

Application Performance Management in a Virtualized Environment

Growing business demands for new IT functionality (web sites, self-service portals, ecommerce, etc.) has led to a proliferation of hardware and software in the data center. Initially, though the cost benefits of x86 servers were (and still are) compelling, concerns around performance and reliability dictated a “one server, one service” implementation approach, where individual servers were limited to one application or a small group of highly connected applications that provide a specific service. The capabilities and performance of this class of server have improved dramatically, but in many data centers this has resulted in extensive “server sprawl,” with each server running typically at 15-20 percent utilization.

The under-utilization of server computing power in most data centers represents a potential area for significant cost savings: If more than one application could run on each server (“multi-tasking”), then fewer servers would be needed, less electrical power would be consumed and expensive hardware would be freed up for other tasks. Just as important, capital expenditure on new hardware could be delayed or even cancelled.

Running multiple applications on a single server is not as simple as it seems. Conventional multi-tasking systems require that applications use the same base operating system and services. In a typical data center, applications frequently have different operating system requirements (Windows, UNIX, Linux, etc.) and are even tied to different releases of the same operating system.

Virtualization provides a solution to the multi-tasking problem by loading each application and its own unique operating system “instance” as an image into a separate “virtual machine” (VM), which is then run alongside

other VM images on a specially configured server. This technology, first successfully commercialized by VMware, has become so successful that according to Gartner, 80 percent of IT departments now see virtualization as one avenue to achieve significant cost-saving goals.¹

The downside to virtualization is the impact it has on application performance management (APM) solutions. As new hardware and software technology is introduced into the IT environment, IT needs to be able to maintain a complete 360° view of application performance in the new environment in order to ensure service delivery promises and SLAs are met. However, virtualization represents a significant “blind spot” for APM. The performance of applications running in this environment can be almost invisible to many legacy APM solutions, making it hard to isolate, analyze and fix performance problems as they occur.

End users are not at all concerned if the applications they use are virtualized or not, as long as they continue to perform well. This highlights the need for an APM solution that can monitor the entire IT infrastructure, including virtualized servers, and provide accurate, actionable data for proactive problem identification and rapid resolution. The ideal APM solution for a virtualized environment should quickly pinpoint the root cause of any issue, no matter how elusive or intermittent, and determine its true business impact. The loss of visibility when moving applications to a virtualized environment can dramatically affect the business outcome of a virtualization project, increasing the need for a flexible, extensible APM solution.

This white paper focuses on the APM challenges of implementing VMware's ESX server, the leading virtualization solution in use today, and:

- the application performance challenges when running in a VMware ESX environment
- successful approaches to solving these challenges
- how Compuware's Vantage 11.5 provides a complete VMware APM solution.



APM CHALLENGES OF OPERATING IN A VIRTUALIZED ENVIRONMENT

Almost any application is a candidate for moving to a virtual environment. To date, IT organizations have imposed some constraints with tier 1 applications that have large CPU and I/O requirements, but continuous improvements in server hardware and virtualization software means that even these types of applications can be successfully virtualized.

As mentioned earlier, data centers have historically employed a “one service, one server” strategy (especially on x86-based servers), where physical servers are dedicated to running a pre-defined single service or

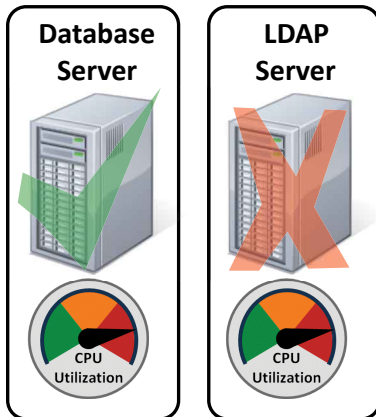


Figure 1

each of the servers involved (the database server and the LDAP server) immediately shows that the LDAP server application has high CPU utilization, warranting further investigation. High CPU activity on the database server is quite normal.

