Introduction to Data Model-driven Management

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Summary

NETCONF/YANG provide a standard interface to interact with network devices in order to update a configuration file or retrieve state data.

- NETCONF (NETwork CONFiguration) “provides mechanisms to install, manipulate, and delete the configuration of network devices” [RFC6241].
- YANG “is a data modeling language used to model configuration data, state data, Remote Procedure Calls, and notifications for network management protocols” [RFC7950].

Background and Motivation

- 2002 IAB Network Management Workshop (RFC3535)
  - "*The goal of the workshop was to continue the important dialog started between network operators and protocol developers, and to guide the IETFs focus on future work regarding network management. This report summarizes the discussions and lists the conclusions and recommendations to the Internet Engineering Task Force (IETF) community.*"

Operator Requirements (RFC3535)

1. Ease of use is a key requirement...
2. …clear distinction between configuration data, data that describes operational state and statistics.
3. …be able to fetch separately configuration data, operational state data, and statistics from devices, and to be able to compare these between devices.
4. It is necessary to enable operators to concentrate on the configuration of the network as a whole rather than individual devices.
5. Support for configuration transactions across a number of devices…
6. …it should be possible to generate the operations necessary to get from A to B with minimal state changes and effects on network and systems.
7. …mechanism to dump and restore configurations …pulling and pushing configurations from/to devices…
8. …consistency checks of configurations over time…
9. …common database schema for network configuration….
10. …text processing tools such as diff, and version management tools such as RCS or CVS, can be used to process configurations…
11. …role-based access control model and the principle of least privilege…
12. …consistency checks of access control lists across devices.
13. Devices should be able to hold multiple configurations.
14. …support both data-oriented and task-oriented access control.

NETCONF/YANG

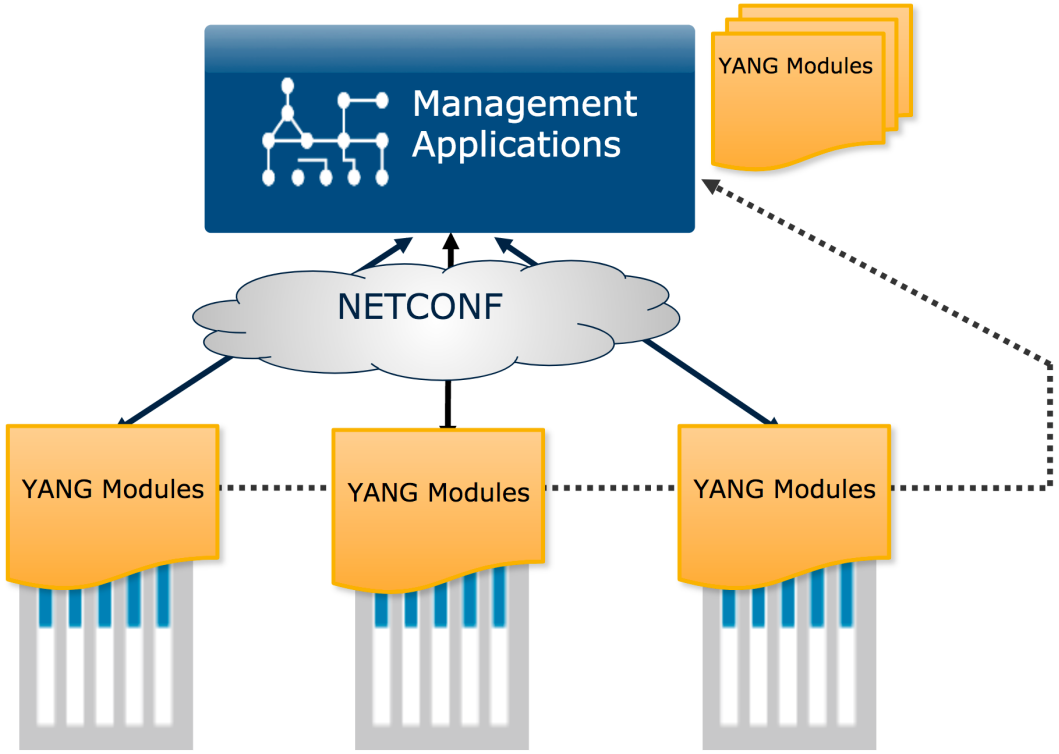
NETCONF (RFC6241)

- Configuration Management Protocol
- Distinction between configuration and state data
- Multiple configuration data stores
- Configuration change validations and transactions
- Selective data retrieval
- Extensible

YANG (RFC6020/RFC7950)

- Data Modeling Language for Networking
- Human readable
- Hierarchical data models
- Structured and Reusable types and groupings
- Extensibility through augmentation mechanisms
- Data modularity (modules and sub-modules)
- Defined versioning rules

