YANG for 802.3 Ethernet

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1. Introduction

YANG is quickly becoming a de-facto data modelling language for next generation network management systems, replacing the legacy Management (MIB)/Simple Network Management Protocol (SNMP) -based tools. When combined with a reliable transport protocol (such as NETCONF, for example), YANG provides substantial advantages to operators, simplifying end-to-end network deployment and providing vendor-independent service modelling across different hardware platforms.

The development of YANG data models has seen incredible growth in many industry organizations, such as the IETF, Metro Ethernet Forum, and the IEEE 802.1 Working Group. This document describes the current Ethernet management model and the path to developing YANG data models for Ethernet interfaces.

2. What is YANG?

YANG is a data modelling language, which replaces the rigid structure of MIB with a very flexible and extensible way to describe different data types, aggregating them into different object types, used to express for example interfaces, devices, network topology, or even protocol models, and build on existing models to create more complex data structures. YANG data models describe configuration, monitoring, administration, and notification capabilities in a device-independent but an end-to-end network service-oriented manner, providing network management in simple, human-readable language syntax.

YANG decouples network management from individual devices, providing an abstract way of describing network elements and more specifically – services instantiated on network elements, decoupled from underlying network equipment hardware models. This in turns provides a vendor-independent way to model network devices, relying on vendor to perform their own mapping from YANG concepts and data models into underlying hardware, which is hidden away from the network configuration tools that are not required to understand hardware platforms anymore.

YANG also provides a way to achieve end-to end network configuration and management following the concept of Software Defined Network (SDN). Operators can implement their target network services by using corresponding YANG data models to

configure and monitor their controllers and controlled devices including individual network elements, such as switches, routers, gateways, and others.

Besides, since YANG can be carried over a variety of network protocols, when coupled with NETCONF, YANG adds a transaction-oriented configuration flow, with roll-back, configuration backup, and verification capabilities to add error handling, allowing operators to provision multiple network elements associated with the given service instance without having to worry about configuring individual network elements separately.

To examine the how YANG fits into Ethernet, we first review how Ethernet systems are currently managed, and then will discuss some of the limitations of the current approach.

3. Current Ethernet Management Model

The current management model for Ethernet interfaces relies on a number of functional elements, i.e., pervasive access to Ethernet PHY via its interface registers (MDIO), pervasive access to MAC and MAC Control functions, and a high layer Management Information Block (MIB) collecting information and exposing them for access over SNMP (Simple Network Management Protocol). All of these elements are illustrated at high level in Figure 1.

Ethernet registers provide information about the given Physical Layer Device (PHY) or its elements, including different sets of counters tracking various aspects of PHY operation and management controls for different functional elements of the PHY, including for example Forward Error Correction. Access to these registers is provided over a pervasive MDIO interface interconnecting individual PHY layers and providing bidirectional flow of information between PHY elements and an SNMP agent. This agent is typically running on any Ethernet interface, and maps information received over the MDIO interface into a MIB. MAC and MAC Control for each Ethernet interface relies on MDIO interface to have access to all management registers instantiated the PHY to control its operation and query the current status.

Information about the given Ethernet interface, including current statistics, state, and control information, is stored in the local instance of MIB managed by the SNMP agent operating on the Ethernet interface. The Ethernet defined MIB provides a standardized way of accessing information stored on the Ethernet interface. This information is usually accessed by a management station across the network. Depending on the version

of the SNMP agent, access to MIB information may be more or less efficient in terms of number of exchanged query / response pairs and may or may not have strong authentication / encryption, or other properties. Regardless of the SNMP version, the MIB/SNMP-based management model suffers from drawbacks outlined in the following section.