When applications are virtualized and collapsed inside a single piece of hardware, the “one-to-one” relationship between applications and hardware becomes a “many-to-one” relationship, and legacy monitoring solutions lose their analytical capabilities. The key issues are:

- limited visibility into transactions, especially between VMs on the same ESX host
- limited visibility into the physical-to-virtual relationship between hardware and applications
- difficulty understanding the performance impact of Virtual Machine Managers (VMM).

Each of these has a serious impact on any APM solution that isn't configured to operate in a VMware environment.

Limited visibility into transactions, especially between VMs on the same ESX host:

Legacy monitoring solutions may still allow administrators to get basic metrics on the processing and resource utilization of ESX host and guest VMs, but they do not provide visibility into the performance and availability of individual business-critical applications running on those VMs, especially when those applications are communicating with

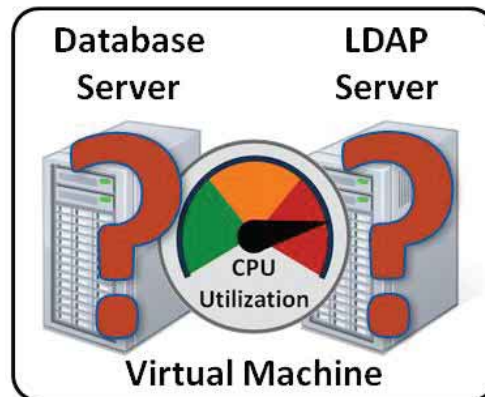


Figure 2

each other. The underlining issue is that not only are the applications themselves virtualized, but the networks and storage systems that they use are also virtualized. The network traffic between two applications on a single ESX server is also virtual, and not exposed to an APM agent monitoring the physical NIC card. Let's use the previous example in a virtualized environment. Now when users complain about slow logins to the e-mail system, there is no way to tell whether the application on the LDAP server is slowing down, waiting for a response from the database server, or whether the virtualized database application on the same server is just behaving normally.

Limited visibility into the physical-to-virtual relationship between hardware and applications:

The legacy APM challenge becomes even greater when ESX's advanced “Dynamic Provisioning” feature is used, allowing applications to be dynamically re-provisioned to any available host in the virtual server pool. A legacy APM solution only understands static provisioning (applications have a fixed mapping to specific physical servers), so when a dynamically provisioned server shows indications of a problem, the APM solution could easily attribute it to the wrong application. Even worse, if users start to complain about performance, the APM solution could easily have an application mapped to the wrong server, sending IT troubleshooters off in completely the wrong direction. In both situations, the APM solution provides misleading and inaccurate reports, leading to confusion and significant delays in resolving the problem.

Difficulty understanding the performance impact of Virtual Machine Managers:

The VMM or “Hypervisor” is an underlying control program which manages the creation, scheduling/prioritization and termination of virtual machines (Guest VM images) on each ESX server. Although it is completely invisible to each VM, the Hypervisor can have a significant impact on the performance of applications running in the image. For instance, if it assigns a low priority to a particular VM image, the applications in that image may appear to be running slowly. The APM solution may conclude, incorrectly however, that there is an application issue or the server is failing. The Hypervisor can also introduce effects which, if not properly understood by the APM solution, can lead to erroneous results. For instance, the passage of time in a VM is not always in sync with the passage of time in the real world. This phenomenon, called “clock skew,” can be accounted for if the APM solution is able to communicate with the Hypervisor.

In summary, virtualization makes it more difficult to identify most application performance problems, understand the business impact they may cause, and isolate the root cause. Troubleshooting an intermittent slowdown in a virtualized environment becomes a big challenge for even the most seasoned IT professional. Where do you look? What exactly do you look for? Many of the current metrics typically used as proxies for application performance will return invalid or misleading data in a virtualized environment. Even simple performance metrics such as CPU utilization percentage and memory consumption must be viewed and analyzed in a completely new light.