NETCONF and YANG in Context



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NETCONF Overview

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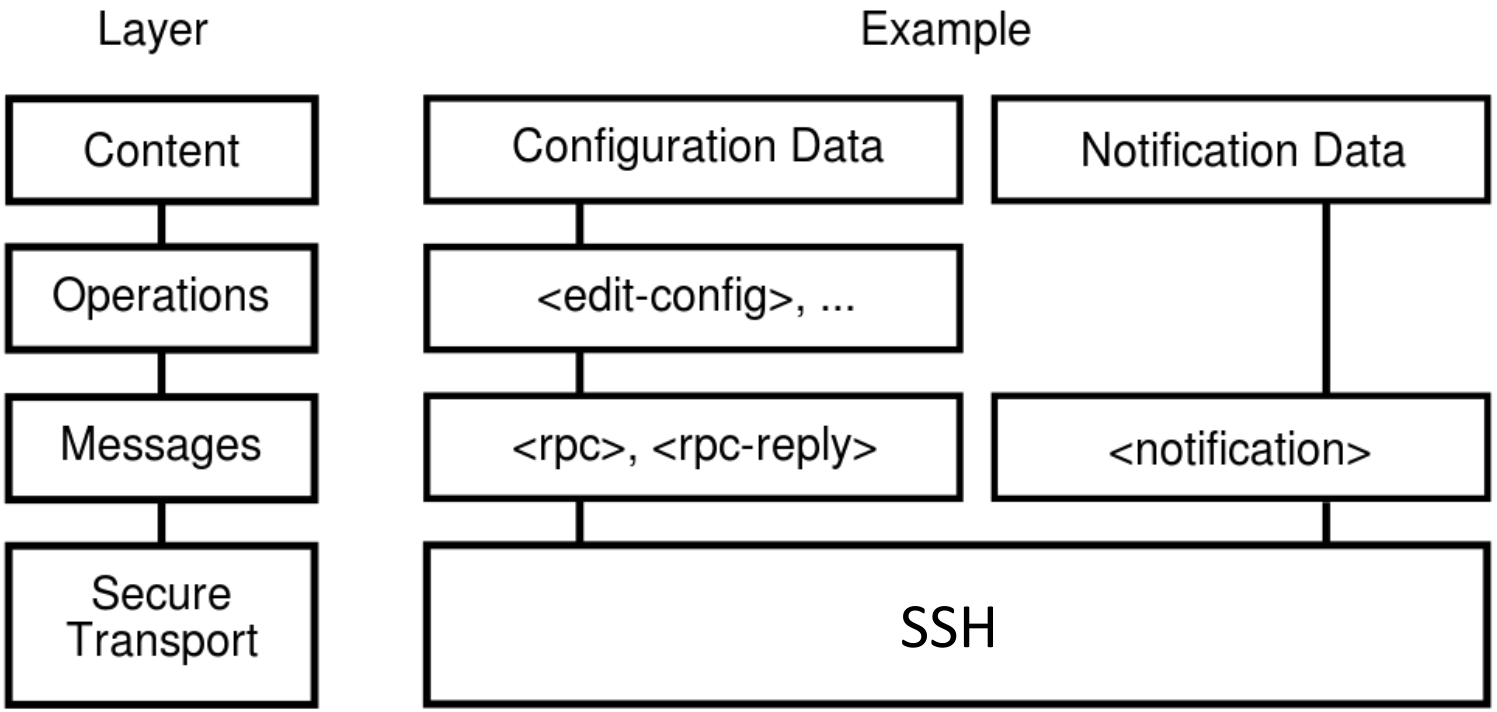
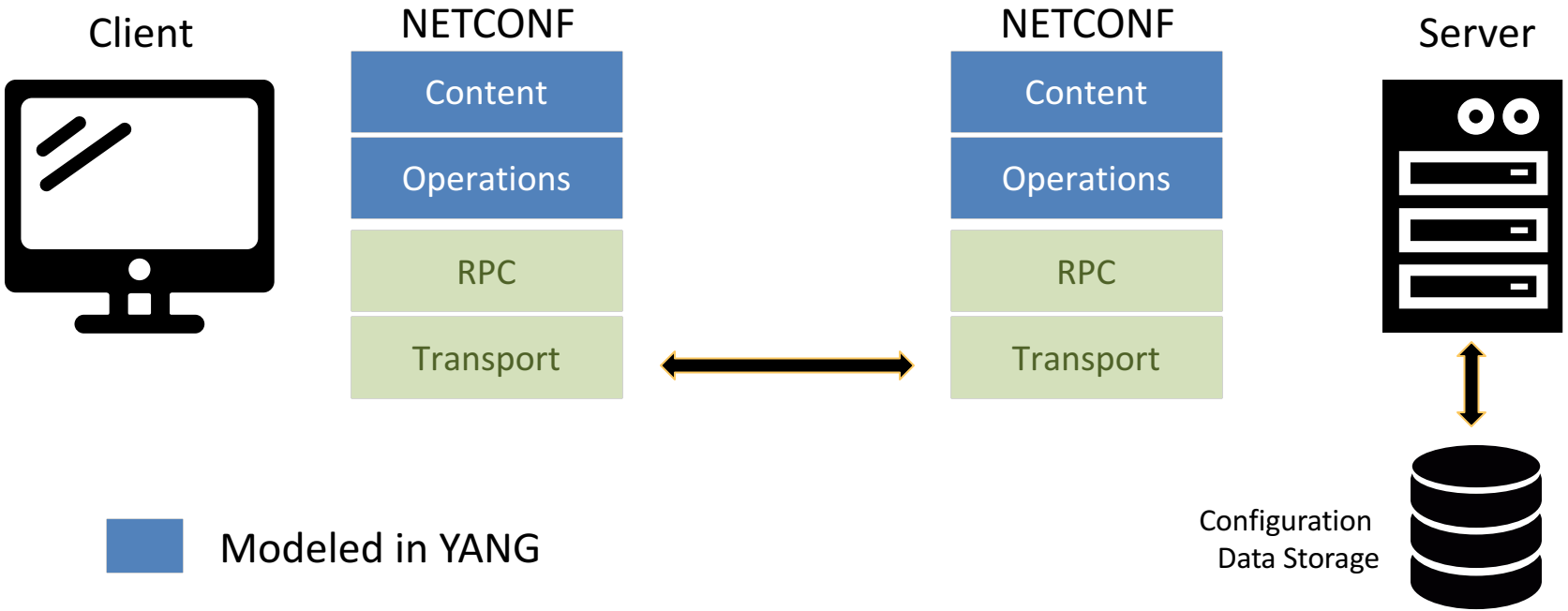
NETCONF Protocol Stack



