The purpose of this document is to provide a comprehensive review of the WAN Performance and Capacity for your VMware SD-WAN Deployment. For this report VMware has compared your deployment against hundreds of similar deployments, based on industry, location, and number of edges, in order to provide you clear insights and action items for your consideration. This information will assist you in improving your network.

**Document Structure**

The document is defined in the following sections:

- Executive Briefing
- Company Report
- Edge Report
- Methodology

**Executive Briefing**

A brief summary of the key findings and next steps outlined in this report.

**Company Report**

A high level view of the WAN performance for your datacenters and branches.

**Edge Report**

An in-depth analyses of each edge in your deployment to provide actionable insights.

**Methodology**

In this section we will provide the math and methodologies used in all calculations for this report.

**Bookmarks and Links**

To make this report more navigable, a table of contents was built into this report linking to each section and edge. In addition to this, links for each edge sorted from worst to best for both QoE and Capacity are also provided. A formula was used to identify the edges with the most potential to improve.
Executive Summary

In this section a specialist will provide a list of recommendations and actions based on the report findings.

Example1:

From a HUB perspective we noticed a lack of redundant links. This to some extent represents a risk in the network as it is a single point of failure. The general recommendation is to have 2+ diverse links at each hub site. Given the size of the deployment the recommendation would be 3+. This fact reflects on the overall HUB availability which for your company was below similar companies.

Example2:

From the 1464 Edges that were analyzed 30% of them had QoE is below their local average. Based on the Downtime cost for your company "100$/min" we recommend that their wan to be upgraded. For each edge we provided a list of local INTERNET providers and their observed QoE.

Key Statistics

Hub Availability

99.968% Hub Availability - The standard goal is 99.999%. We observed that similar companies had better Hub Availability. We recommend Retail Inc to try to improve their Hub Availability by adding additional links.

Hub Capacity

The hubs have better capacity usage than 67.5% of competitors. We did not see any particular concerning aspect in the HUB capacity. We believe the current capacity should be sufficient for the near future.

Branch Connectivity

69.7% of Edges have better QoE than the region. A total of $1,461,685 per month could be saved by applying the recommendations in the edge specific pages. This is the main action item from this report. Around 300 edges WAN connectivity should be improved.

Branch Competitive

RETAIL INC branches have better QoE than 57.1% edges in this industry.
Hub Summary
The Retail inc network consists of 4 large Hubs that support over 3000+ retail stores. Around 80% of the traffic in the network is branch to hub traffic. The capacity and availability of the hub is of the utmost importance.

After reviewing the performance of the branch users and comparing them with other edges in their region, our recommendation is that RETAIL INC improved the QoE of the HUBs.

The recommendation would be to either add a second connection or change the existing connection to a different ISP. VMware results show that the number of connections is the single most important factor on the overall connection of the site when using SDWAN. In most cases two poor connections are better than single connection. From a capacity perspective most branches seem to be okay with no need to add capacity in most cases.

Capacity
From a capacity perspective we noticed that Retail inc is using 11.33% of its total capacity in the hubs. That is 6.3% more capacity usage than other customers with similar size and location and 4.67% more than other customers in the same industry. The Hub using the higher capacity uses below 30%.

Below please see the trend of capacity over the last few months. You can see capacity is down slightly after the holidays.

Availability
RETAIL hubs have worse uptime than the industry and companies with a similar size. The best remedy for this is likely to add another link via another ISP to the hub. Availability is shown here in the five-nines format. RETAIL achieves three-nines.
Branch Summary
Retail Inc network has over 1400+ branches that connect to 4 Hubs. The branches are present in 3 continents.

From a Capacity perspective Retail Inc branches have better capacity than similar branches in the industry and comparable to companies of same size and geography.

From a QoE perspective Retail Inc has worse performance than similar size companies and companies in the same industry. This performance issue does not seem to be caused because of lack of good WAN connections at the Retail Inc branch locations. When comparing Retail Inc WAN connections we often found that WAN connections can be improved.

The recommendation would be to do a detail analyses of the 300+ edges that have inferior QoE than expected. Our estimations would be that addressing these Brownouts/Blackouts could save the company over $1,461,685 per month.

Capacity
From a branches perspective we noticed that RETAIL is using 2.41% of its total capacity in the branches. That is 0.27% more capacity usage than other customers with similar size and location and 0.78% less than other customers in the same industry.

