Junos OS Programmability Use Case for Web Services

Overview

Our Web services customers run some of the largest networks, both in their data centers and in their WAN (core, edge, peering). To operate reliably at such scale, reducing and even removing direct human intervention is essential—in both provisioning and continuous life-cycle management of their equipment.

Automation has been massively deployed by these operators for some time now. Depending on the operator, automation has involved on-box and off-box scripting, programmatic configuration generation, and insertion of middleware provisioning systems. Increased use of automation has resulted in the gradual removal of human operators from day-to-day interaction with routers and switches, and their replacement with software for generating and imposing configuration, as well as for reacting to failures.

This increased use of programmatic tools has resulted in significant operational gains for many of the large Web services customers. Provisioning errors have been reduced, handling of routine failure events has been streamlined and standardized, and personnel needs for network management have been reduced. These gains in efficiency have focused operators' attention even more on programmability: the development of dedicated management interfaces that are specifically designed for efficient interaction directly between switches/routers and programmatic management tools. While simplicity and human readability is still important, that is not the main driving factor; ease of computer interaction is.

Top Business Challenges

As configuration and operational complexity increases, the challenge of operating cost-effectively and error-free at hyper-scale increases as well. This amplifies challenges customers have with:

- **Personnel onboarding:** It takes many months for new personnel to become effective in understanding, interpreting, monitoring, and changing complex configurations. The more tasks are codified, the less new personnel need to be trained and supervised.
- **Preserving tribal knowledge:** Documenting the reason for various configuration and operation decisions is often more challenging than the actual implementation of those decisions. Customers desire to codify these decisions once they are made, in order to avoid having to always "recall" and "re-think" the reasons that led to them.
- **Vendor-specific training:** An aspect of programmability is to be able to develop internal systems against vendor-neutral models, such that internal provisioning and monitoring infrastructure can be common across various vendor implementations.

Top Technical Challenges

Automation has been an integral capability in Juniper Networks® Junos® operating system for many years, and has been widely deployed by many in the Web services space. Past automation falls into the following broad groups:

- **Commit/op/event:** The Junos OS commit/op/event scripts have been widely used to validate/correct configuration, expand configuration syntax, react to events programmatically, and enhance existing operational commands. Transformation languages like XSLT and SLAX have been in common use, and some customers are transitioning to Python-on-Box for the same purpose.
- **Off-box configuration automation:** Proprietary Junoscript and its standardized cousin Network Configuration Protocol (NETCONF) have been the main mechanisms for allowing a centralized management platform to use remote primitives to view and manipulate configuration data in Junos OS using its internal data model, described in YANG. Lately, there have been a number of server-side toolkits developed to facilitate NETCONF bindings for a variety of popular programming languages like Perl, Python, Ruby, and Java.

NETCONF and scripting continue to be important tools in the automation arsenal, but they tend to be applicable to configuration management and basic monitoring activities. New needs for interaction with devices have emerged, inspired by SDN,

and modeled after the methods developed for managing the highly scalable compute infrastructure in the massively scalable data centers (MSDCs). Some of these needs are:

- To impose very rapid and frequent configuration changes to devices, outside of the usual configuration/commit process
- To create state (ephemeral or permanent) on devices under the command of a centralized controller, using either standardized protocols (like PCEP) or using APIs to communicate directly with Junos OS daemons
- To obtain very high-fidelity telemetry from devices, in a variety of serialization formats
- To interact with the Packet Forwarding Engines (PFEs) in a more direct manner than previously possible, so that novel forwarding behaviors can be achieved

These goals go beyond what is normally viewed as automation, and call for development of purpose-built interfaces specifically for machine interaction. Programmability complements automation, and allows for more intimate interaction between the customer's operational environment and Juniper devices.

Junos Programmability Solution

Juniper realizes the critical importance of programmability to reach the next level of scale, automation, and change management. Our approach to delivering programmability tools is comprehensive, and includes three major functionality planes.