NETCONF and YANG Architecture

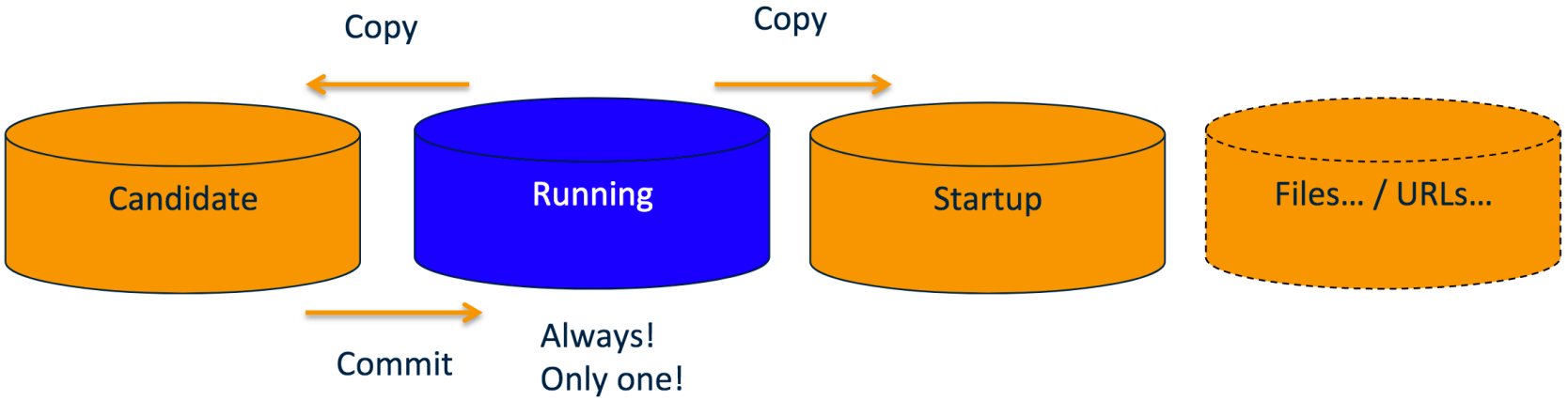


https://github.com/cmoberg/netconf-yang-training

NETCONF Operation Review

- Session Establishment includes Capabilities advertisement
  - Capabilities are functionalities that supplement base operation
- Common Operations
  - Data Manipulation: <get>, <get-config>, <edit-config>, <copy-config>, <delete-config>, <discard-changes> (:candidate)
  - Transaction Management: <commit> (:candidate, :confirmed), <cancel-commit> (:confirmed)

NETCONF Configuration Data Stores



- Named configuration stores
  - Each data store may hold a full copy of the configuration
- Running is mandatory, Startup and Candidate optional *(capabilities :startup, :candidate)*
- Running may or may not be directly writable *(:writable-running)*
  - Need to copy from other stores if not directly writable

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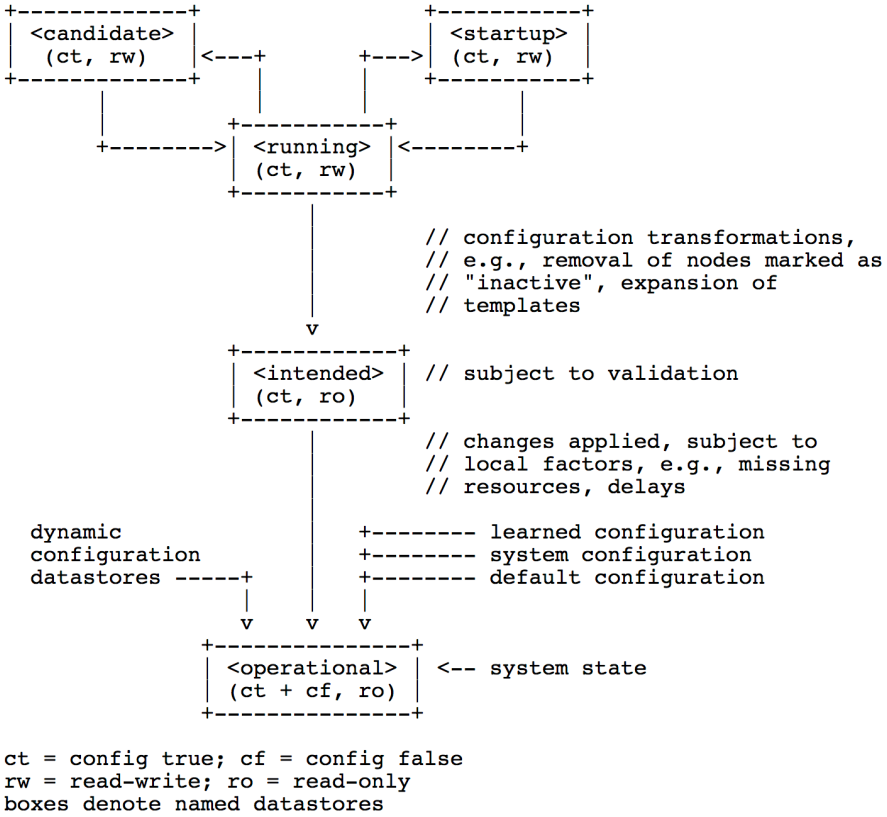
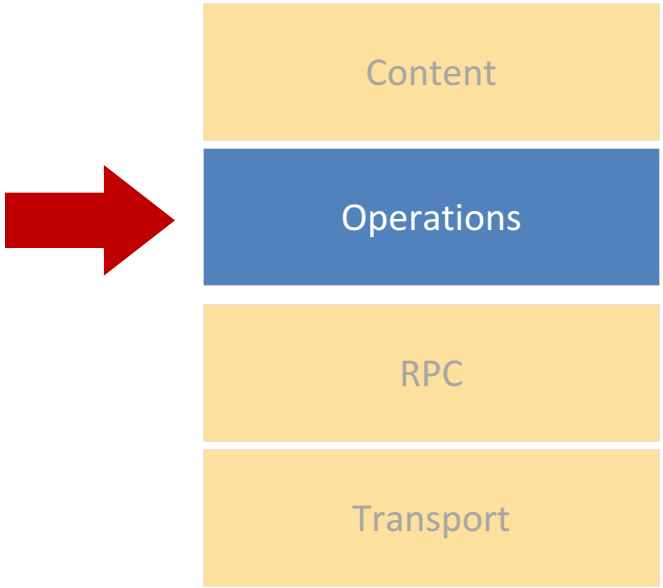
Architectural Model of Datastores



