NETCONF Interoperability Lab

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***Abstract*—Interoperability testing is an important part of the lifecycle of a protocol. Interoperability tests not only help to reduce implementation bugs, but they also often improve the accuracy of a protocol specification. In a pursuit to improve Network Configuration (NETCONF) interoperability and foster it for community-based education, we have developed and deployed a NETCONF Interoperability Lab. The lab provides a platform to execute test-cases against an online catalogue of NETCONF server and client implementations. The NETCONF Interoperability lab is available online at:** `http://www.interop-lab.net`.

I. Introduction

There is a growing need for tools and related specifications to evaluate the interoperability and compliance of implementations of standardized network management protocols. Interoperability problems are typically caused by a number of different factors: a) Errors and ambiguities in standards. b) Human programming errors. c) Different interpretations of the standard. d) Different choice of options allowed by the standard. As such, it is not uncommon that interoperability tests uncover ambiguous parts of a specification and parts that are under-specified. This is why, within the Internet Engineering Task Force (IETF), interoperability reports are generally needed in order to advance specifications on the standards-track [1].

The availability of open labs that can be used for interoperability testing will help alleviate such challenges. These labs ease validation of reference implementations and foster their acceptance in the market place. The fact that major components of a testing lab are made publicly accessible (test specifications, tools, execution environments) will not only directly benefit the developers, but also potential users by providing a common testing ground within the lab. In this pursuit, we have developed and deployed an open lab that can be used for NETCONF interoperability testing.

The NETCONF protocol [2] and the associated YANG data modeling language [3] are the foundations of a new network management framework evolving in the IETF. Some early work on NETCONF interoperability testing was published in 2009 [4]. However, since then, implementations have matured significantly and the core NETCONF specifications have been revised in order to remove ambiguities and to address problems encountered with the first revision. A first NETCONF interoperability testing event based on the revised NETCONF specifications took place in Atlanta in November 2012[1], prior to the 85th IETF meeting. While such interoperability testing events can be very productive (it is not uncommon that bugs discovered during the day get fixed over night), it is costly to organize and participate in them. In this paper, we describe an online NETCONF interoperability testing lab that is accessible 24 hours a day. Such an online testing facility is not only expected to improve interoperability, it may also be effectively used for educational purposes.

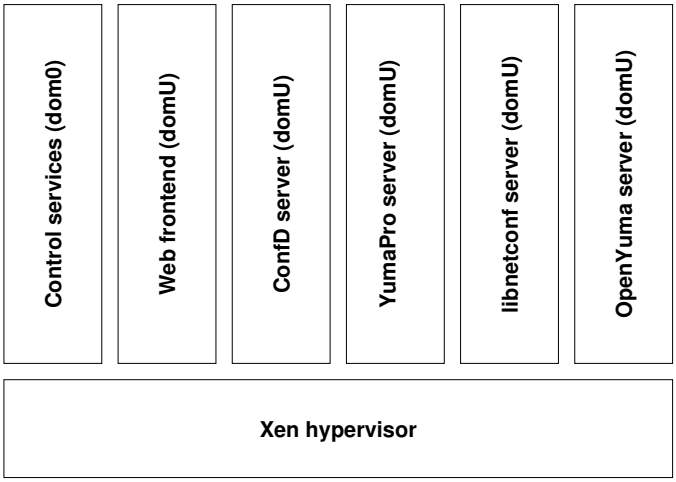

Fig. 1. NETCONF Interoperability Lab server infrastructure: Separate virtual machines are used for each NETCONF server. The virtual machines run Debian, while the hypervisor is based on Xen using a Debian Xen dom0. A separate virtual machine is deployed to provide the web frontend. The NETCONF servers are dual-stacked and reachable both over IPv4 and IPv6.

II. System Architecture and Features

The NETCONF interoperability lab is deployed using a dedicated physical server and a collection of virtual machines as shown in Fig. 1. The Xen dom0 can also be used to implement required control services. NETCONF servers are deployed in a sandboxed environment with configurations that limit the amount of changes that test users can make. In this first phase, we consider it sufficient to periodically restart the servers to perform an occasional cleanup of configuration changes made by test users.

