Juniper Networks NorthStar Controller
Functionality Test Report

Introduction

IP/MPLS has been the technology of choice for service providers for the better part of a decade and a half. Backbone network engineers are comfortable and confident in planning, designing, and implementing Label Switched Paths (LSPs) to transport customer traffic across their networks. Juniper has been an advocate for RSVP-TE based implementations for MPLS LSP signaling mechanism, stating that RSVP-TE provides high availability and scalability required by today's service providers.

Service providers are looking for new revenue streams with new or enhanced services. Such solutions include service provisioning portals and elastic bandwidth. In order to enable this level of programmability, service providers relay on standard based protocols and tools.

Juniper Networks invited EANTC to execute a set of tests exploring their Software Defined Networking (SDN) controller – NorthStar Controller. Juniper's NorthStar Controller is exactly the kind of tool that could help service providers achieve the agility they desire. Juniper suggests that instead of network engineers laboring over LSP configuration on routers's CLI, operator can now leverage REST APIs and/or the graphical user interface of NorthStar Controller to set paths in the network. Juniper also claims that using NorthStar Controller in brownfield networks, with tens of thousands of LSPs, can optimize the network to reclaim unused resources and defer capacity expansions. These statements and functions are the focus of this report.

Test Equipment

Ixia Communications supported the test with an Ixia XM2 chassis and tester interfaces. Since the focus of the test was the functionality of Juniper's NorthStar Controller, we did not set high bandwidth requirements. We therefore were happy to use Gigabit Ethernet interfaces to emulate customer traffic.

Test Highlights

- → **Demonstrated benefits of resources and network's global view**
- → **Measured network path optimization using path computation**
- → **Confirmed dynamic LSP adjustments using auto-bandwidth**
- → **Verified dynamically resource maximization with TE++**

Test Bed – Devices and Configuration

For the purpose of the tests Juniper engineers set up a 56-node network. The network topology, depicted in figure 1, was designed to mimic a service provider network with three Autonomous Systems. Two Autonomous Systems (AS) were using IS-IS and one AS used OSPF as IGP. Every AS had a single route reflector that in turn peered with NorthStar Controller. The route reflectors would learn the traffic engineering state of the network using IGP and then share the Traffic Engineering Database (TED) with NorthStar Controller using BGP-LS.

The network constructed by Juniper included Juniper's MX80, MX104, MX240, M320, MX960, MX480, MX2020, T640, T1600, PTX3000, and the PTX5000. In addition to the physical routers, four instances of Juniper's vMX (virtual MX router) were used, one of them as Juniper Virtual Route Reflector (Juniper VRR). We noted no difference in functionality between tests that relied on network paths in which legacy components were used and those executed over current generation routers. Based on our experience, Juniper's NorthStar Controller could be used in brownfield deployments as its functionality is dependent on the control plane software functions supported by the routers and not the router's hardware revision.

NorthStar Controller Base Functionality

NorthStar Controller is built on a foundation of IETF-defined protocols to communicate with the devices in the network and calculate paths. Juniper's North-Star Controller supports PCE initiated LSPs – these are created by NorthStar or the Path Computation Element (PCE); Delegated LSPs – configured on the router and then delegated to NorthStar Controller; and PCC controlled LSPs – created and maintained by the router. All three types of LSPs were used in the test.

Tests Results

The results presented in the sections below are driven by the functions available on NorthStar Controller in its 1.0 version.

LSP Optimization

In networks using a large number of LSPs, the potential loss of network capacity, due to LSPs reserving bandwidth, typically leads service providers to growing the physical network capacity by purchasing more interfaces and links. Juniper suggested, that when the NorthStar Controller has a complete view of the network, it could optimize the network paths and enable service provider to defer capacity expansions.

In order to mimic such a situation, we started with a network that included 648 LSPs. Only 85 LSPs were adequately optimized which meant that NorthStar Controller could potentially find additional 563 LSPs to optimize. Since the path optimization parameter Juniper used for the test was hop count, we recorded the total number of hops in the network in its non-optimized state to be 5,189 hops. Our expectation was that once optimization takes place, this number will be significantly reduced.

We used NorthStar Controller's Path Analysis tool to get an overview of the complete network and then asked for the optimization capacity. NorthStar Controller reported that, as expected, 563 LSPs could be optimized. We then ran the optimization process. NorthStar Controller reported that 562 LSPs were optimized resulting in a total number of hop count reduced to 2,864 hops. This results in optimization efficiency of 45% in term of hop counts. One LSP was not optimized since after all optimization was complete, no more optimization capacity was available.