The branches are using slightly more resources over the last few months indicating slightly more activity after the holidays.

QoE
Please see below how RETAIL compares with similar compares with similar companies. We compared with companies in same industry as well as companies with similar deployments.
**Capacity**

This edge uses 4.01% of its total capacity. That is 1.59% more capacity than most of your other Edges, and 1.41% more capacity than most Edges in the region.

**Quality of Experience**

The average downtime for this edge is 8.82 minutes per month. This edge has more outages than most Edges in the region, using links with better metrics from the table below should increase the Edge availability. Adding a second WAN link to the site would improve site availability. A total of $339 in productivity could be saved per month by applying the suggestions.

**ISP QoE Table**

<table>
<thead>
<tr>
<th>ISP</th>
<th>Edge Count</th>
<th>AVG Hours of Degradation</th>
<th>AVG Blackouts</th>
<th>AVG Score</th>
<th>AVG Low Score</th>
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<td>6.62</td>
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</table>

* ISPs used by this edge
** Colour Key: Best observed ISPs by us ordered from Solid green(highest rank) down to light green(lowest rank).
*** The rank is based on a combination of highest AVG Low Score and Lowest AVG Hours of Degradation.
**Capacity**

This edge uses 80.47% of its total capacity. That is 78.05% more capacity than most of your other Edges, and 77.41% more capacity than most Edges in the region.

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**Quality of Experience**

The average downtime for this edge is 173.76 minutes per month. This edge has more outages than most Edges in the region, using links with better metrics from the table below should increase the Edge availability. A total of $16,155 in productivity could be saved per month by applying the suggestions.

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**ISP QoE Table**

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<th>ISP</th>
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* ISPs used by this edge

** Colour Key: Best observed ISPs by us ordered from Solid green(highest rank) down to light green(lowest rank).

*** The rank is based on a combination of highest AVG Low Score and Lowest AVG Hours of Degradation.
Capacity
This edge uses 0.96% of its total capacity. That is 1.46% less capacity than most of your other Edges and 1.97% less capacity than most Edges in the region.

Quality of Experience
The average downtime for this edge is 149.52 minutes per month. This edge has more outages than most Edges in the region, using links with better metrics from the table below should increase the Edge availability. A total of $13,839 in productivity could be saved per month by applying the suggestions.

ISP QoE Table

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</table>

* ISPs used by this edge
** Colour Key: Best observed ISPs by us ordered from Solid green(highest rank) down to light green(lowest rank).
*** The rank is based on a combination of highest AVG Low Score and Lowest AVG Hours of Degradation.
Capacity
This edge uses 1.33% of its total capacity. That is 1.09% less capacity than most of your other Edges and 2.04% less capacity than most Edges in the region.

Quality of Experience
The average downtime for this edge is 135.28 minutes per month. This edge has more outages than most Edges in the region, using links with better metrics from the table below should increase the Edge availability. Adding a second WAN link to the site would improve site availability. A total of $12,504 in productivity could be saved per month by applying the suggestions.

ISP QoE Table

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<th>AVG Blackouts</th>
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</table>

* ISPs used by this edge
** Colour Key: Best observed ISPs by us ordered from Solid green(highest rank) down to light green(lowest rank).
*** The rank is based on a combination of highest AVG Low Score and Lowest AVG Hours of Degradation.
How to read the Report

This section has all the information that are necessary to understand and read the detailed report easily.

Note that the information in this section is presented just for explanation purpose and they don’t reflect any details about customer network, for such details please proceed to next section once you are comfortable with report diagrams and sections.

The section will cover 2 items which are Report Terminologies and Report Graphs.

Report Terminologies

Edge Throughput

It is the 5th highest total WAN utilization consumed by the edge over a 1-month period for a duration of 5 min.

Edge Throughput Calculation Formula

Edge Total Throughput = sum of all WAN links consumed bandwidth reported by Edge to VCO divided by 5 minutes interval. i.e. (All links consumed total traffic (Bytes)/5 Min interval) which gives a throughput sample then by repeating the step for a 1-month duration, we will be able to get all samples for a complete month. Then pick 5th highest throughput/sample to avoid unplanned/unusual peaks.