SOLVING THE APM CHALLENGES IN A VMWARE ENVIRONMENT

To avoid the loss of application visibility when moving to a virtualized environment, there is clearly a need for an APM solution that understands all aspects of the environment. Collecting and analyzing network, server and virtualized host metrics are still important, but do not always provide a true picture of the end-user impact of performance issues. Another key requirement is needed to objectively measure and understand the end-user experience (EUE). An ideal solution should quickly pinpoint the root cause of any issue, no matter how elusive or intermittent, and determine its true business impact.

[While this white paper focuses on collecting and analyzing network, server and virtualized host metrics in a VMware environment, more information on end-user experience monitoring, fault isolation and business impact assessment is available through other Compuware white papers (www.compuware.com/e2e).]

For any APM solution to work effectively, the environment must be appropriately monitored or instrumented. The end-user experience (measured as the end-user transaction response time) can be obtained through passive network monitoring of real users or by emulating users through synthetically generated transactions. The hardware and the applications running on the hardware can be monitored from embedded or remote agents.

Figure 3 depicts how a typical environment might be monitored. Ignoring the VMware server (the green box) for a second, the data collected from the various probes and agents are fed into a separate data analysis application (the service model), where the analysis is conducted and availability and status is determined. Typically, passive network probes are placed within the data center at locations where network traffic can be analyzed from the end-user perspective as well as between the application tiers. Synthetic users can be placed at critical locations to get additional performance data from various geographic locations where necessary. The hardware and application infrastructure can be monitored from agents installed on the native hardware or remotely when possible.

Virtualization (the green box) changes the landscape by introducing the concept of a virtual network. This is not a physical network; it is actually a VMware software emulation running inside each physical ESX server. However, this is completely transparent to the other applications running on that server. Network traffic capture and analysis poses some challenges when the physical network no longer exists.