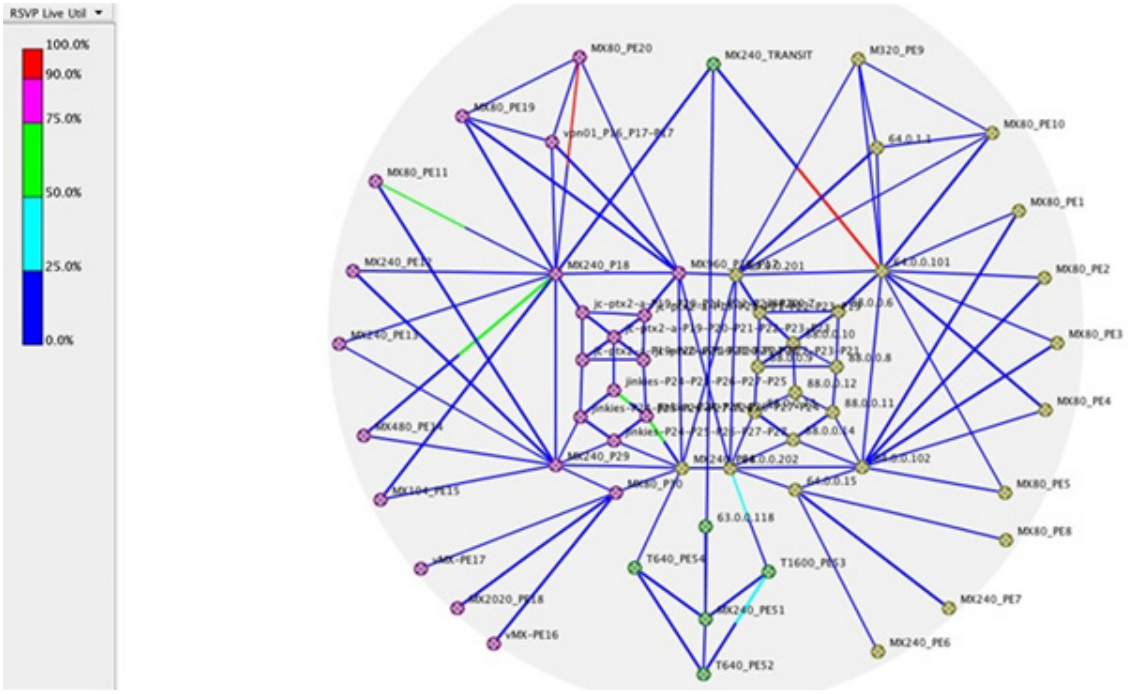

Figure 1: Network Topology as Shown by NorthStar Controller

We expect that the benefits to each network will differ based on its configuration and setup. However, the base-function – LSP optimization which we verified here, is clearly a mean for carriers to make the most of their existing networks and increase the value of the existing infrastructure.

Diverse Path LSPs

To meet strict SLA for certain mission critical business services such as backup, service provider must sometimes guarantee end-to-end node, link and even transport LSPs diversity (i.e. taking into account the optical infrastructure transporting the service). Juniper explained that feedback from their tier-1 service provider indicates that doing such calculations in the current state of the art tools, is very time consuming, often taking hours, as well as error prone due to its manual nature.

Juniper's NorthStar Controller includes a function with which the operator can set LSPs to be defined as diverse, choosing the diversity level to be path, node or Shared Risk Link Groups (SRLG). For testing purpose, we used NorthStar Controller to define two paths, starting in one AS and terminating on the other. Once we verified that the non-diverse tunnels used the same path, we asked NorthStar Controller to add diversity. Indeed, as figure 2 depicts, the resulting tunnels, in all three cases, were diverse and did not cross the same elements

There are several benefits to such capability. While the signaling protocol used to establish LSPs (RSVP-TE) offers high availability mechanisms, typically services still incur a sub-50 ms hit. With the ability to set diverse paths, the carrier could, in essence, reach zero-loss transport services for its premium customers or services.

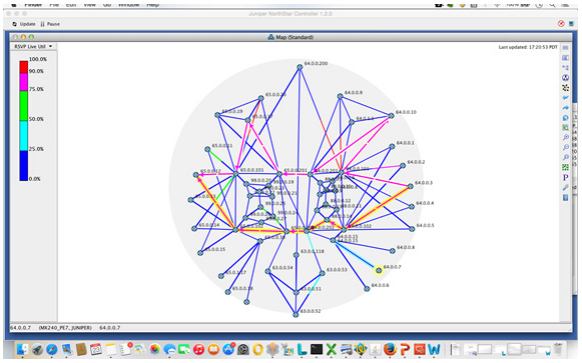

Figure 2: Diverse Paths Across Autonomous Systems

Premium Path Analysis

Another potential service that could be implemented using NorthStar Controller's help is what Juniper calls "Premium Path Analysis". The idea behind this feature is to map application requirements, such as latency, packet delay variation (PDV), costs or customer defined metric, to LSPs. For example, when latency is used as a parameter, the carrier could support Voice over IP (VoIP) or Mobile Backhaul services using Premium Path Analysis.

