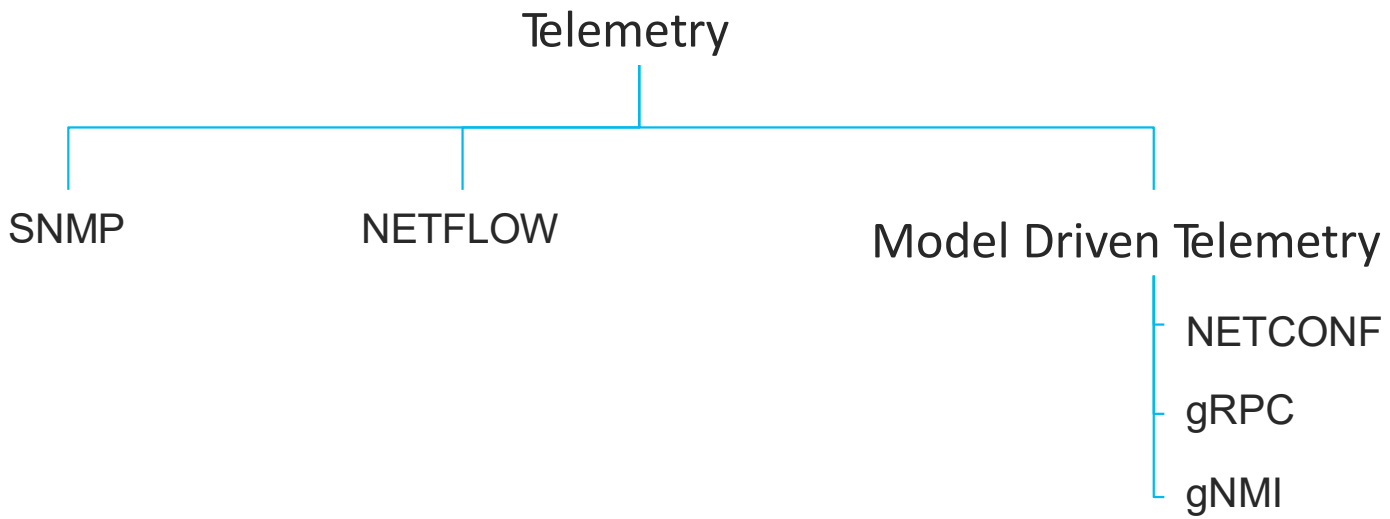
Model Driven Telemetry



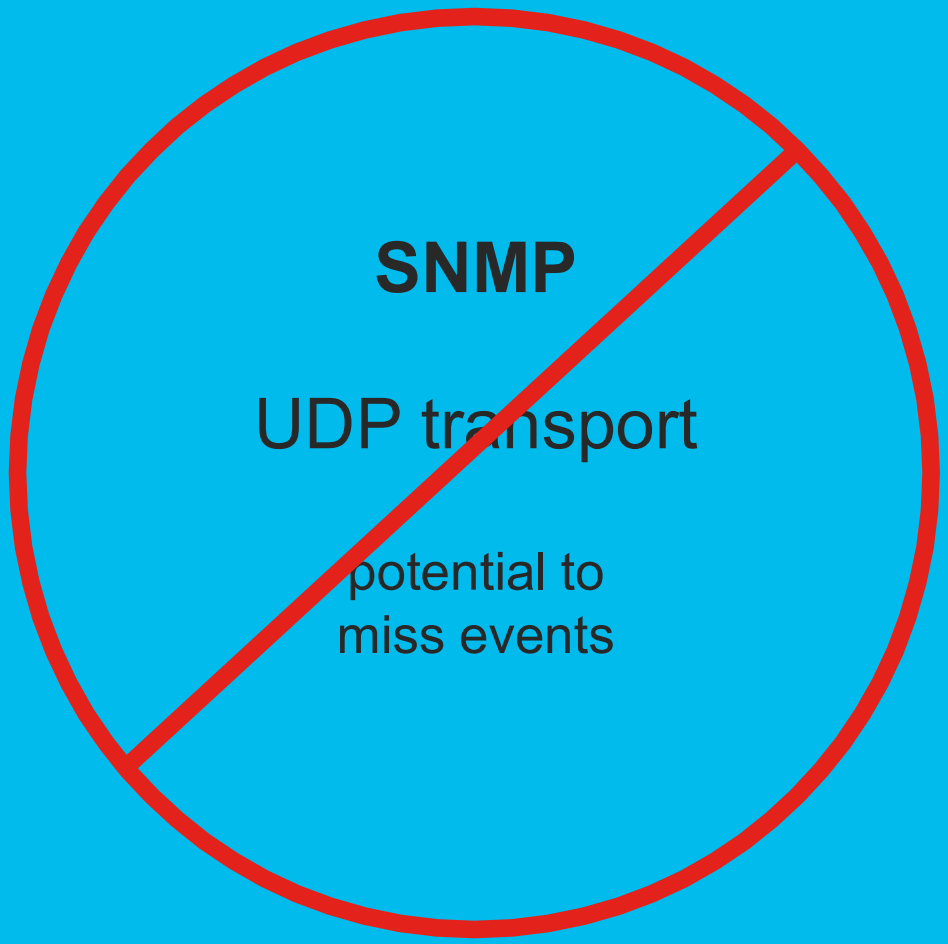
Network Telemetry is a new revolutionary feature!!