The NETCONF interoperability lab provides the following services: a) Access to a set of NETCONF server implementations including supporting material. b) An online catalogue of NETCONF server implementations including those that for various reasons (e.g., license restrictions) cannot be part of the lab. c) An online catalogue of NETCONF client implementations including those that for various reasons (e.g., license restrictions) cannot be part of the lab. d) A collection of basic tests written in a portable high-level language that can be used for offline testing of NETCONF servers. It is possible

[1] `http://www.internetsociety.org/articles/successful-netconf-interoperability-testing-announced-ietf-85`

978-1-4799-0913-1/14/$31.00

to execute these test cases against NETCONF servers that are part of the lab or against other remote NETCONF servers.

III. NETCONF CLIENTS AND SERVERS

The following NETCONF client and server implementations have been considered for integration into the NETCONF interoperability lab:

1) ConfD: Tail-f licenses its NETCONF implementation, ConfD and associated tools to device manufacturers. A special license agreement has been drafted to regulate its usage as part of the lab: `http://www.tail-f.com/confd`.

2) YumaPro: YumaWorks also licenses its NETCONF implementation, YumaPro to device manufacturers. A special license agreement will be established to regulate its usage as part of the lab: `http://www.yumaworks.com/yumapro`.

3) OpenYuma: YumaWorks released an early version of the codebase with an open-source license under the name of Yuma, which was later picked up by the NETCONF open-source community and rebranded as OpenYuma. The NETCONF interoperability lab provides access to the OpenYuma implementation: `http://github.com/OpenClovis/OpenYuma`.

4) libnetconf: The `libnetconf` project [5] is developing an open source implementation of NETCONF. The core components are implemented as a C library. The NETCONF interoperability lab provides access to this open-source implementation: `https://code.google.com/p/libnetconf`.

IV. FEATURE COMPARISON

Table I enlists basic NETCONF capabilities and protocol extensions supported by each implementation. The standardized YANG data models supported by each server implementation are enlisted in Table II.

Capability	ConfD (v5.0)	YumaPro (v13.04)	OpenYuma (v2.2.5)	libnc (v0.6)
:base:1.0 [6], [2]	✔	✔	✔	✔
:base:1.1 [2]	✔	✔	✔	✔
:writable-running:1.0 [2]	✔	✖	✖	✔
:candidate:1.0 [2]	✔	✔	✔	✔
:rollback-on-error:1.0 [2]	✔	✔	✔	✔
:startup:1.0 [2]	✖	✖	✖	✔
:url:1.0 [2]	✔	✔	✖	✔
:xpath:1.0 [2]	✔	✔	✔	✖
:confirmed-commit:1.0 [6]	✔	✔	✔	✖
:confirmed-commit:1.1 [2]	✔	✔	✔	✖
:validate:1.0 [6]	✔	✔	✔	✔
:validate:1.1 [2]	✔	✔	✔	✔
:notification:1.0 [7]	✖	✔	✔	✔
:interleave:1.0 [7]	✖	✔	✔	✔
:partial-lock:1.0 [8]	✖	✔	✔	✖
:with-defaults:1.0 [9]	✔	✔	✔	✔

TABLE I. NETCONF CAPABILITIES SUPPORT

V. ACKNOWLEDGEMENTS

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Data Models	ConfD (v5.0)	YumaPro (v13.04)	OpenYuma (v2.2.5)	libnc (v0.6)
ietf-inet-types [10]	✔	✔	✖	✖
ietf-yang-types [10]	✔	✔	✖	✖
ietf-netconf-monitoring [11]	✔	✔	✔	✔
ietf-netconf-notifications [12]	✔	✔	✖	✖
ietf-netconf-acm [13]	✔	✔	✖	✔
ietf-netconf-with-defaults [9]	✔	✔	✔	✖

TABLE II. YANG DATA MODELS SUPPORT

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