To test Premium Path Analysis, we set an original path with 14 hops and a certain Traffic Engineering (TE) metric. TE metric does not take into account other network characteristics such as latency, loss, packet delay variation (PDV), however, Juniper's NorthStar Controller is able to combine these network characteristics which then translate into application characteristics, and enforce these constraints on the LSPs.

Using NorthStar Controller, we choose the LSP associated with the service and changed the tunnel routing method to "Delay". At this point we recorded that the reported value for the LSP was 5 million milliseconds (obviously a fictive value based on our own configuration). Once the channel type parameter was changed and applied, the path length changed to 5 hops and the delay was reported as zero milliseconds.

We then changed back the path to TE metric and confirmed that the latency and hop count increased again.

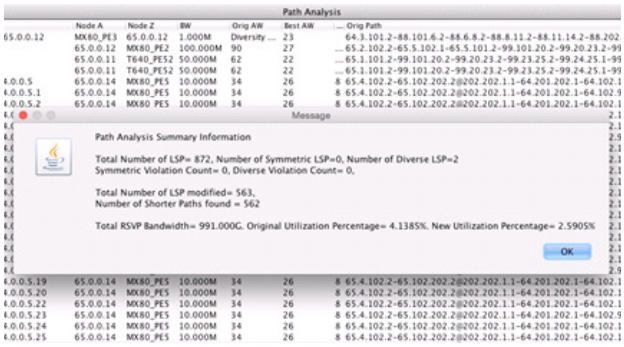

Figure 3: LSP Optimization Information

Scheduled Maintenance

Within the operations group at a service provider, several roles exist. The engineers responsible for activating services are not always the same engineers as the ones responsible to the health of the network. The knowledge of the impact of a schedule maintenance on the services carried in the network, could help service provider increase the service availability by planning the most risky operations to times in which the services are least used.

In this test we used NorthStar Controller Simulation, a tool meant to be used by the maintenance team, to check the impact of planned maintenance on the network. The tool reported which LSPs will be impacted if we took a 7 node cluster out of operations for maintenance. NorthStar Simulation was able to quickly let us know if we have the resources to support such events. NorthStar Simulation also reported which LSPs are affected and provide the new path should we proceed with such an event.

We decided that for the purpose of this test, we would go ahead with the maintenance. We then switched back to the NorthStar Controller interface (as opposed to the Simulator) and scheduled the maintenance. For practical reason we scheduled the maintenance event to 2 minutes in the future, however the maintenance could be scheduled for any date. We set the maintenance duration for 5 minutes. Indeed, within 2 minutes the LSPs were reconfigured and after 5 minutes were set back into operations.

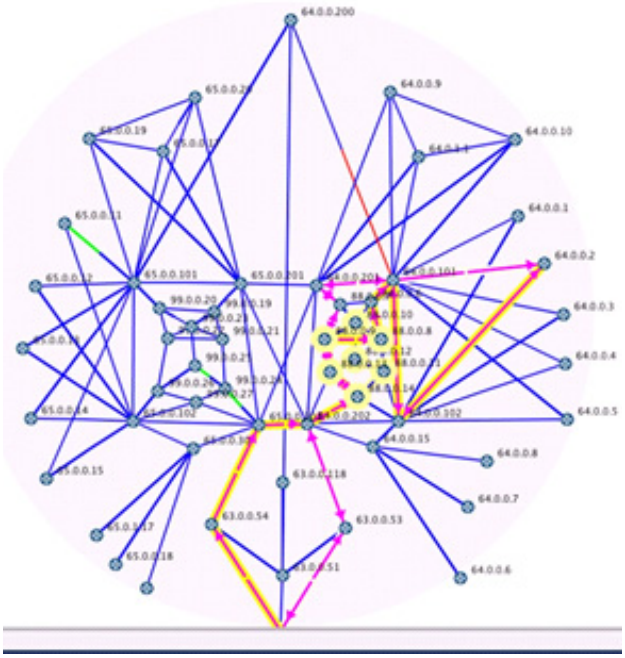

Figure 4: Scheduled Maintenance Nodes View

The benefits of such a tool to the network operator are two fold – initially the tool helps the operations team make smart decisions on when and where to make network changes that will impact services with the goals clearly being to minimize impact on the customer. The second benefit is the practical fact that by scheduling the maintenance using NorthStar Controller, the maintenance team could focus on the maintenance and not on manual configuration of rerouting traffic. The latter is the job of NorthStar.

