Sophisticated Dynamic Thresholds

With VMware vCenter Operations

TECHNICAL WHITE PAPER
At a Glance

VMware vCenter™ Operations automates operations management using patented analytics to provide the intelligence and visibility needed to proactively ensure service levels in dynamic virtual and cloud environments. This document provides a brief description of dynamic thresholding, a sophisticated technique employed by VMware vCenter Operations to determine the upper and lower range of normal behavior for each metric in a data set to help better understand when a metric is “not normal”.

Overview

VMware vCenter Operations is a breakthrough in automated Performance Analytics for IT Systems and Business Processes. This solution provides real-time analytics and a number of uniquely valuable capabilities, such as ability to:

• Present dynamic role-based performance dashboards illuminating analytically determined health and performance of critical applications, technology silos, and individual resources.
• Send a single, proactive smart alerts indicating when to pay attention to brewing problems as well as root cause analysis indicating what to pay attention to, allowing ample time to avert problems before users or business processes are impacted.
• Perform advanced on-demand analytics in a continuing effort to optimize the operation of your entire enterprise.

vCenter Operations accomplishes all this by leveraging the raw performance data already collected by your existing monitoring landscape. Through sophisticated and patented analysis of this raw data, vCenter Operations determines the normal behavior of your applications and business services, from a metric, resource, tier, application, or multi-application level.

vCenter Operations determines, in real-time, when observed abnormalities are occurring and how they are impacting the current performance. vCenter Operations also determines if the abnormalities are early indicators of emerging problems which require the attention of IT Operations and/or Business Owners. Moreover, vCenter Operations determines how performance trends can help to optimize your enterprise. All of this is done completely automatically and without any user input.

Example Data Categories that can be analyzed with Dynamic Thresholds:

• VMware vSphere™ data
• Network data
• O/S data
• Application data
• User Experience data
• Transaction data
• Business data
• Batch data
• Any data that can be represented numerically or in discrete text values

Analytic Foundation

The analytical foundation of vCenter Operations rests on the sophisticated manner in which it determines the normal behavior of each performance metric examined. As described above, vCenter Operations has the ability to analyze any type of performance metric, and experience tells us there are many, many different types of data
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(e.g., network data, o/s data, application data, user experience data, business data, etc.), which have many different performance profiles. Because of this it would be entirely inadequate to use a single method or algorithm to characterize every metric’s normal behavior, as many other analytic tools do (e.g. typically, they assume a classic “bell-shaped” normal distribution and then ask the question “how many standard deviations away from median is acceptable?”).

Instead, vCenter Operations leverages many different algorithms. In fact, every 12 hours, the vCenter Operations analytical engine pulls the full history of each metric found in vCenter Operations’ repository. Then, vCenter Operations runs that data history through eight difference algorithms, and each one determines an expected upper and lower level for that metric for each of the 12 upcoming hours. Once this is done, yet another algorithm is applied that competitively scores each upper-and lower-level for each hour and determines which of the eight algorithms ‘wins’ for that level for that hour. The effect of this process is to produce the optimal hour-by-hour range of normal behavior, or dynamic threshold (DT), for each performance metric.

To further illustrate this sophistication, here is a brief description of the DT algorithms that are competitively applied:

• An algorithm that can detect linear behavior patterns (e.g., disk utilization, etc.).
• An algorithm that can detect metrics that have only two states (e.g., availability measurements).
• An algorithm that can detect metrics that have a discrete set of values, not a “range” of values, (e.g., “Number of DB User Connections,” “Number of Active JMVs,” etc.).
• Two different algorithms that can detect cyclical behavior patterns that are tied to calendar cycles (e.g., weekly, monthly, etc.)
• Two different algorithms that can detect general non-calendar patterns (e.g., multi-modal)
• An algorithm that works, not with time-series or frequently measured values, but with sparse data (e.g., daily, weekly, monthly batch data)

The screenshot below illustrates an example of a learned DT for a performance metric, in this instance a metric that represents the average number of hits measured on all Web servers (“Avg Hits”) of a particular public-facing application. Note the hour-by-hour adjustment to the upper and lower gray area surrounding the blue line (the blue line is the actual metric measurement) – this is the DT that was determined by vCenter Operations based strictly on its assessment of the history of the metric’s performance.

Figure 1. Example Dynamic Threshold
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One other illustrative point seen in the example image is the narrower DT range for the off-peak hours of the day for this metric, versus the wider DT range during the peak hours of operation. vCenter Operations determined automatically that the variability of the measured values for this metric during the off-peak hours of the day was low and thus it could afford to narrow the band of expected behavior accordingly. In contrast, the historical variability of the measurement during peak hours suggested a need to widen the band. To do otherwise would have resulted in either unnecessary “false-positive” indications, or alternatively, a loss of sensitivity to abnormal conditions.

How normal is your IT data? Not very!

To further illustrate the importance of applying a variety of algorithms when determining a metric’s dynamic threshold, VMware set out to example the affects of its competitive approach when a large quantity of production performance metrics are examined. The intent is to determine which of the eight algorithms used by vCenter Operations would ultimately “win” the competition, thus showing the variety at play in production environments.

The results clearly indicate that the more deterministic algorithms—those that detect linear, binomial, discrete, sparse patterns—would always win when applied to those types of metrics; their ratio of wins was a direct affect of the data set examined. The real question was the relative effectiveness of the four remaining algorithms with respect to one another, and perhaps most interesting, how they stacked up against a presumed normal distribution found in so many of the analytics tools available on the market today.

The chart below illustrates the results of this examination. Note the distribution of winning algorithms for each of the different non-deterministic algorithms. As it turns out, the non-calendar based cycle detection algorithms were predominate. This implies that in most cases a person could not simply “assign” an effective cycle designation such as “this metric should behave differently on Friday than on other days”. And, in fact, only a mathematical examination can effectively detect underlying patterns in many cases (i.e., a full 71 percent of the time).

Figure 2. Winning Cyclical Algorithms
So how well does a classic “bell-shaped” normal distribution algorithm fare when thrown into competition with the four non-deterministic algorithms in vCenter Operations? Not surprisingly, it barely shows up. Furthermore, upon examination of the instances when the bell-shape algorithm does win, the difference in the selected upper and lower ranges for the associated metrics is almost imperceptible. So while this algorithm technically won on a few rare occasions, its affect on the ability to detect metric abnormalities was indistinguishable. In contrast, on occasions when one of the eight other algorithms won, they did so significantly when compared to the upper and lower thresholds determined by the normal algorithm.

About VMware vCenter Operations

VMware vCenter Operations uses patented analytics and visualizations to automate performance, capacity and configuration management. It collects and analyzes performance data, correlates abnormalities and identifies the root cause of building performance problems. vCenter Operations provides capacity management to optimize resource usage and policy-based configuration management to assure compliance and eliminate sprawl and configuration drift.