Configuration/Management Plane Programmability

The current trends here move us toward completely model-based, declarative configurations that integrate with modern management systems. The Junos OS schema is described in a YANG model, which is distributed with each new release of Junos operating system, and is consumed by the customer's own YANG-based management system.

A fairly new initiative in the industry (OpenConfig) aims to describe the configuration and management interface to devices in a vendor-neutral fashion. Juniper is fully supportive of this effort and was the first vendor to publish an OpenConfig-compliant model for BGP, as well as a translation mechanism to the Junos OS YANG model. OpenConfig developments are very active and new models are being developed. Juniper is committed to implementing these new models as they become finalized.

Telemetry streaming is another very significant area of development. Large-scale networks produce a staggering amount of data that needs to be analyzed so that fast and accurate management decisions can be made. SNMP, the traditional protocol for obtaining data from devices, falls woefully short. It was designed for much smaller volumes of data polled at significantly less frequent periods than are now required. Junos Telemetry Interface is a technology that allows substantially higher volumes of data to be streamed from devices to collectors at a very low cost to the devices, resulting in a much more scalable solution. Juniper has been deploying early versions of this technology with large Web-services customers to ensure that their significantly higher telemetry reporting needs are met.

Control Plane Programmability

In an increasing number of use cases, it is necessary to allow for a centralized controller to override the forwarding behavior derived by routing protocols. A common example of this is the Egress Peer Engineering (EPE) solution, commonly deployed by Web services customers on Juniper platforms.

This type of override can be achieved in multiple ways, and early deployments used extensions to protocols (BGP-LU and PCEP, for example) to provide a channel between a controller and a router to communicate this override.

As the need for such software-defined control of the network increases, Juniper has developed a ground-up infrastructure (Juniper Extension Toolkit, or JET) which allows an external controller (or a custom-built agent on the router) to directly communicate with Junos OS daemons using exposed APIs. Customers can now create systems that can read the Junos OS forwarding table, analyze it, and augment it based on proprietary policy.

Forwarding Plane Programmability

Lastly, many innovative customers want to take advantage of the power of Juniper hardware, but wish to control it more directly to achieve novel forwarding behaviors based on internal proprietary knowledge of their application needs. Juniper will accommodate these advanced needs by developing a common API layer which exposes the rich capabilities of Juniper PFEs in a way that is consumable by customers. A common API allows customers to control any Juniper-produced hardware (whether it is custom-built or merchant silicon) using a single development on their end.

Summary

Massive deployment of automation has allowed many of our Web services customers to achieve significant operational improvements in their networks. As they have continuously reduced the amount of human-router direct interaction, they have focused their attention on programmability—the development of purpose-built interfaces for programmatic interaction between their operations support systems (OSS) and router/switch devices.

Juniper has a comprehensive programmability approach, targeting functionality at the configuration, control, and forwarding planes.

Additional Resources

- FAQ on Automation: http://forums.juniper.net/t5/Automation/FAQ-Junos-Automation/ta-p/283803
- Automation Solutions: www.juniper.net/us/en/solutions/automation
- Day One Books on Automation: www.juniper.net/us/en/training/jnbooks/day-one/automation-series
- This Week: Applying Junos Automation Book: www.juniper.net/us/en/training/jnbooks/day-one/automation-series/applying-junos-automation
- Blogs on Automation: http://forums.juniper.net/t5/Automation/bg-p/NetworkAuto
- TechWiki page on Automation: http://forums.juniper.net/t5/Automation/tkb-p/Automation_Scripting

For More Information

To find out more about Juniper Networks products and solutions, please visit www.juniper.net.

About Juniper Networks

Juniper Networks is in the business of network innovation. From devices to data centers, from consumers to cloud providers, Juniper Networks delivers the software, silicon and systems that transform the experience and economics of networking. The company serves customers and partners worldwide. Additional information can be found at www.juniper.net.

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