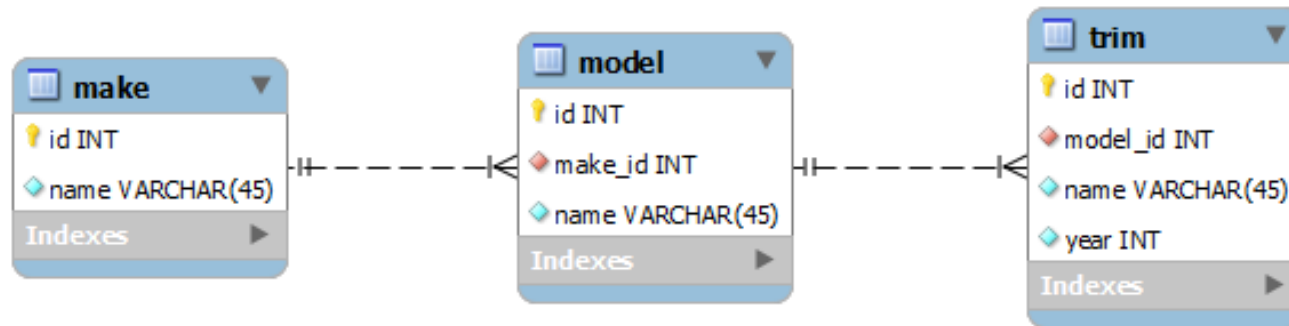# Data Models

- A data model is a well understood and agreed upon method to describe something.
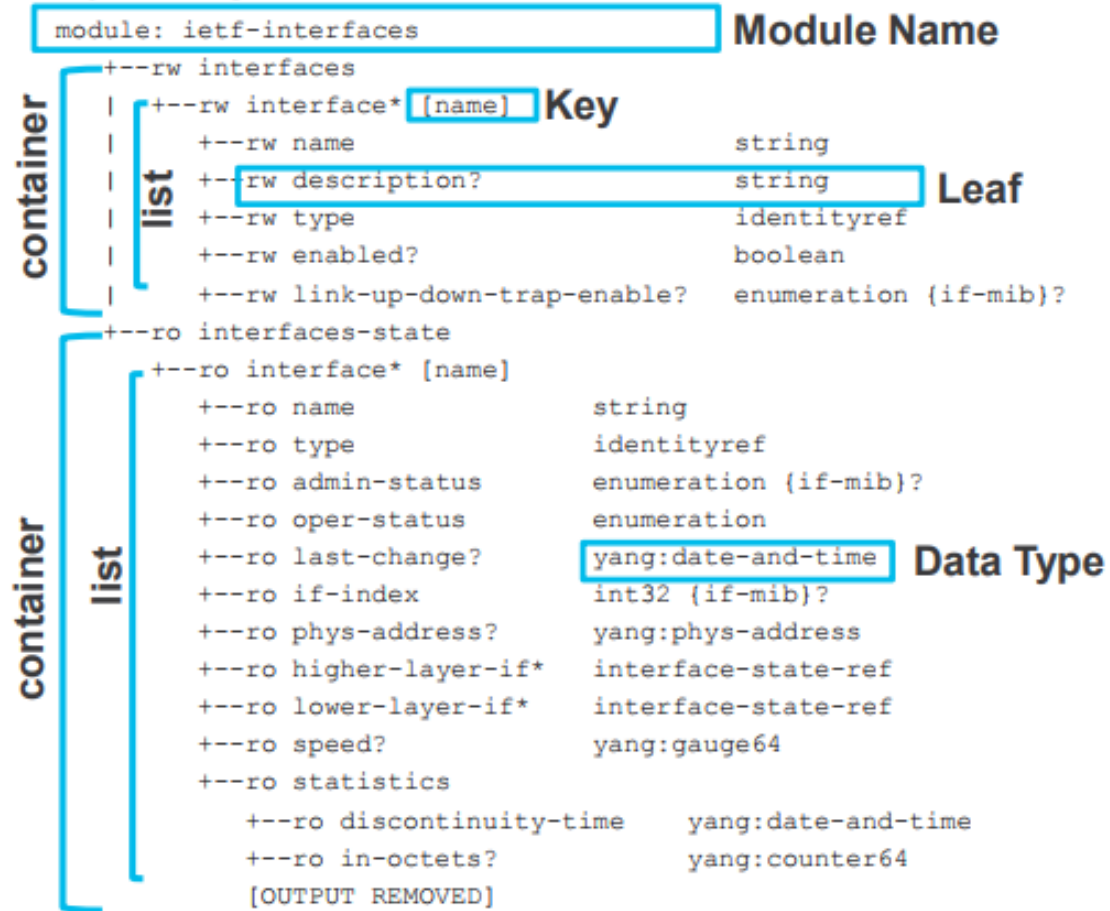
YANG Yet Another Next Generation