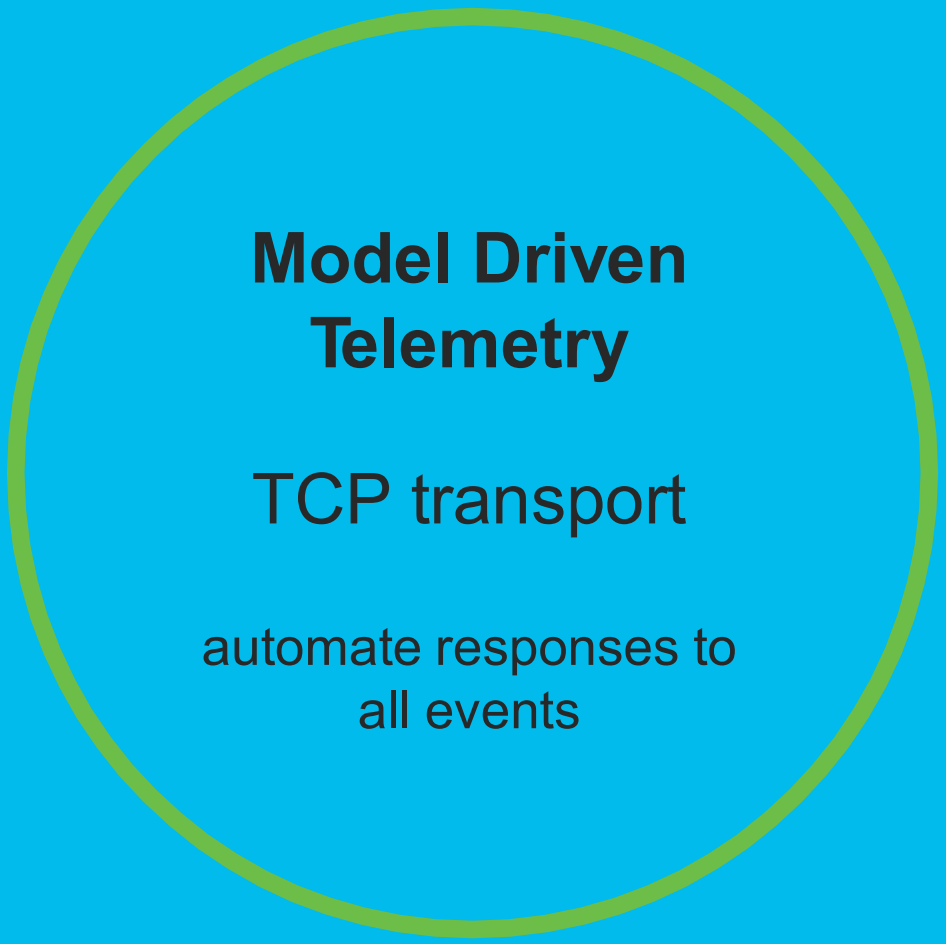
Is it really?..