Time-Based LSP Scheduling

Juniper NorthStar Controller's holistic view of the entire infrastructure, combines with the controller's ability to push new network paths onto the routers, empowers the controller to collect path requests for specific time and schedule them if the resources are available. Juniper calls this function Time-Based LSP scheduling (sometimes known as Bandwidth Calendaring). A service provider could use this function to schedule resource usage for special events, when the provider expects more customer demand such as high profile sporting events. The carrier could also sell excess bandwidth, monetizing excess capacity in their network.

In order to confirm the availability of the function, we set up two scenarios. In the first scenario we created a 100Mbit/s service and made sure that we could send traffic without loss using it. We then used the calendaring tool to add 100Mbit/s to the service for a period of 5 minutes to simulate a customer bandwidth increase request. NorthStar Controller reported that the new bandwidth LSP was set and later (5 minutes later) also changed back the bandwidth to its original value. During this whole period we used the traffic generator to send traffic in the LSP and made sure that no packet loss was recorded.

It is important to note that while the LSP bandwidth was changed, the data plane enforcement is expected to be done by the router itself, not by the NorthStar Controller. Typically, as Juniper explained, carriers will match such services with templates for automatic policies enforcement.

In the second test scenario we were looking for a path in which additional bandwidth was not available in order to validate that NorthStar Controller could also provide a bandwidth enforcement mechanism. After all, if bandwidth is not available, it will be useful for the operator to know and to be informed that a path cannot be set.

We identified a router's interface that was already using 85% of the bandwidth available for a single LSP (850Mbit/s were assigned to an LSP on a Gigabit Ethernet port). At that point we tried to schedule another 200Mbit/s LSP and were notified by the NorthStar Controller GUI that "tunnel added however unroutable". Juniper explained that the controller, as expected, did not allow us to create the new LSP in the network since resources were not available and that the notification is meant for troubleshooting purpose.

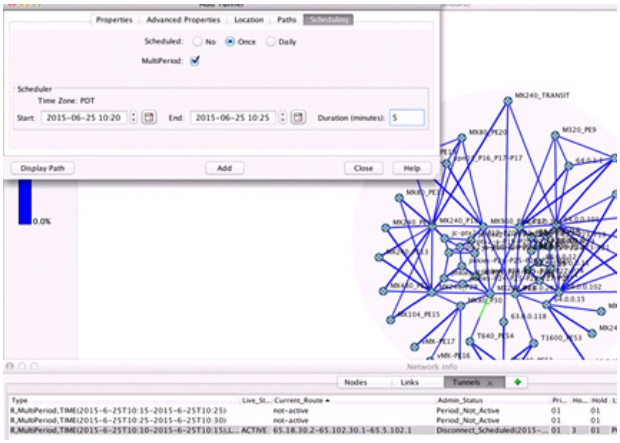

Figure 5: Scheduled LSP

Automatic Bandwidth

When the protocols used in the network are advanced enough, the network can adjust its transport bandwidth to the subscribers' needs. Juniper's NorthStar Controller, when managing a Juniper-based network, collects LSP statistics from the routers and can control and change the amount of bandwidth assigned to an LSP on the fly. The benefits of this approach is to enable LSPs to adjust with usage. Combined with the controller's global view, Juniper NorthStar Controller is able to make network path computation changes based on global constraints.

In order to verify that the function works as expected, we selected two LSPs in the network. We configured one LSP with Automatic Bandwidth and the other, sharing the same physical path, to be a regular LSP with 500Mbit/s reserved bandwidth. We started sending 500Mbit/s on the regular LSP and only 100Kbit/s on the Automatic Bandwidth LSP. Once the adjustment period passed, and we recorded no changes to the LSPs bandwidth as expected, we started increasing the Auto-Bandwidth LSP traffic to 500Mbit/s. At this point, NorthStar Controller adjusted the LSPs bandwidth and we recorded a new LSP bandwidth of 519Mbit/s. It was also interesting to see that the network, as a results of using Constraint Shortest Path First (CSPF), moved the regular LSP to a new path that had available bandwidth.

We have seen that Automatic Bandwidth function worked as expected and can allow service providers more dynamic network resource allocation. We also identified that the bandwidth measured by the routers and used by NorthStar Controller to adjust LSP dynamically is taking into account the important core network headers, therefore, providing a true and accurate overview of network resources availability.