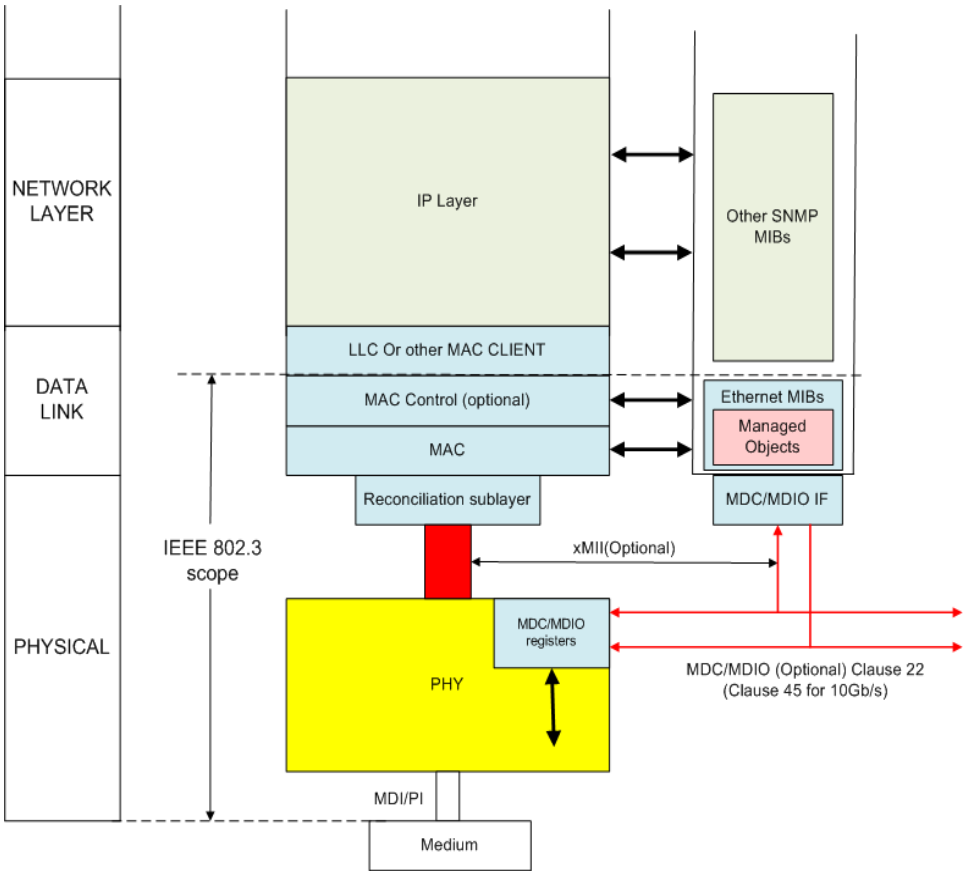

Figure 1: Ethernet management functional elements

4. MIB/SNMP Management Limitations

The MIB structure is designed with device management in mind and follows the legacy network management philosophy quite closely. Each network device is managed separately, and service configuration requires configuration of multiple separate network devices. Each network device is configured separately, without any information about the state and service configuration of the surrounding network elements. This provides a device-centric network management, rather than the service-oriented network management paradigm of today.

In the device-centric network management paradigm, there is no service state information maintained on any network device. The only way to model individual services is via an external, third-party network management system (NMS) platform capable of (a) polling state from individual network elements, (b) correlating state information to a given service instance, and (c) associating this information into a logical service construct. Even when such platforms are available, they are generally not vendor-interoperable, since each network equipment vendor offers their own NMS platform, requiring operators to perform further in-house integration in higher layer NMS platforms.

Additionally, the device-centric network management paradigm is operation-oriented, where batch configuration of multiple devices associated with the given service instance is not available. There is no way to send a single service definition to all affected devices in a single transaction and rely on their proper configuration. Each network device needs to be updated separately via a directed series of configuration operations.

The lack of state information on the network element itself, combined with no rollback and no configuration backup capabilities within the network elements led to severe limitation of the exiting MIB/SNMP based device-centric network management paradigm, which are intended to be addressed with YANG-based service-oriented modelling and transaction-oriented configuration flow.

5. MIB/SNMP and YANG/NETCONF

The definitions for the current Ethernet management model are contained in Clause 30 in [802.3], with the MIB definitions included [802.3.1]. The management agent provides remote access to the manager via communication channel. In case of MIBs the SNMP manager on the NMS interacts with the SNMP agent on the Ethernet device via SNMP. The individual managed objects defined in [802.3] Clause 30 and expressed in terms of [802.3.1] MIB are instantiated on the managed station.

For YANG/NETCONF, the high level management model is identical to the one used by MIB/SNMP (see [802.3], Figure 30-1). The management protocol used between the manager and agent is modified to NETCONF and YANG is used to define and organize individual managed objects.

The use of YANG as the data modeling tool does not change the existing management model within PHY and its mapping into the Ethernet registers, but only affects the interaction between the managed device and the network manager.