https://tools.ietf.org/html/rfc8342

NETCONF Operations



- Base Operations
- Additional Operations (Capabilities)

```
<rpc message-id="101"
xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
     <source>
       <running/>
     </source>
   </get-config>
</rpc>
```

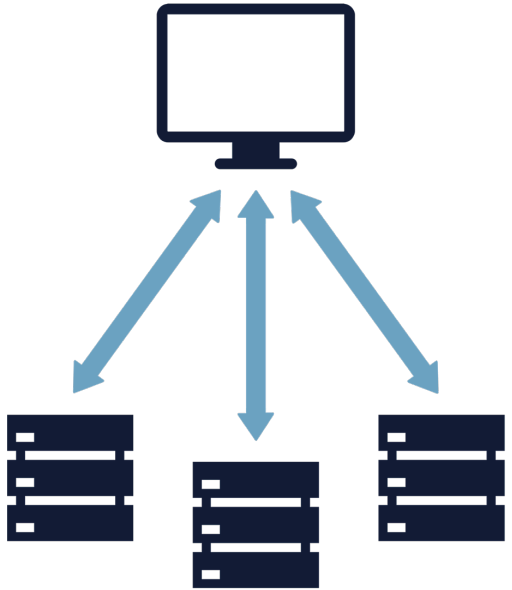
https://github.com/cmoberg/netconf-yang-training

I need to be able to configure a service on the network and not individual devices!

NETCONF provides primitives to:

In parallel:

- Acquire locks on multiple devices
- Upload configuration changes
- Change running configuration and test
- Make changes permanent
- Release locks



https://github.com/cmoberg/netconf-yang-training

Sample NETCONF Use Cases

- Network-wide transactions
- Applying and testing a configuration
- Testing and rejecting a configuration
- Rollback when device goes down
- Transactions requiring all devices to be up
- Backlogging transactions
- Synchronizing

Reading List

- RFC6241: Network Configuration Protocol (NETCONF)
- RFC6242: Using the NETCONF Protocol over Secure Shell (SSH)
- RFC8040: RESTCONF Protocol
- RFC8342: Network Management Datastore Architecture (NMDA)
- RESTCONF Extensions to Support the Network Management Datastore Architecture (draft-ietf-netconf-nmda-restconf)

YANG Overview

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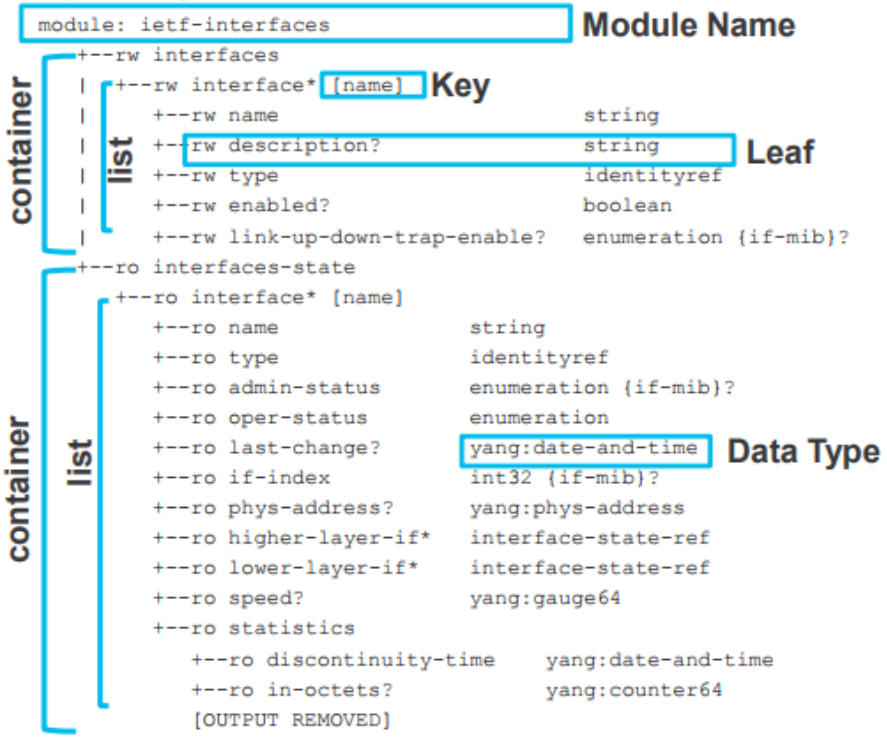
What is YANG?