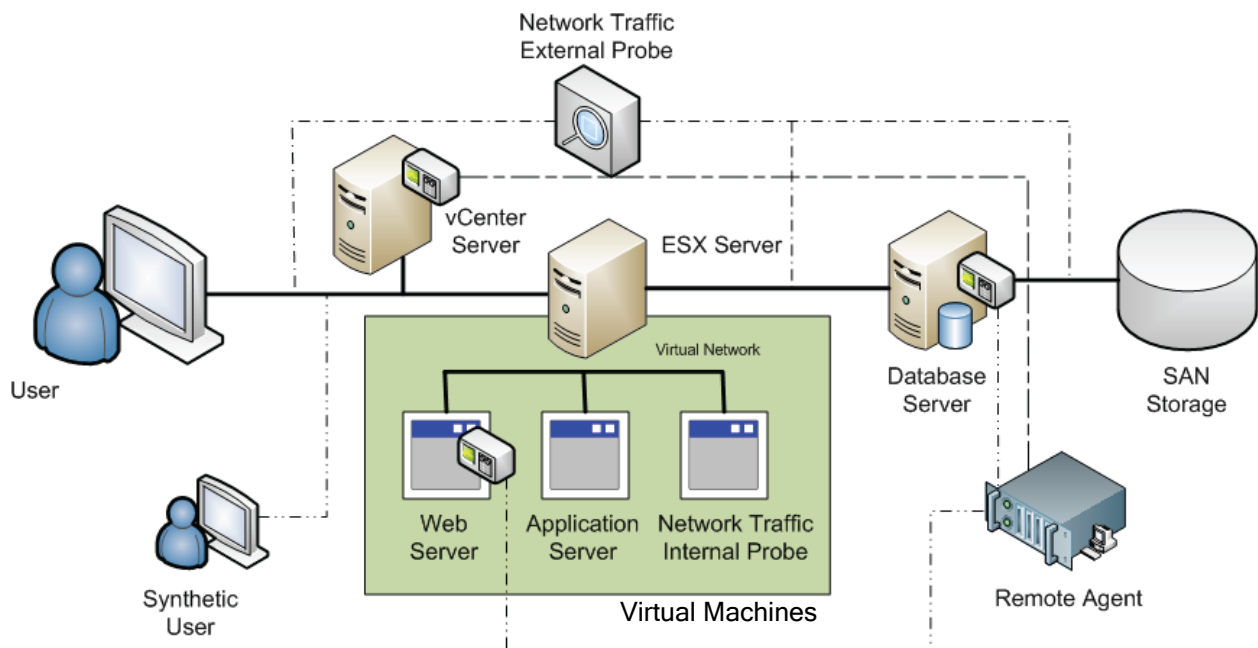


Figure 3

Within the VMware environment, these problems can be solved as follows:

Application and Transaction Visibility: To provide complete visibility into application transactions, including those that are residing on the same ESX server, and to provide information on dynamic mapping of applications across ESX servers, there are two instrumentation choices:

1) Virtual Network Probe

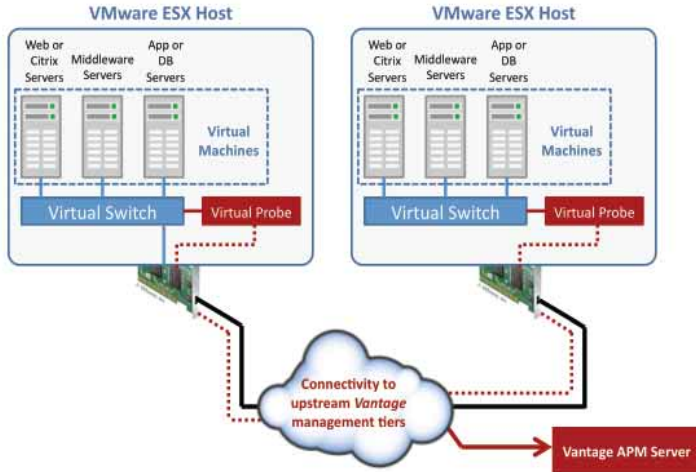


Figure 4: Compuware "Virtual Probe" Architecture

A network monitoring application (the Virtual Probe Appliance) is installed on a VMware guest image. The virtual probe collects and communicates virtual network data inside the ESX server in exactly the same way as a physical probe collects and communicates physical network data in the real world. Virtual NICs (vNICs) on the virtual network are configured in "promiscuous mode" making the traffic visible to the internal probe.

2) Cisco Nexus 1000V Switch

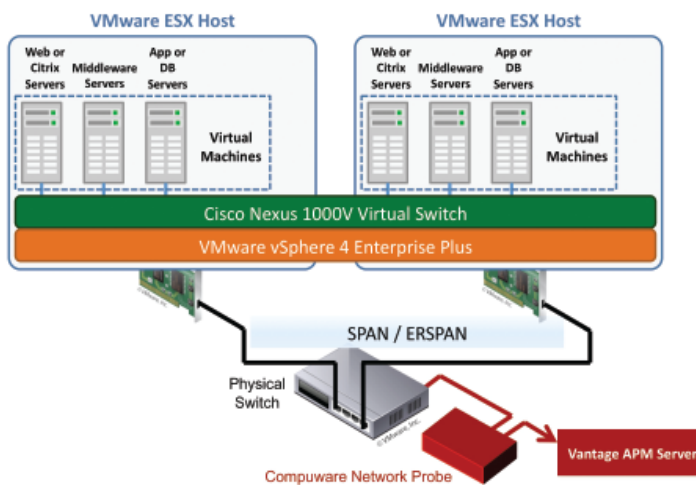


Figure 5: Compuware with Cisco Nexus 1000V Integration

An additional approach which is effective in larger, enterprise caliber environments is to incorporate the Cisco Nexus 1000 V Series Switch² into your VMware platform. These are intelligent virtual (software) machine access switches that operate inside the VMware ESX Hypervisor and offer exactly the same set of features as Cisco's physical switches—providing a single, common set of provisioning, configuration and networking features across the entire networking environment, both virtual and physical. From an APM point-of-view, a key feature of the 1000V Switch is it enables port spanning, which means it can be used as the equivalent of a hardware switch. Attach an external network monitoring device, and you can analyze all virtual network traffic as if it were coming from a physical mirrored port.