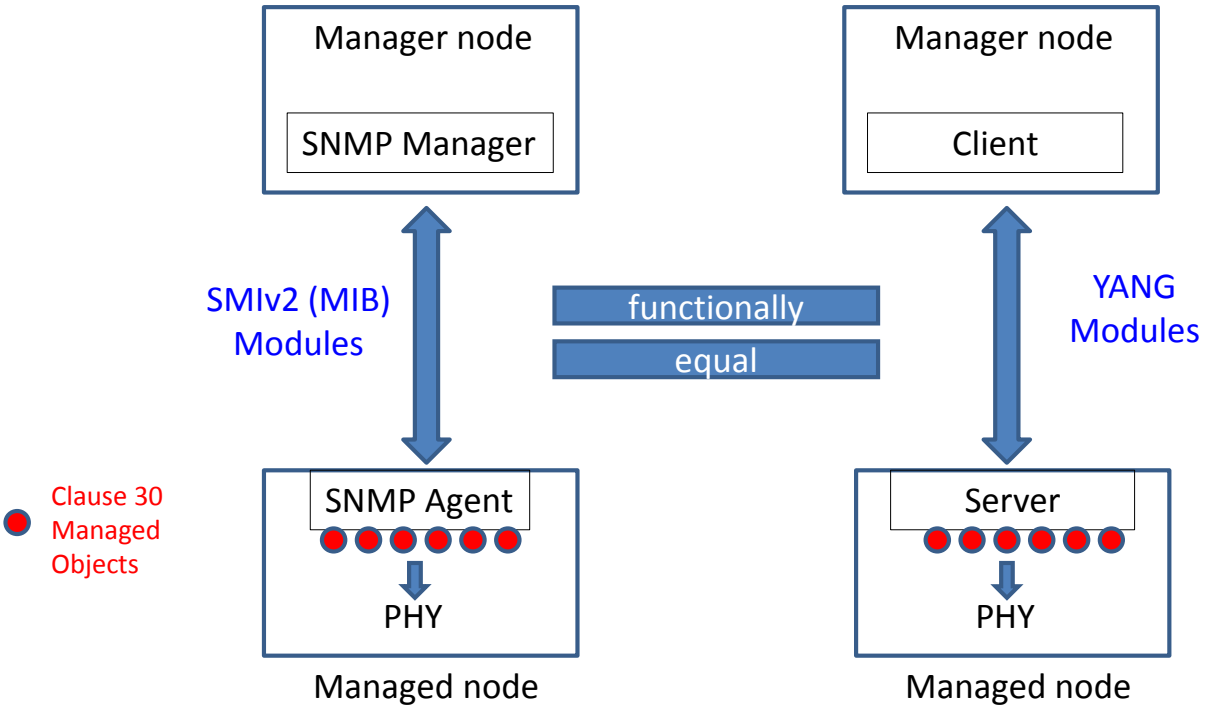

Figure 2: Functional comparison between YANG/NETCONF and MIB/SNMP

6. Scope of YANG development for IEEE Std 802.3 Ethernet

It is anticipated that the development of YANG models for Ethernet interfaces would rely heavily on extension of already existing IETF interface models, such as [RFC 7223]., adding Ethernet-specific extensions (counters, management objects, etc.). Ethernet-like MIB functionality could be defined first with YANG, relying primarily on existing Ethernet managed objects combined with some Ethernet registers not exposed today. The translation of the existing MIBs into YANG models is not considered the most effective approach, as this would create a large number of device-oriented model parameters in the new YANG model, which is intended to be more end-to-end network service-oriented.

Once the basic YANG data model for Ethernet becomes available, it could then be applied to other members of the Ethernet (for example, Ethernet Passive Optical Network – EPON) family through extension. However, these models must be developed to interoperate seamlessly with other YANG data models currently being developed within the IEEE 802 community [802.1].

7. Summary

YANG represents the data modelling language for next generation NMS solutions, replacing the legacy MIB/SNMP-based systems. The availability of standardized YANG data models for Ethernet interfaces will drive the development and adoption of end-to-end network service-oriented provisioning solutions, eliminating the need to model individual network elements in NMS solutions and facilitating rapid roll-out of customer services.

The use of YANG as the data modeling tool does not change the existing management model within PHY and its mapping into the Ethernet registers, but only affects the interaction between the managed device and the network manager.

8. References

[802.3] IEEE Std 802.3-2015, Standard for Ethernet

[802.3.1] IEEE Std 802.3.1-2013, IEEE Standard for Management Information Base (MIB) Definitions for Ethernet

[802.1] IEEE P802.1Qcp and IEEE P802.1Xck

[RFC 7223] A YANG Data Model for Interface Management, M. Bjorklund, May 2014