- YANG (IETF, 2010) is a data modelling language which provides a standardized way to represent the operational and configuration data of a network device.

- It can be used both internally and when packaged for transmission.

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YANG format

```
module: ietf-interfaces                              Module Name
+--rw interfaces
|  +--rw interface* [name]  Key
|     +--rw name                           string
|     +--rw description?                    string         Leaf
|     +--rw type                            identityref
|     +--rw enabled?                        boolean
|     +--rw link-up-down-trap-enable?       enumeration {if-mib}?
+--ro interfaces-state
   +--ro interface* [name]
      +--ro name                  string
      +--ro type                  identityref
      +--ro admin-status          enumeration {if-mib}?
      +--ro oper-status           enumeration
      +--ro last-change?          yang:date-and-time   Data Type
      +--ro if-index              int32 {if-mib}?
      +--ro phys-address?         yang:phys-address
      +--ro higher-layer-if*      interface-state-ref
      +--ro lower-layer-if*       interface-state-ref
      +--ro speed?                yang:gauge64
      +--ro statistics
         +--ro discontinuity-time    yang:date-and-time
         +--ro in-octets?            yang:counter64
         [OUTPUT REMOVED]
```

container

list

container

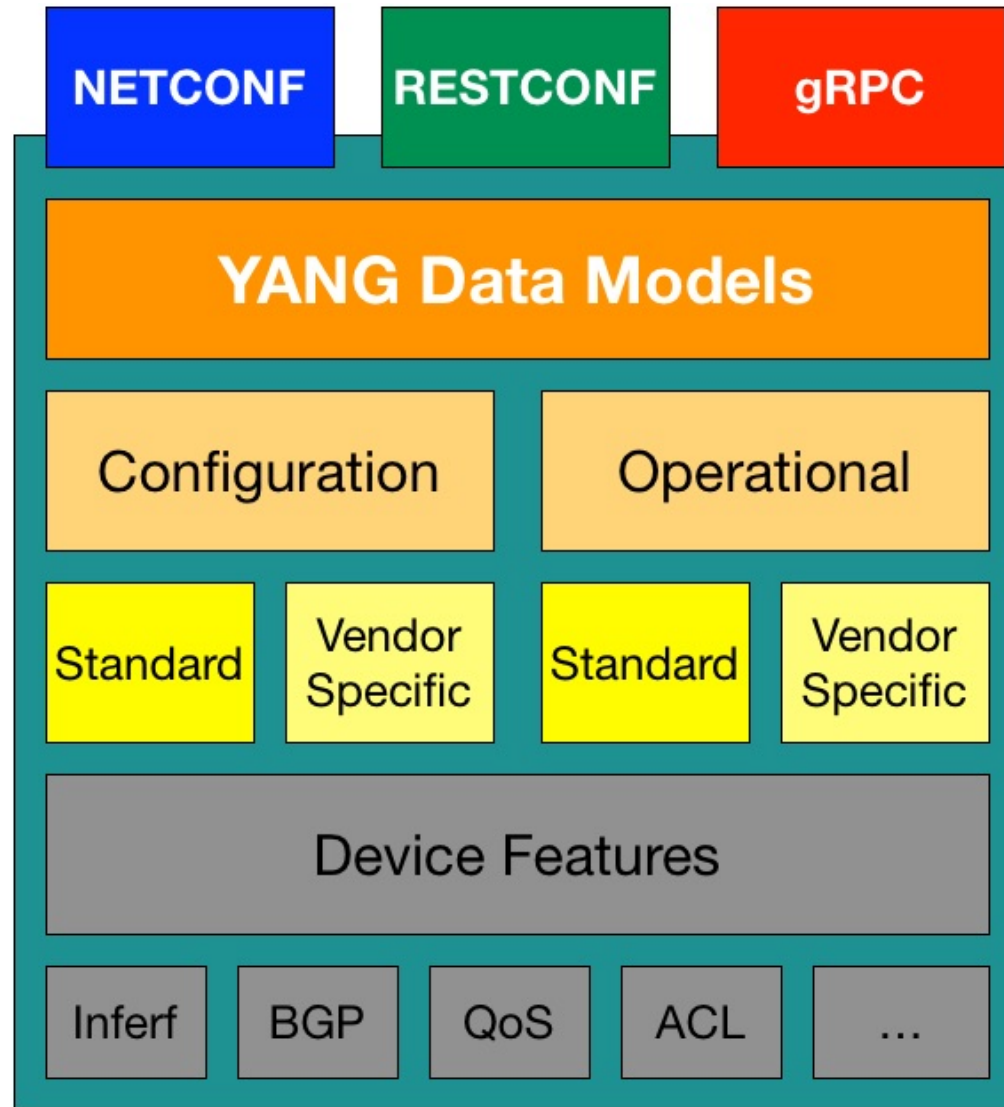list

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Network Management Transport

- The configuration and operational status of a network device's components and services can be remotely read or written to.

- NETCONF, RESTCONF and gRPC are APIs which describe the protocols and methods for transport of network management data.
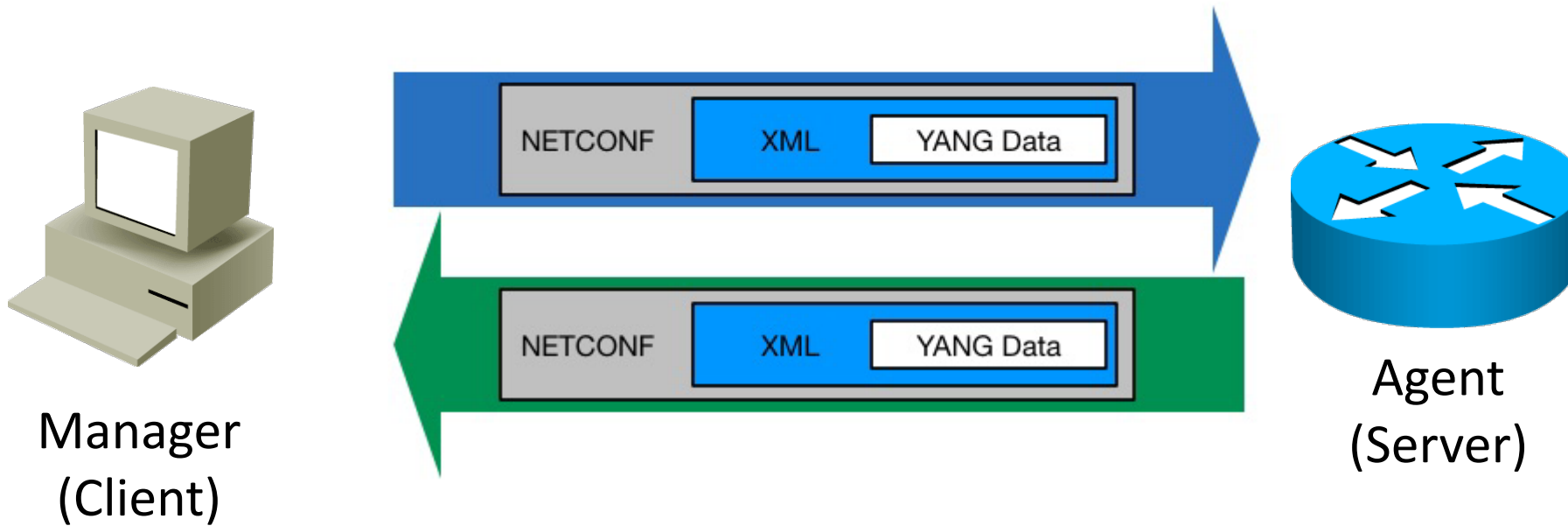
NETCONF Communications