- Data Modeling Language
  - Configuration and State Data
  - Detailed descriptions of Devices/Protocols
- Tree Structure
- Compact Syntax for Human Readability
- Modules are self-contained YANG definitions
  - Sub-modules contribute additional definitions to a module

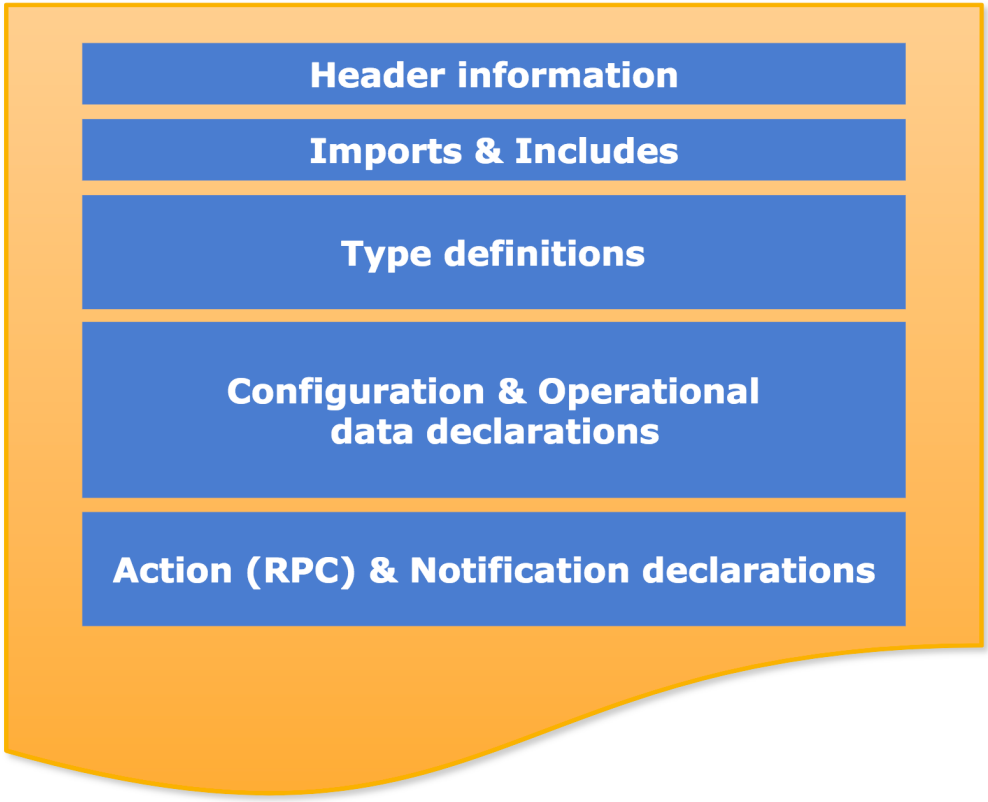
YANG Components



- **Container** - A collection of information logically grouped. Such a container for configuration, and one for state.
- **List** - Within a container you can have a list or even multiple lists. Such as a list of interfaces.
- **Key** - Each item within the list is references via a key.
- **Leaf** - Inside our list we have leaf's. Containing our information.
- **Data Type** - Each leaf is associated against a data type.

https://www.fir3net.com/Networking/Protocols/an-introduction-to-netconf-yang.html

YANG Module Contents



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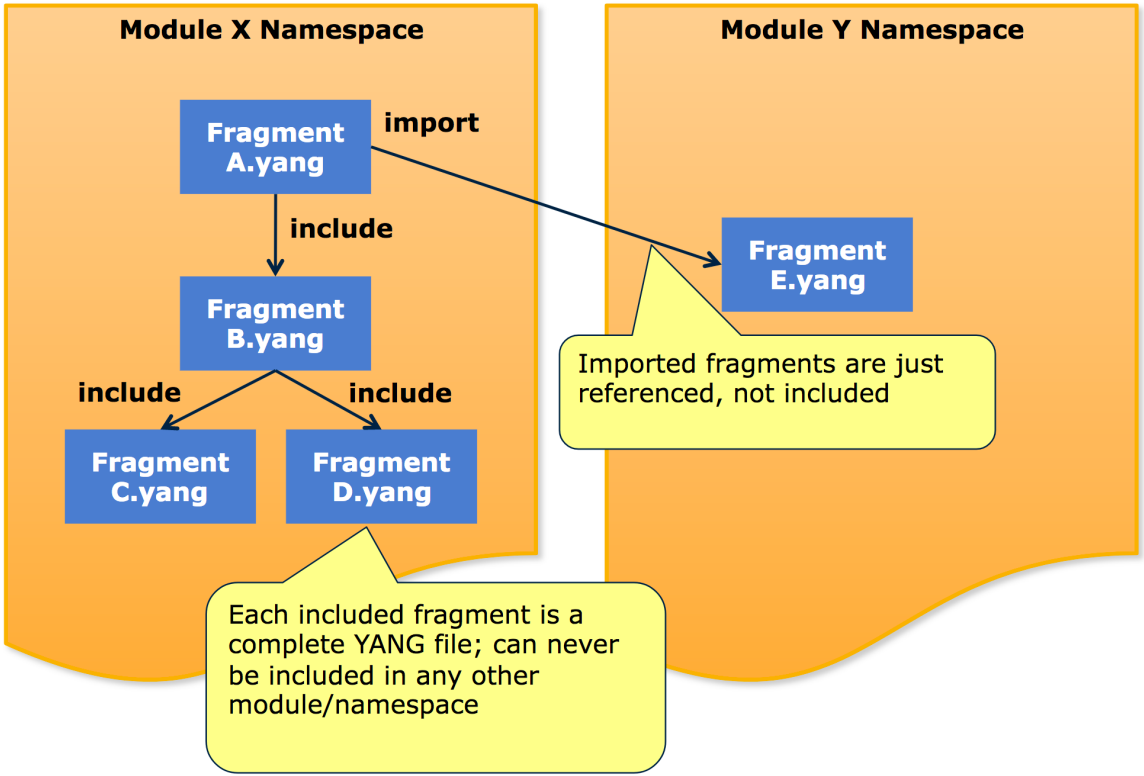
Imports & Includes



https://ripe68.ripe.net/presentations/181-NETCONF-YANG-tutorial-43.pdf

Reading List

- RFC6020: YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)
- RFC6087: Guidelines for Authors and Reviewers of YANG Data Model Documents
  - See also draft-ietf-netmod-rfc6087bis
- RFC6244: An Architecture for Network Management Using NETCONF and YANG
- RFC6991: Common YANG Data Types
- RFC7950: The YANG 1.1 Data Modeling Language
- RFC8340: YANG Tree Diagrams
- RFC8343: A YANG Data Model for Interface Management
- RFC8344: A YANG Data Model for IP Management
- RFC8349: A YANG Data Model for Routing Management (NMDA Version)