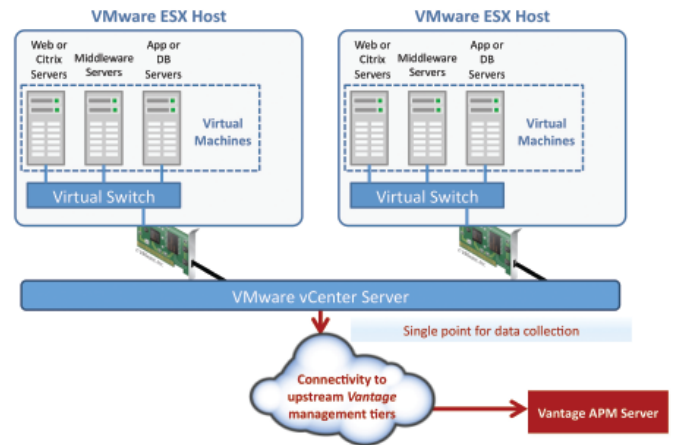


Figure 6: Compuware with "vCenter" Architecture

Retrieving data from Virtual Machine Managers: Each ESX server uses a Virtual Machine Manager (or "Hypervisor") to manage the virtual machines running on that server. To facilitate the management of multiple Hypervisors across the network, VMware's vCenter Server acts as a single point of information for virtual infrastructure administrators. It offers an extensive set of APIs (Application Programming Interfaces) allowing third-party applications access to data collected by vCenter. The Vantage vCenter adaptor discovers and collects information on virtual-to-physical relationships and dynamically tracks the performance of these key elements as resources are allocated and de-allocated within a given VMware environment. Vantage combines application service quality data from virtual probes or the Cisco virtual switch with performance indicators from vCenter to provide application owners and systems analysts with a complete, 360 degree view of application performance.

VANTAGE 11.5—A COMPREHENSIVE APM STRATEGY FOR VMWARE ENVIRONMENTS

Vantage 11.5, Compuware’s industry-leading APM solution, monitors and manages application performance across the entire delivery chain from the one perspective that really matters: the end user. Vantage 11.5 delivers relevant, actionable information that links application performance issues with business impact. Vantage 11.5 eliminates all of the APM challenges in a VMware environment by offering all three of the VMware-specific monitoring options (Virtual Probe Appliance, full compatibility with Cisco’s Nexus 1000V Switch and integration with VMware’s vCenter Server). With Vantage 11.5, you can:

Monitor application performance from the end user’s perspective.

Vantage’s EUE Monitoring solution provides you with a comprehensive picture of end-user experience by deploying passive network analysis monitoring or synthetic transactions from within or outside a virtualized environment. For passive monitoring, network agents can be deployed in key data center locations on both physical and virtual environments. Synthetic agents can be deployed at strategic locations on the corporate network. For external web application monitoring, Gomez offers a SaaS model which requires a zero-agent deployment.

Gather critical ESX server and Guest VM metrics to quickly determine if the virtualized environment is the issue.

Leveraging the Vantage vCenter data adaptor, ESX-based key performance indicators (KPIs) and important VM-to-host relationship information is discovered and tracked dynamically. Configuration is as simple as pointing the Vantage adaptor at a vCenter Server instance and selecting the appropriate environments to monitor. This vSphere environmental information is then correlated to application service quality indicators, so you can understand VM and ESX host performance in the context of the application services that support

those components. Along with ESX performance counter monitoring, Vantage can track vMotion events, along with the top CPU-consuming process for each VM.