# NETCONF and YANG Yet Another Next Generation

- NETCONF was designed as a replacement for SNMP

- NETCONF and YANG provide a standardized way to programmatically inspect and modify the configuration of a network device.

- YANG (IETF, 2010) is a data modelling language which provides a standardized way to represent the operational and configuration data of a network device.

- NETCONF (IETF, 2006) is the protocol that remotely reads or applies changes to the data on the device.

- XML encoding is used.

- The transport is over SSH or TLS.

NETCONF Protocol Stack

- **Content** – the data to be inspected or changed.

- **Operations** – e.g. <get-config>, <edit-config>. Initiated via RPC methods using XML encoding.

- **Messages** – RPC Remote Procedure Calls (RPC allows one system to request another system to execute code).

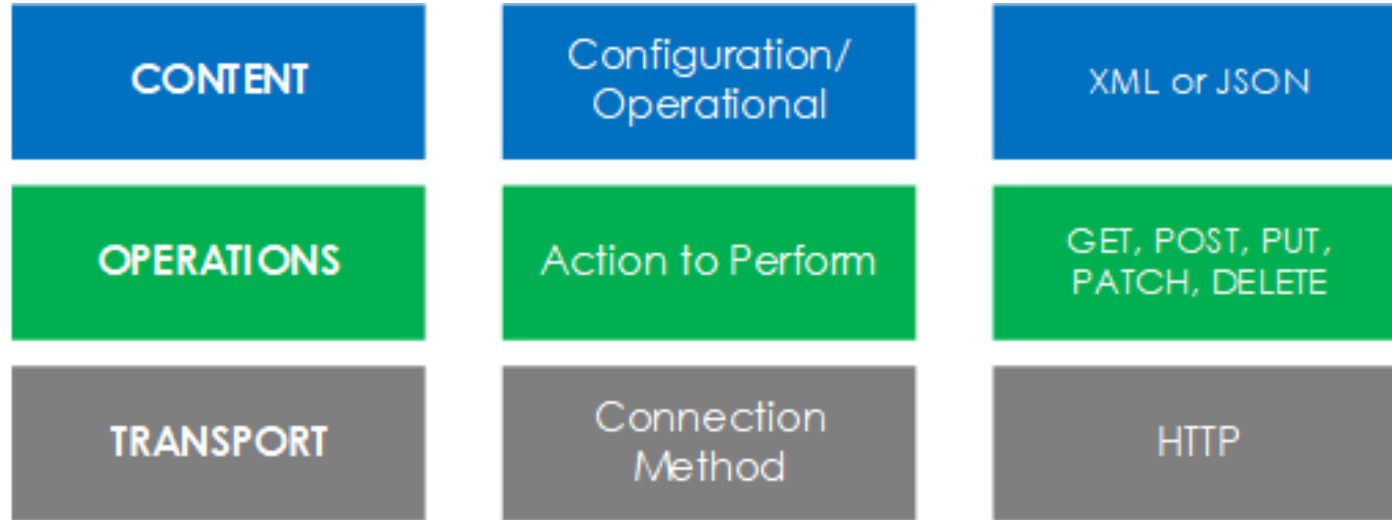- **Transport** – between client and server. Supports SSH or TLS.