Current State

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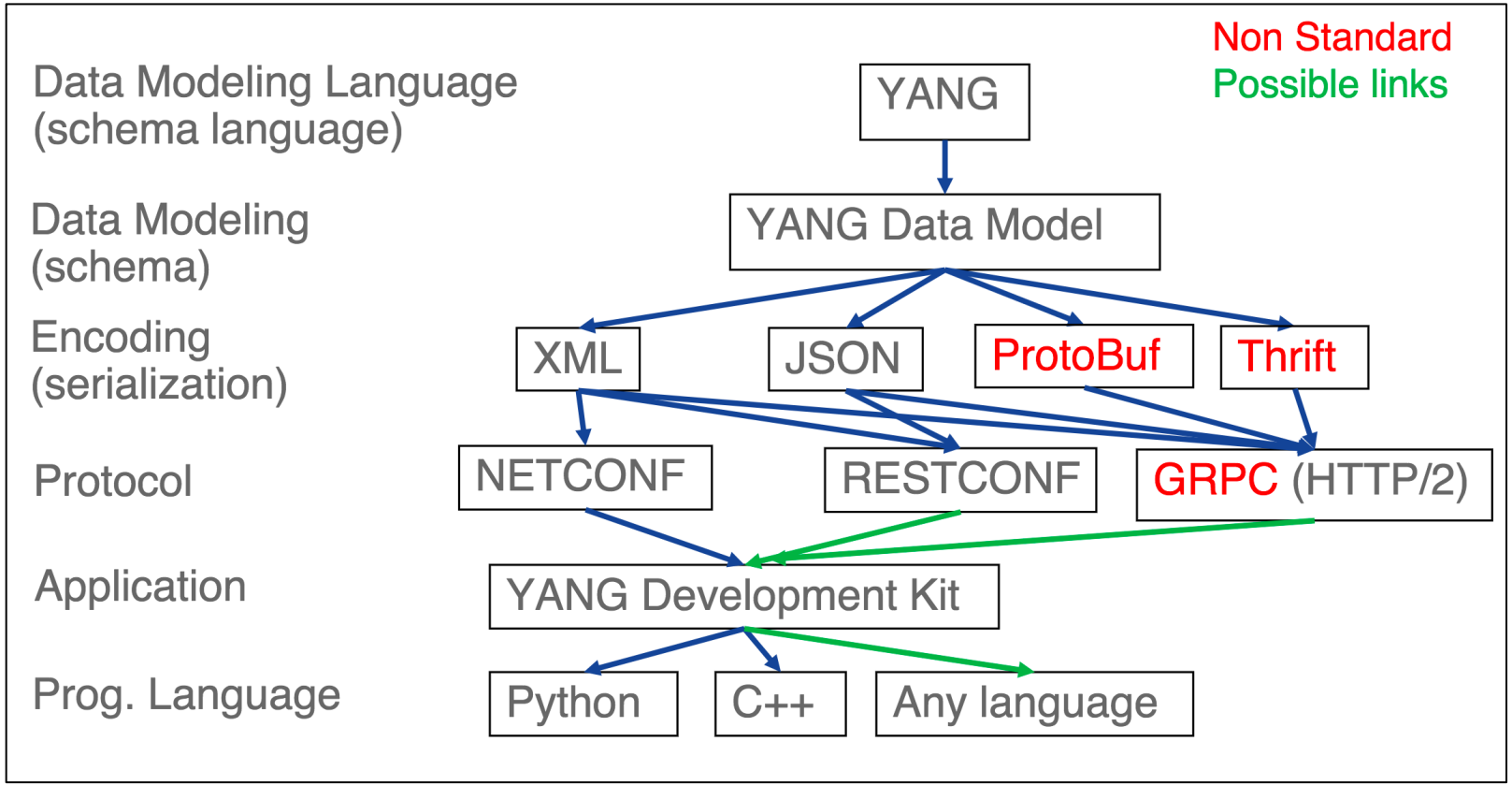