Edge Capacity

It reflects the actual Edge utilization across the links defined by dividing Edge 5th Top throughput to Edge available Bandwidth. i.e. (50 Mbps throughput / 100 Mbps Links * 100) would give 50% Capacity consumed

Edge QoE

As a general term used by VCO on the Edge Tab, QoE is a graph displayed for 3 applications (Voice, Video, Transactional) where we show Link metrics (Latency, Jitter and Packet Loss) before and after using SD-WAN during specific duration (Monthly is used in our report).

Edge QoE Before

Displays the Link readiness for traffic based on the actual measured jitter, latency and packet loss.

Edge QoE After

Displays the quality of experience for this Edge after optimizations have been applied.

QoE Link Colors

The VCO display the links based on 4 colors which are green (Completely health), Yellow (Moderately impacted), Red (Severely impacted), and Gray (disconnected).

Link Blackout

It is the state where the link QoE goes from any color state to unknown state (blackout).

Link Brownout

It is the state where the link QoE goes from green state Completely health) to Red state (Severely impacted).

Link Score/Quality Score

The quality score gives a value between 0 (being the worst) and 10 (being the best) to show delivered service level for an application.
QUICK FACTS
• This field in the report will always include useful summarized info. That represent the section as an overview.

BRANCHES QUICK FACTS
Branches
• Total number of branches in customer network.
Average Links Per Branch
• total number of links divided by number of branches.
Branches with HA Enabled
• Total number of branches using High Availability

Edge QoE Calculation Formula
Fetch daily Links Quality Metrics for voice traffic (most sensitive traffic) as a series of samples, then extract the blackout and brownout number of occurrences.

Link Blackout Duration Calculation Formula
The amount of time the link had been in that blackout state.

Link Blackout Duration Formula
Blackout Duration = No. of blackout samples * sample duration (usually between 5-7 min).

Link Brownout Duration
The amount of time the link had been in that brownout state.

Link Brownout Duration Formula
Brownout Duration = No. of brownout samples * sample duration (usually between 5-7 min).

Total Degradation Duration
The amount of time the link had been in both blackout and brownout state.

Total Degradation Duration Formula
Degradation Time = Brownout time + Blackout time.

QOE Link score Calculation Formula
QOE score = ((time in green * 10) + (time in yellow * 5)) / total time.

Lowest QOE Score
It is the score of the hour with most degradations.

Similar Customers
Represent Customers with similar deployment size and scale comparable to the customer.

Industrials
Represent Customers from the same industrial/sector field that is relevant to customer. i.e If the customer from Health Sector, then Industrials will represent other companies within Health Sector as well.

Dataset
A collection of related sets of information that represent an element and usually a numerical type of data is used in our report.
QUICK FACTS

This field in the report will always include useful summarized info. That represent the section as an overview.

EDGE QUICK FACTS

Edge Name
- Edge hostname as defined in VCO

Location
- Country and city of Edge location.

Activated On
- Edge first activation date.

Serial Number
- Edge serial number.

Bandwidth
- Edge assigned Bandwidth

WAN Links
- Edge WAN ISP Providers

Features Used
- Summary of critical features used by Edge

Report Graphs

Boxplot Chart

It is the main type of charts that has been used in our report to show how the datasets have been distributed across customer SD-WAN as well as in comparison to other regional/sectors information.

Example Graph:

From the above chart if we consider (This Customer) box plot, we can easily understand how our data is spread out and also extract (Five Number Summary) information which are:

- **min**
  The minimum (the smallest number in the data set) is shown at the far left of the chart. It's approx. 0.0 from above chart.

- **Q1**
  It is the first quartile (Q1) shown at the far left of the box and it represents the middle number between the smallest number (not always the minimum) and the median of the dataset. It's approx. 1.75 from above chart.

- **median**
  The middle value of the dataset. It's around 2.5 from above chart.

- **Q3**
  It is the Third quartile (Q3) shown at the far right of the box and it represents the middle number between the median and the highest value (not always the maximum) of the dataset. It's around 4.0 from above chart.

- **max**
  The maximum (the largest number in the dataset) is shown at the far right of the chart. At approximately 8.75 from the chart.

Comparison Observations:

- The Interquartile range box (coloured boxes) represents almost the middle 50% of the data.
- The Edge box plot itself is comparatively short which suggests that the edge operates at the same capacity percentages.
- This Customer and the region box plots are comparatively tall which suggests that they have different values or hold quite different opinions about capacities or represented aspect.
- The obvious differences between The Edge compared to Customer and Region shall help the customer to understand when their edges operates at better or worse conditions.