NETCONF Protocol Stack
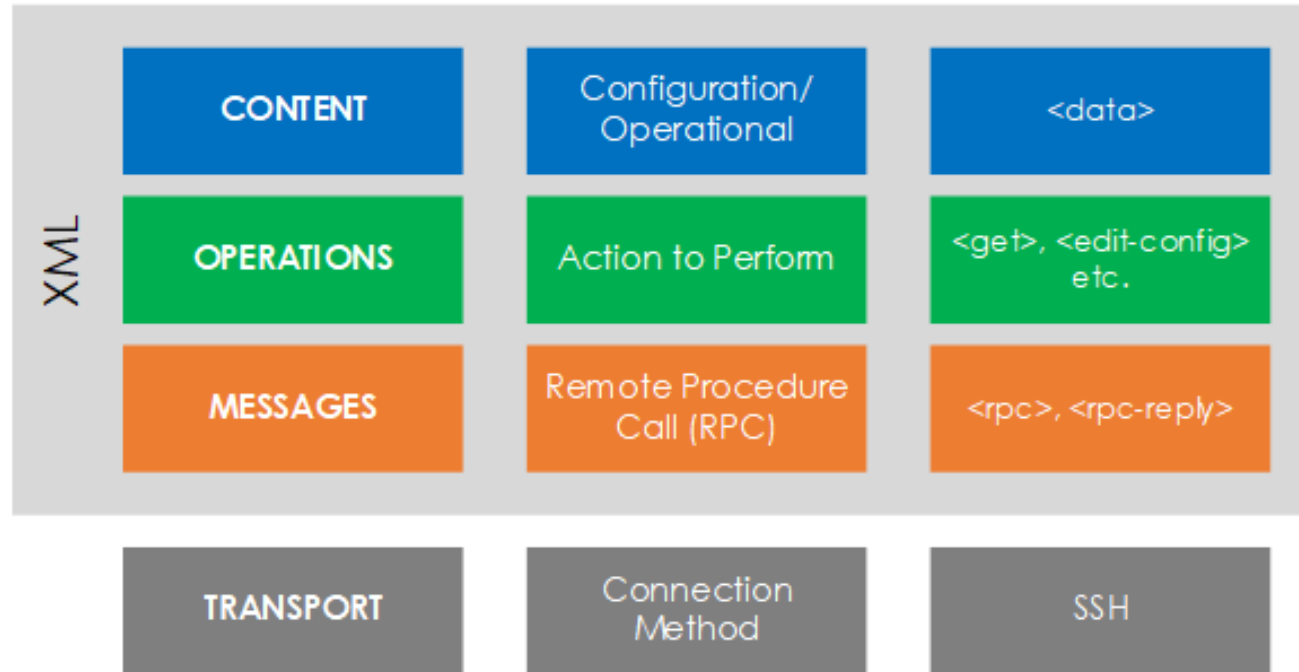
RESTCONF

- RESTCONF (standardized in 2017) builds on NETCONF
- It is an IETF draft that describes how to map a YANG specification to a RESTful interface
- Uses HTTP verbs over a REST API
- RESTCONF is not intended to replace NETCONF, but is simpler to use
- XML or JSON encoding is used.
- The transport is HTTP(S).

RESTCONF Protocol Stack

CONTENT	Configuration/ Operational	XML or JSON
OPERATIONS	Action to Perform	GET, POST, PUT, PATCH, DELETE
TRANSPORT	Connection Method	HTTP

gRPC

- Google RPC is an open source remote procedure call system initially developed at Google in 2015.

- It is well suited to collecting telemetry statistics.

- GPB Google Protocol Buffers encoding is used.

- The transport is HTTP/2.

Postman

- Postman is a very popular tool to test the operation of REST APIs
- It can be downloaded as a standalone application or run as a Chrome plug-in
- Collections and environment variables allow you to easily reuse requests
- Requests can be exported as code in multiple programming languages
- (cURL in Linux or the requests module in Python can also be used to test APIs)