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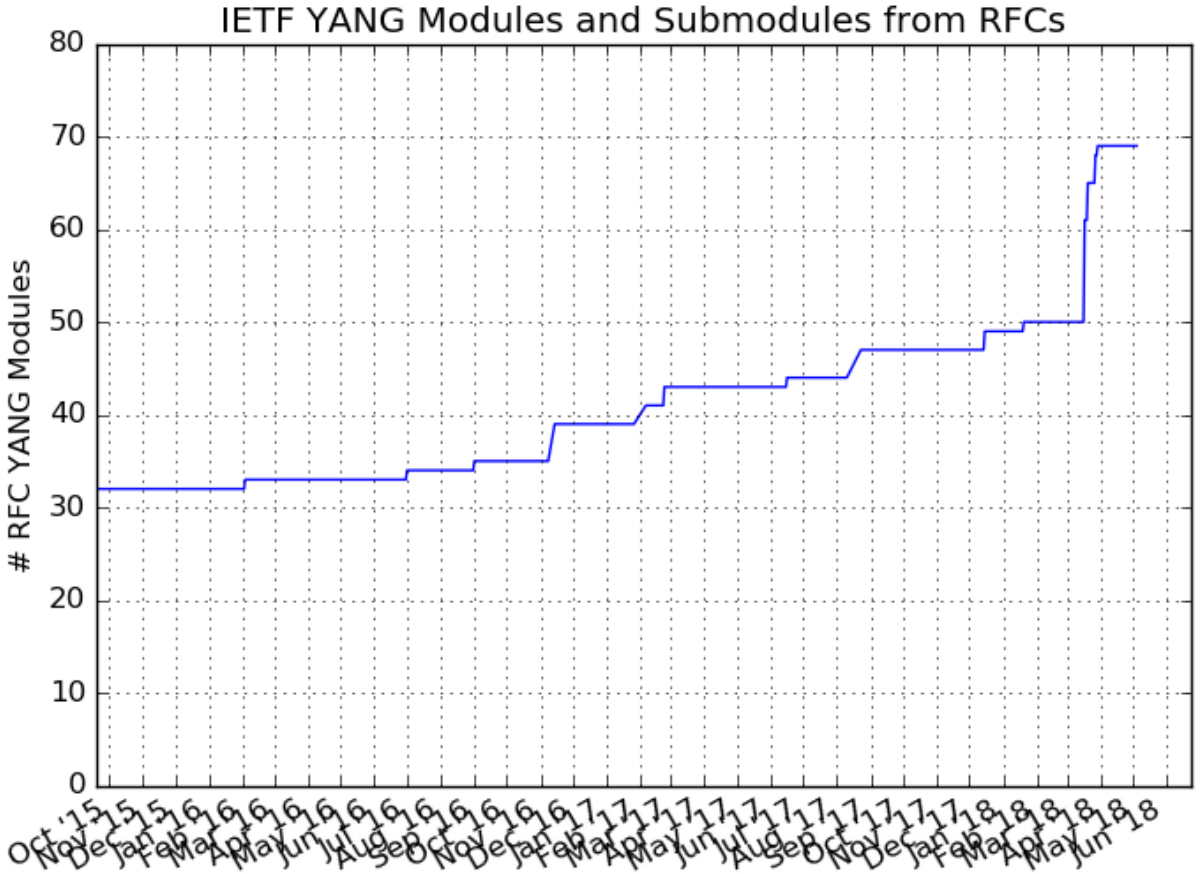
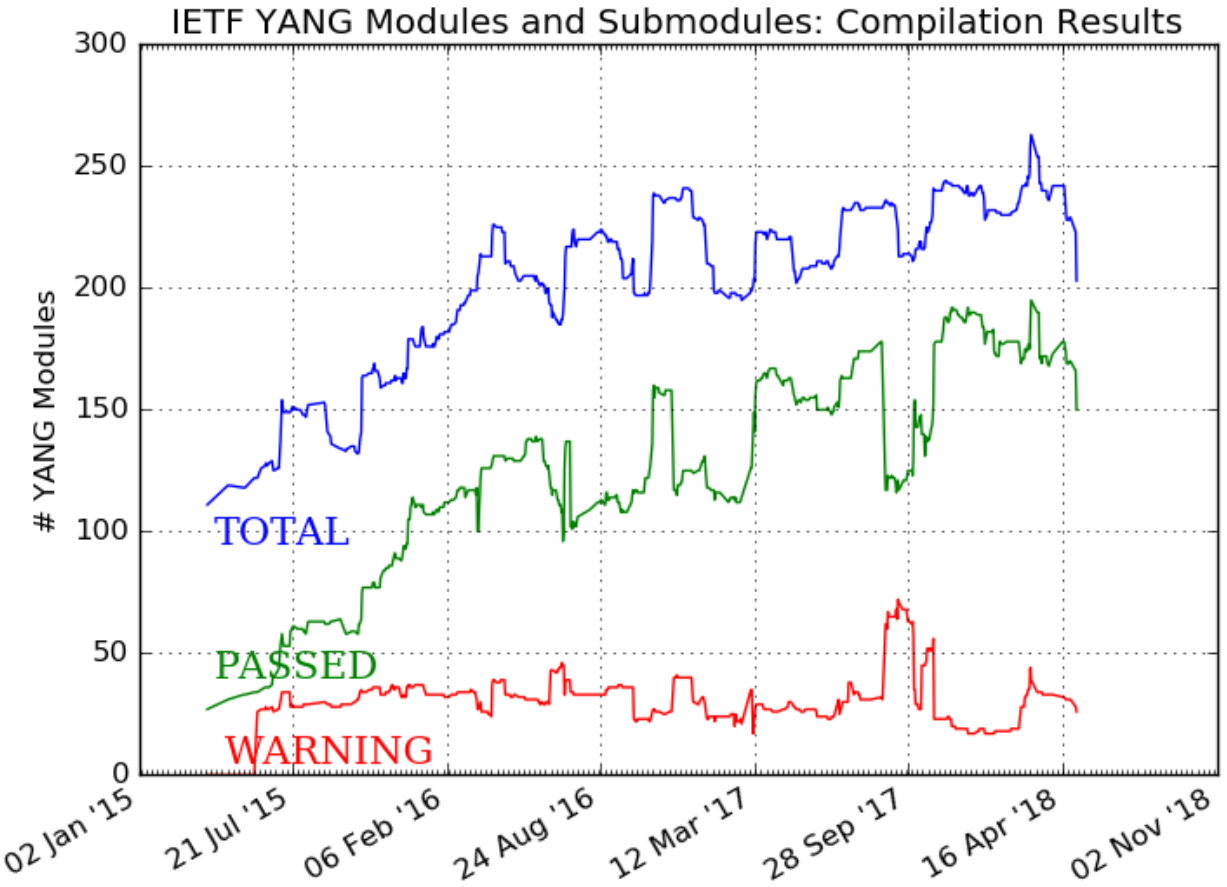