Telemetry Hierarchy

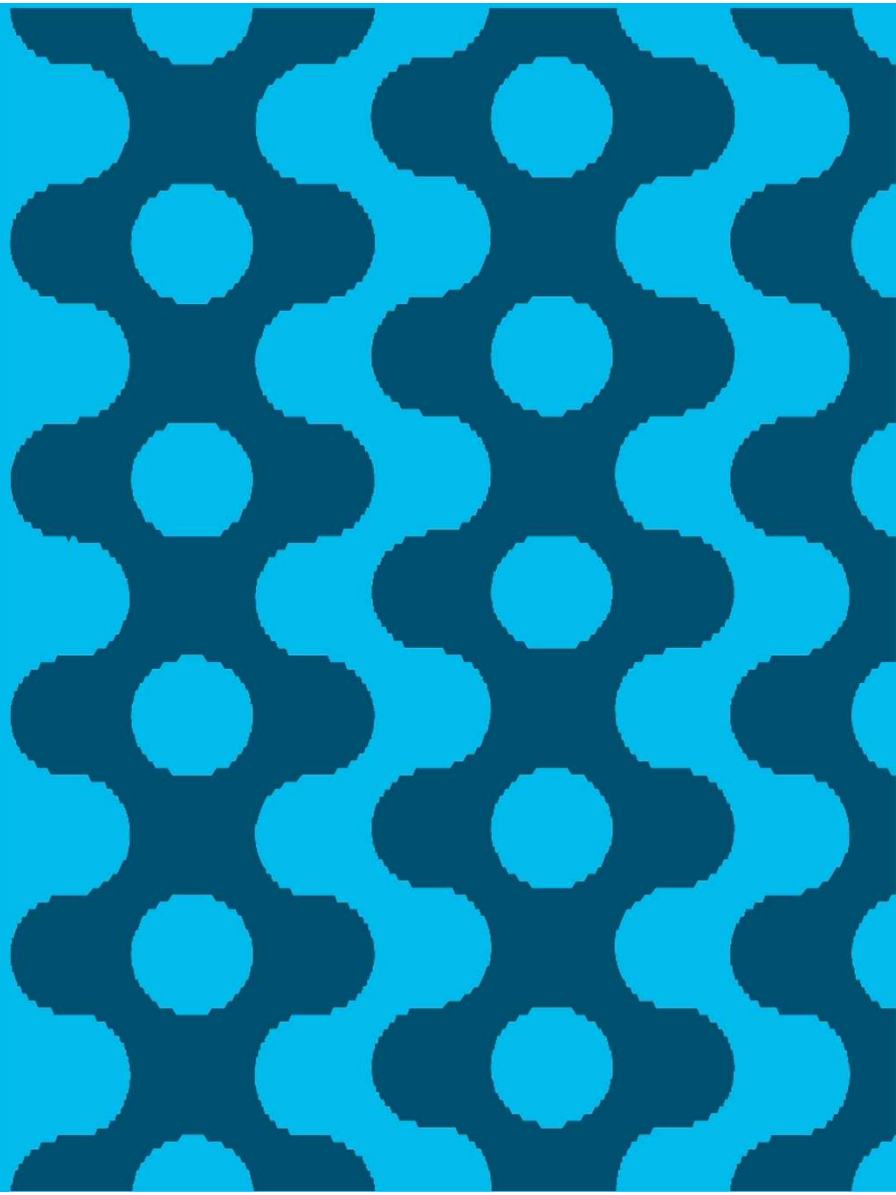


Why Model Driven Telemetry is Important



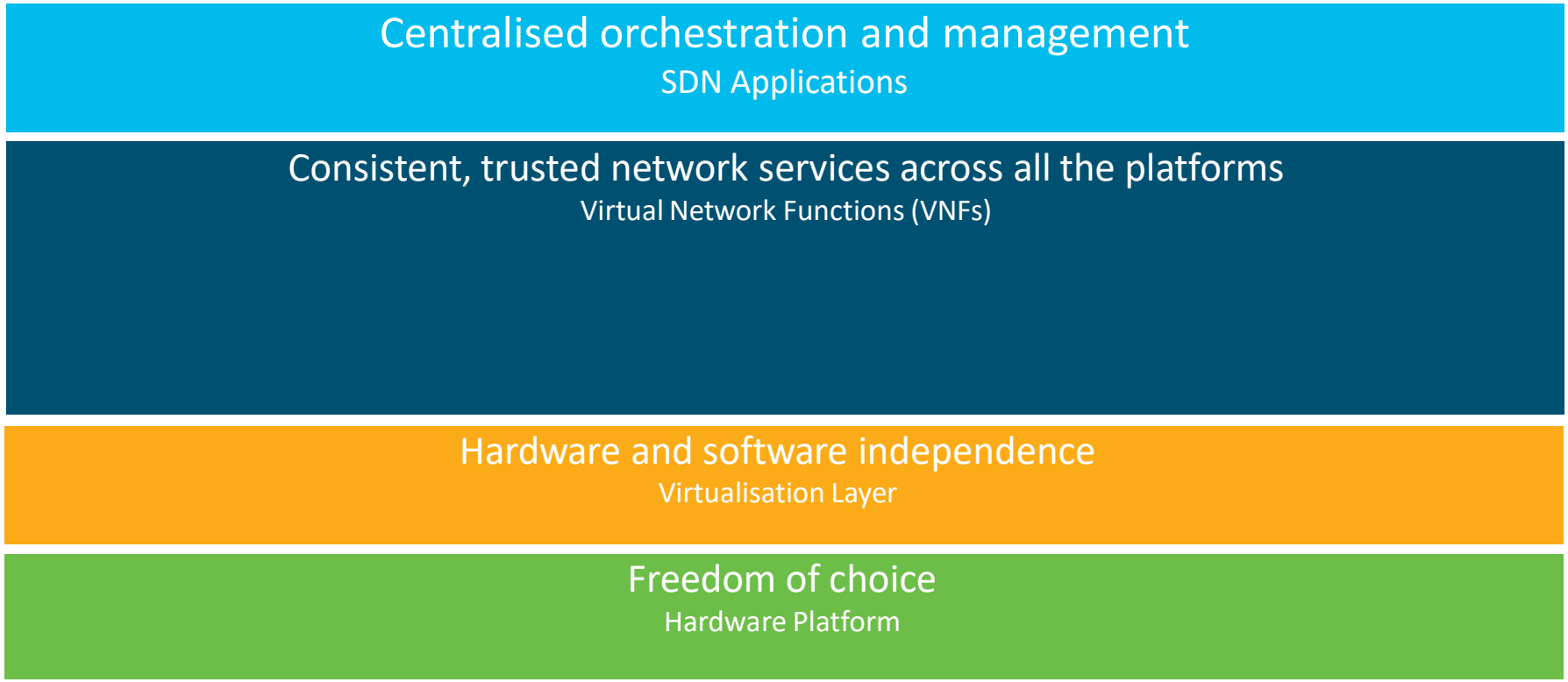


Network Functions Virtualisation (NFV)



What is Enterprise NFV?

Enterprise Network Functions Virtualisation



Customised Network Services for Your Network

IT Agility

1 Select your network functions

- ☑ vRouter
- ☑ vFirewall
- ❑ vWAN optimisation
- ❑ vWLAN controller
- ☑ Third-party services

2 Select your preferred platform

- ❑ Cisco® ISR, UCS® E-Series
- ☑ Cisco ENCS
- ❑ Cisco® UCS C-Series

3 Orchestrate and automate services

Automation Tools

Elastic Services

Run on Any Platform

Deploy in Minutes

In other words…