Be tolerant of timekeeping issues or “clock skew” introduced by running VMs on PC-based operating systems. Time-based performance measurements typically rely on hardware interrupts delivered to the native OS to calculate elapsed time. The problem with this method comes from the fact that a VM may not be running when the interrupt is fired. Time, as measured by the guest image, falls behind real time. A VMware virtual machine deals with this problem by keeping track of the current timer interrupt backlog and delivers interrupts at a higher rate when the image is running. This is referred to as “apparent time.” VMware has published a white paper (www.vmware.com/files/jp/pdf/vmware_timekeeping.pdf) describing this phenomenon in detail.

Virtual monitoring products do not necessarily need to run in a virtualized environment to collect and analyze application performance about those that do. However, in some cases, it is impossible to avoid or, in fact, is advantageous to run monitoring components in a virtualized environment. The Vantage product line has tested and validated that each product can run on a VMware machine. There are considerations to take into account and recommendations are available. In most cases, testing has revealed no appreciable performance degradation when running virtual or otherwise on comparable hardware. “Clock skew” typically introduces timing variances in the 1 millisecond range. Since most Vantage users are typically viewing metrics reported with 100 millisecond timings or higher, the variance is subtle. However, on severely taxed hosts, it is preferred if Vantage is placed on a dedicated VM and run at high priority. A monitoring product’s timing measurements will only be as accurate as how often it runs.

Infrastructure					
Service Title	Service Quality		Availability		MTBF
	Current ▲	Duration	Current	Overall	
Web Servers for Live Quot...	Critical 	8m 48s		88.14%	3h 58m
Servers for Live Quote	Warning 	8m 53s		100.00%	
Database Servers for Live...	Normal 	8h 59m		100.00%	
Message Servers for Live ...	Normal 	8h 59m		100.00%	
Virtual Infrastructure fo...	Normal 	9h 1m		100.00%	

Figure 7

Isolate the root cause of application performance problems—no matter how elusive or intermittent—and effectively reduce MTTR. The service tree shows a service model dependency relationship which allows the user to quickly determine where the problem originated. Analysis charts indicate Processor time (Figure 8b) is spiking at the same time the insurance application is experiencing degradation at the web tier. However, the wait time performance indicator on the ESX host is not showing significant CPU resource contention. This is indicative of a performance situation that is likely tied to the application processing itself or an improperly configured VM.

Process application metrics through relevant business rules to generate a real-world set of priorities for IT. The Vantage business model supports evaluation. Evaluation is the process of applying business rules to performance metrics and aggregated service quality of dependent services. Evaluation can be as simple as averaging or taking the best or worst, to more complex rules which use a compound set of conditions. Coupled with the concept of business schedules, where service quality and availability can change based on the time of day, it's easy to construct reports that prioritize problems and spot trends.