http://www.claise.be/IETFYANGOutOfRFC.png



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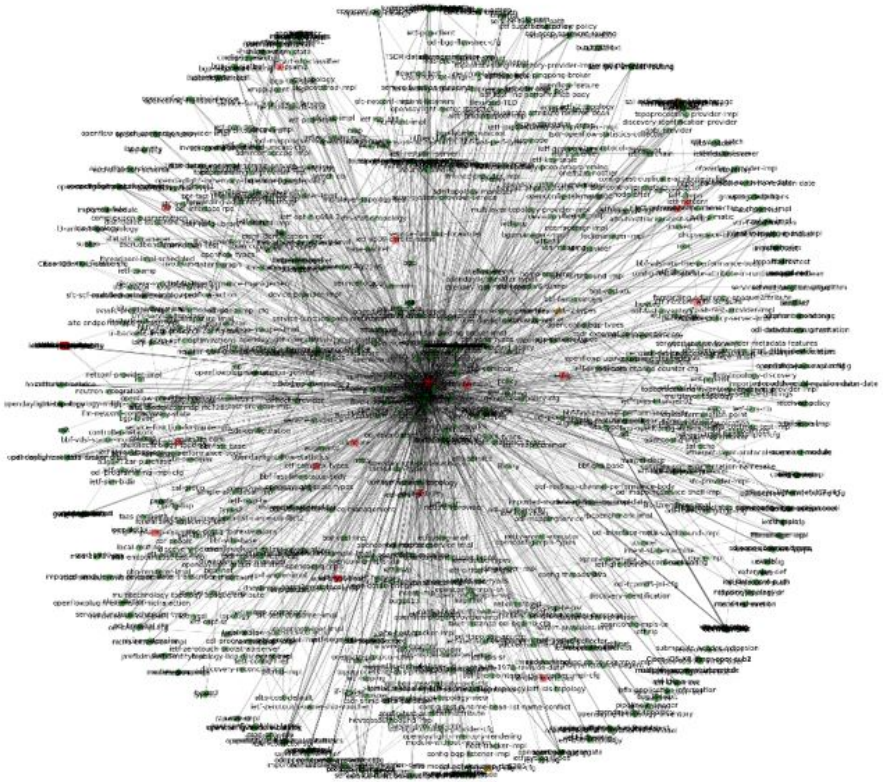
YANG Dependencies



http://www.claise.be/wp-content/uploads/2017/04/all-yang-modules.jpg

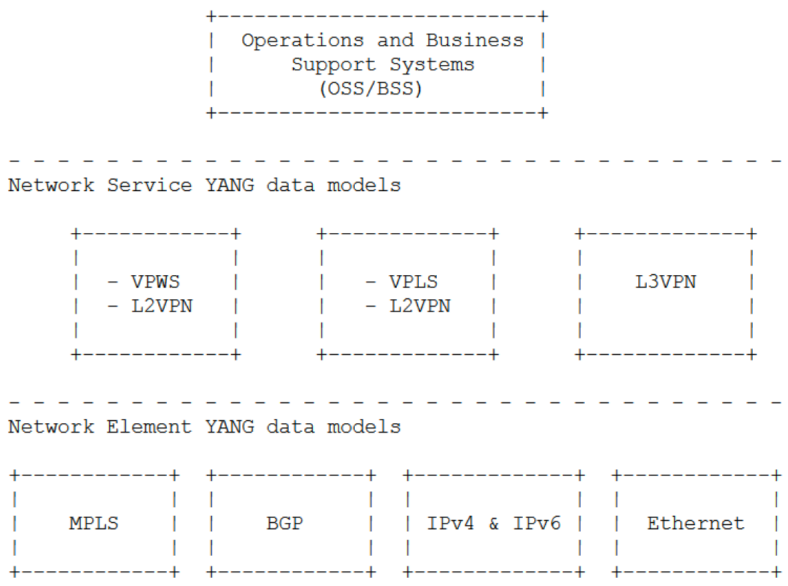
YANG Tsunami in the Industry

TREND

https://pc.nanog.org/static/published/meetings/NANOG72/1559/20180219_Claise_Data_Modeling-Driven_Management__v1.pdf

RFC 8199

SDOs Alignment and Trajectory



https://pc.nanog.org/static/published/meetings/NANOG72/1559/20180219_Claise_Data_Modeling-Driven_Management__v1.pdf

Summary / Call to Action!

- Automation and programmability are required!
- NETCONF/YANG are building blocks to define sets of data model-driven interfaces.
- YANG is the Data Modeling Language of choice in the Industry.
- NETCONF is a protocol that facilitates the manipulation of configurations on network devices.
- Get Involved! Participate in the Development and Implementation of YANG Data Models!
  - YANG Catalog: https://yangcatalog.org/

References

- YANG Catalog: https://yangcatalog.org/
- YANG Data Modules Statistics: http://www.claise.be/2018/02/ietf-yang-modules-statistiques/
- YANG Module Repository: https://github.com/YangModels/yang
- Tutorials:
  - https://www.ietf.org/slides/slides-edu-netconf-yang-00.pdf
  - https://ripe68.ripe.net/presentations/181-NETCONF-YANG-tutorial-43.pdf
  - https://github.com/cmoberg/netconf-yang-training
  - https://pc.nanog.org/static/published/meetings/NANOG72/1559/20180219_Claise_Data_Modeling-Driven_Management__v1.pdf
- IETF Working Groups:
  - Network Configuration (netconf): https://datatracker.ietf.org/wg/netconf/about/
  - Network Modeling (netmod): https://datatracker.ietf.org/wg/netmod/about/

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THANK YOU

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