TE++

A TE++ tunnel includes a set of paths that are configured as a specific container statement and individual label-switched path (LSP) statements that are called sub-LSPs. A TE++ tunnel enables load balancing across multiple point-to-point member LSPs between the same ingress and egress routers. When the path bandwidth is sufficient, the member LSPs, each of which have equal bandwidth, will take the same best path. However, if bandwidth is constrained on the original path, some member LSPs could be rerouted to take an alternate path.

Based on the configuration and aggregate traffic, a container LSP provides support for dynamic bandwidth management by enabling the ingress router to dynamically add and remove member LSPs through a process called LSP splitting and LSP merging, respectively. Member LSPs can also be re-optimized with different bandwidth values in a make-before-break way.

In order to test TE++ function (commonly referred to by Juniper as Elastic MPLS), we started by asking Juniper engineers to create a container LSP with 2 LSPs. We used the Ixia tester to send traffic at 75Kbit/s, well below the splitting bandwidth mark, in the LSPs. Slowly we increased the traffic rate until we reached the splitting mark which we asked Juniper engineers to set at 60Mbit/s.

At 10Mbit/s of test traffic, we verified that both member-LSPs were carrying traffic split evenly. We also recorded that the LSPs' bandwidth was automatically adjusted to 5.3[1]Mbit/s. As we continued to increase the bandwidth to 100Mbit/s 9 new LSPs were created, each with 8.6Mbit/s of bandwidth. The two sub-LSPs with which we started, now had their bandwidth adjusted to 6.9Mbit/s and 4.5Mbit/s.

As we reduced the bandwidth back to 100Kbit/s, we monitored the newly created sub-LSPs all being removed automatically until we eventually were left with two LSPs.

Both Automatic Bandwidth and TE++, as well as Juniper's NorthStar Controller's view of the entire network, are a powerful combination to maximize network usage. If LSPs are able to, dynamically, seek available resources in the network, while still taking into account business constraints, service providers could indeed defer capacity expansions and use the infrastructure more efficiently as Juniper suggested.

Passive Monitor Mode

Recording configuration changes on network devices is common practice for service providers. It is also a very useful function when new process and systems are being deployed – such as an carrier SDN Controller in an existing network. When the operation of the network shifts from command line interface to a graphical user interface based controller, the focus of monitoring network changes shifts accordingly.

Juniper's NorthStar Controller includes a feature called Passive Monitor Mode which records all events in the network and is even able to replay network events depicting changes on the network map. We activated the feature for the duration of a pre-defined set of tests and were able to playback our configuration actions, as well as, automatic network functions such as auto-bandwidth.

While scanning through logs is surely a time-honored tradition for network engineers, the ability to move a slider to a time in which an event happened in the network and then be shown, graphically, the actual event, is hugely advantageous to the healthy operation of the network.

REST API

As Juniper explained, all LSP optimization could be implemented in form of a REST API interface northbound from the NorthStar Controller. Such interface could enable a service orchestrator to request specific network paths in support of its services.

To verify that NorthStar Controller indeed has an open Northbound API, we used a simple web browser extension to invoke the REST API calls supported by this WAN SDN controller to read LSPs, set paths and modify them. While interfacing directly with the API is a good way to verify that the API indeed exist, we expect that applications interacting with NorthStar Controller will use the API and provide an opaque service-based interface to service providers.

Summary

After spending a week with Juniper NorthStar Controller we were very comfortable with the graphical user interface and did not miss the Command Line Interface much. We noted that on some occasions we tended to, almost mechanically, reach for the terminal window to collect some data or make a small change in the network. We were able to suppress those habits and can expect that if Juniper continue to develop NorthStar Controller, future network engineers would not need to bother themselves with the CLI.

We were happy to verify that Juniper's claims, that NorthStar will work well in a brownfield deployment, could optimize network resources usage and defer capacity expansions, are indeed true. As service providers automate and modernize their services and processes, a holistic tool, with smart path computation capabilities, is the right way to automatic services and efficiency gains.

1. Again, indicating the additional headers taken into account in the backbone.

About EANTC

EANTC (European Advanced Networking Test Center) is internationally recognized as one of the world's leading independent test centers for telecommunication technologies. Based in Berlin, Germany, the company offers vendor-neutral consultancy and realistic, reproducible high-quality testing services since 1991. Customers include leading network equipment manufacturers, tier-1 service providers, large enterprises and governments worldwide. EANTC's proof of concept, acceptance tests and network audits cover established and next-generation fixed and mobile network technologies.

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