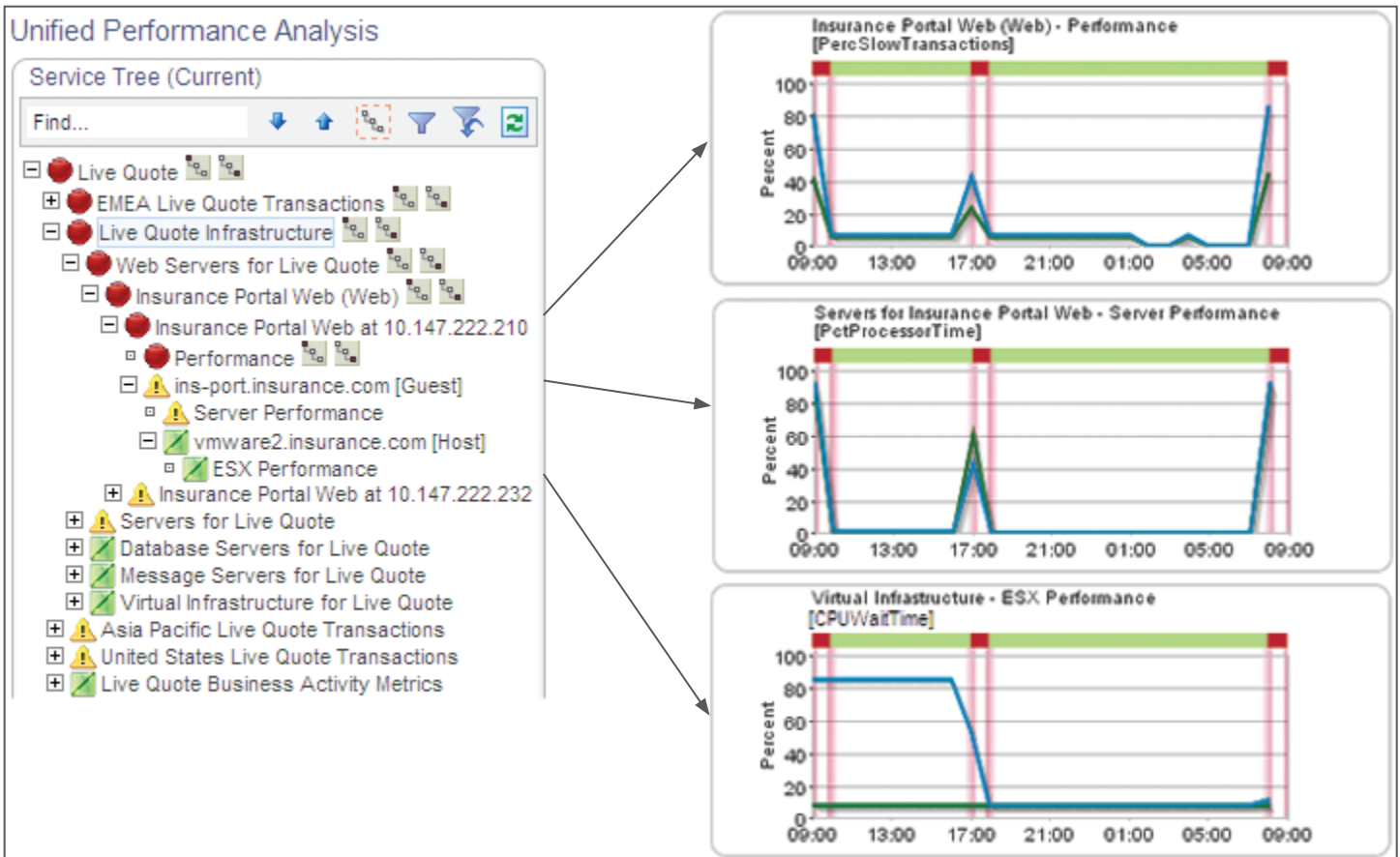


Figure 8a

Figure 8b

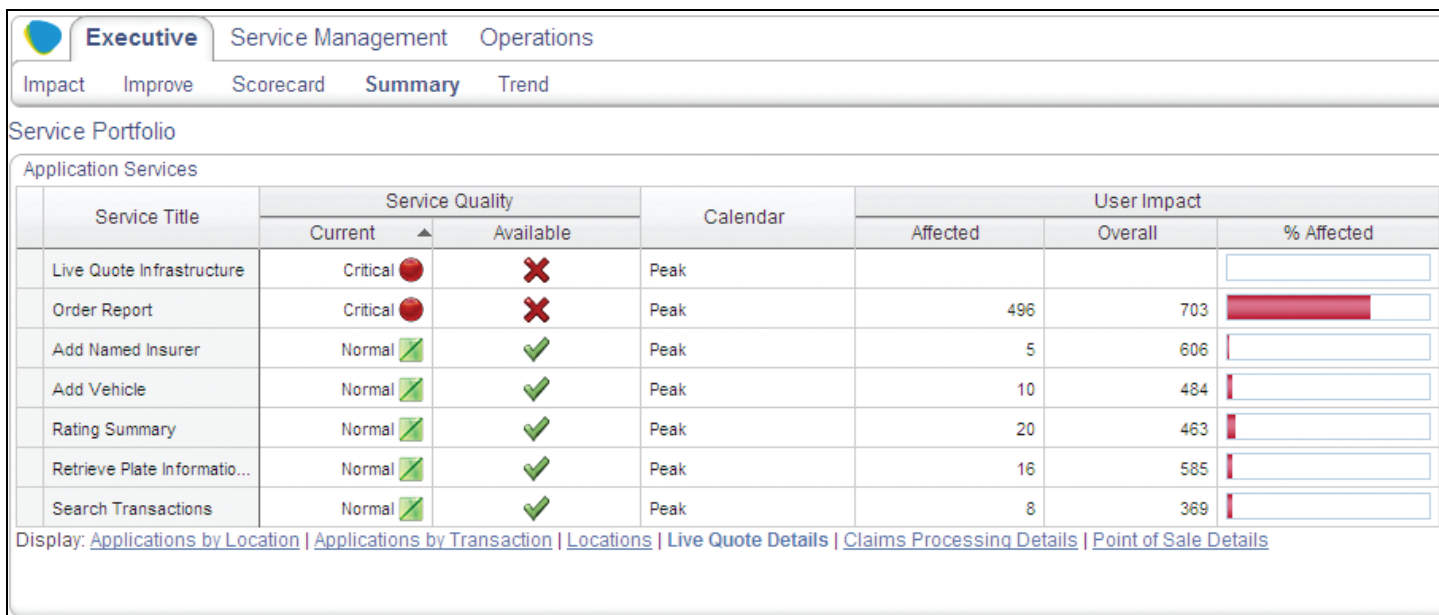


Figure 9

Include out-of-the-box management dashboards that deliver objective facts, eliminate finger-pointing and improve collaboration between teams. Critical application services are updated with real-time status.

Dashboards give a high-level view of application performance and the number of impacted users.

Record baseline application performance metrics prior to virtualization so IT can validate its success:

- Assure the migration by taking a baseline of application performance before, during and after physical-to-virtual migration.
- Ensure service-level visibility before and after virtualization. Take the opportunity to engage application owners and business stakeholders around SLA expectations.
- Enable rapid fault isolation process techniques and service restoration that is aligned with business needs.

CONCLUSION

Most application performance solutions targeting virtualized environments in the market today rely on taking the available monitoring metrics and manually presenting them in a unified view. This approach is fundamentally flawed because it derives the health of the service from an aggregation of infrastructure metrics that might have no relevance to the

quality of service or the health of the virtualized applications that are running. The outcome of this strategy is only a summarized set of information that is no more valuable than the disparate set of metrics with which you started. There is no actionable data.

Compuware's Vantage 11.5 collects network, system, virtualization and EUE metrics from disparate data sources in both physical and virtual environments. The data is then processed through the service model, which applies intelligent status and availability rules. Finally, Vantage presents meaningful, actionable information via dashboards along with reports tailored to the appropriate audiences, such as executives, service managers and IT operations staff. Armed with right information, IT teams can respond faster to poor quality service and save time by enabling faster root-cause analysis.

Compuware has worked extensively with VMware to provide extensive support for VMware environments within the Compuware Vantage Application Performance Management (APM) solution. Unlike most other APM solutions, Vantage provides application performance management in both physical and virtual environments, which means it can be used to provide a consistent APM environment throughout the migration of applications from physical to virtual platforms. In addition, Vantage 11.5 is certified "VMware Ready" to give VMware customers additional assurance that they are choosing the best solution for their APM needs.

REFERENCES

1. "IT I&O Leaders' Key Initiatives: Consolidation and Virtualization – Reducing Cost with Server Virtualization," Phillip Dawson, Gartner; January 21, 2009, page 4.
2. Cisco Nexus 1000V Switch: http://www.cisco.com/en/US/prod/collateral/switches/ps9441/ps9902/data_sheet_c78-492971.html.

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