NetworkAppliance®
The evolution of storage.™

# Onaro® SANscreen® Product Suite

ONARO® Intelligent Storage Delivery

## A Complete Description of the Onaro® SANscreen® Product Functionality

TECHNICAL REPORT

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## Abstract

The purpose of this technical report is to provide both an overview and a detailed functional flow of the entire Onaro® **SANscreen®** product suite for NetApp personnel who want to understand how this set of products fits into the world of storage and storage management. This could include NGS, pre-sales teams, SEs, NetApp management and engineers, PPEs, etc. This paper will also provide NetApp personnel with a better understanding of the entire product suite in order to better ascertain partnering possibilities and the building of joint roadmaps. This paper should also serve as a template for describing the functionality of all SMAI management partners and it will be updated periodically as new functions are announced the the **SANscreen®** product suite.


Network Appliance, a pioneer and industry leader in data storage technology, helps organizations understand and meet complex technical challenges with advanced storage solutions and global data management strategies.

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# SANscreen® Product Overview

## 1) Introduction

Network Appliance Inc. has a very good working relationship with Onaro, Inc. Their product suite does support NetApp storage and they are currently doing development to include even more NetApp management functionality. They currently have hundreds of customers and their base continues to grow. They currently don't have any direct competitors in their base functionality but they do have competitors who compete for the same dollars and some that are starting to develop similar functionality into their products.

## 2) Overview

**SANscreen®** extends datacenter automation to storage with a goal of accelerating application delivery, reducing operating costs and trimming capital spending on storage by as much as 20%.

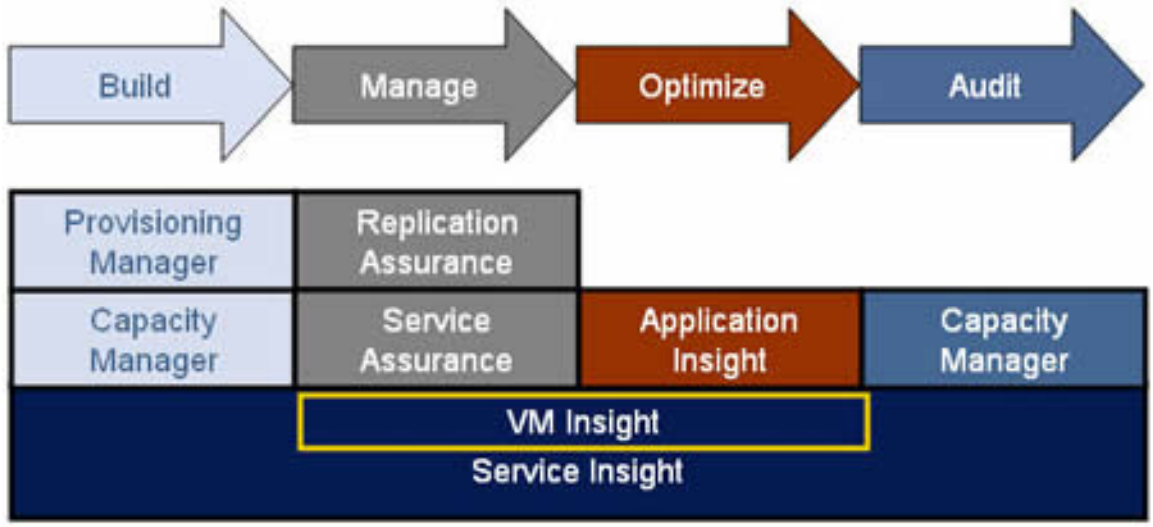
**SANscreen®** supports the four critical processes in datacenter automation for storage:

- Build - The right capacity, at the right time at the lowest possible cost
- Manage - Effectively manage storage service delivery to meet application requirements
- Optimize - Reduce costs, reallocate resources based on actual application demand
- Audit - Chargeback and governance

The Onaro® **SANscreen®** product suite includes:

- **Service Insight**
- **Service Assurance** (formerly **SANscreen Foundation**)
- **Application Insight**
- **Capacity Manager**
- **Provisioning Manager**
- **VM Insight**
- **Replication Assurance**

The figure below provides the overview of the Onaro® product suite.



The entire **SANscreen®** product suite is really enterprise-scalable, currently handling customers up to 20 PB of storage and 70,000 switch ports. The product is agentless, and installs in 3 to 24 hours depending on the size of the SAN infrastructure. The initial discovery for a large shop of 2000 ports can take up to 8 hours of clock time – after that, the changes are monitored in near real time.

I have interviewed at least 5 of their customers and they are in love with the product. One customer told me that their customer council meetings are more like a love fest of very satisfied accounts.

### 3) Product Strengths

Throughout the remaining chapters, you will see an abundance of rich functionality and an intuitive GUI. What makes the **SANscreen®** product suite so rich in function is a set of key technology that permeates the entire set of products. These key product strengths are described below

- **Agentless discovery** – Customers hate agents because they normally require installation through change control windows that usually occur on weekends only. Large enterprise customers usually have between 5000 and 100,000 servers. It would take forever (if ever) to install agents in enterprise shops.

- **Depth of discovery** – The **SANscreen®** product suite discovers servers (including VMWare ESX servers and virtual servers), host OS and applications, HBAs, iSCSI initiators and targets, switches, zones, zone sets, masking and mapping rules, storage, tape drives, and all ports, along with I/O statistics for every port in the storage network. It has the ability to build the total topology from the host application through all layers of virtualization down to the LUN and disks, and even across a WAN to remote switches, storage, and host applications

- **Annotations** – The Administrator has the ability to add annotations to the discovered infrastructure. This could include names for storage objects, tier levels of storage, cost information, business unit information, and other meta data meaningful to the customer. Later, this meta data will appear in all of the GUI displays, reports, alerts, etc.

- **Policy definitions** – The Administrator can define policies that define rules, thresholds, limits, etc. for the entire infrastructure that are used to govern alerts, violations, logging, and change control.

- **Monitoring and Alerts** – There are many built-in monitoring facilities in the **SANscreen®** product suite. Once the initial discovery is complete, will continue to monitor for any changes in the entire infrastructure. This means that discovery is really continuous. The monitoring also applies to any changes put in by the Administrator. Not only are they monitored but they are logged and checked against policies for policy violations or alerts for possible breakages in the infrastructure.

- **Heterogeneous support** – The **SANscreen®** product suite supports most of the common storage devices, hosts, OSes, and applications usually found in Enterprise accounts

- **VMWare/ESX Support** – The emergence of VMWare has brought virtualization to a new peak, and at the same time, has complicated the management of the storage infrastructure. By integrating VMWare information into the infrastructure, Onaro has greatly enhanced their functionality because they can tie-in every piece of information all the way back through the virtualization layer.

- **Intuitive GUI** – The **SANscreen®** GUI is very easy to manipulate, very intuitive, and very functional. The color coding is consistent and the GUI lets you easily drill down to root problems and solutions

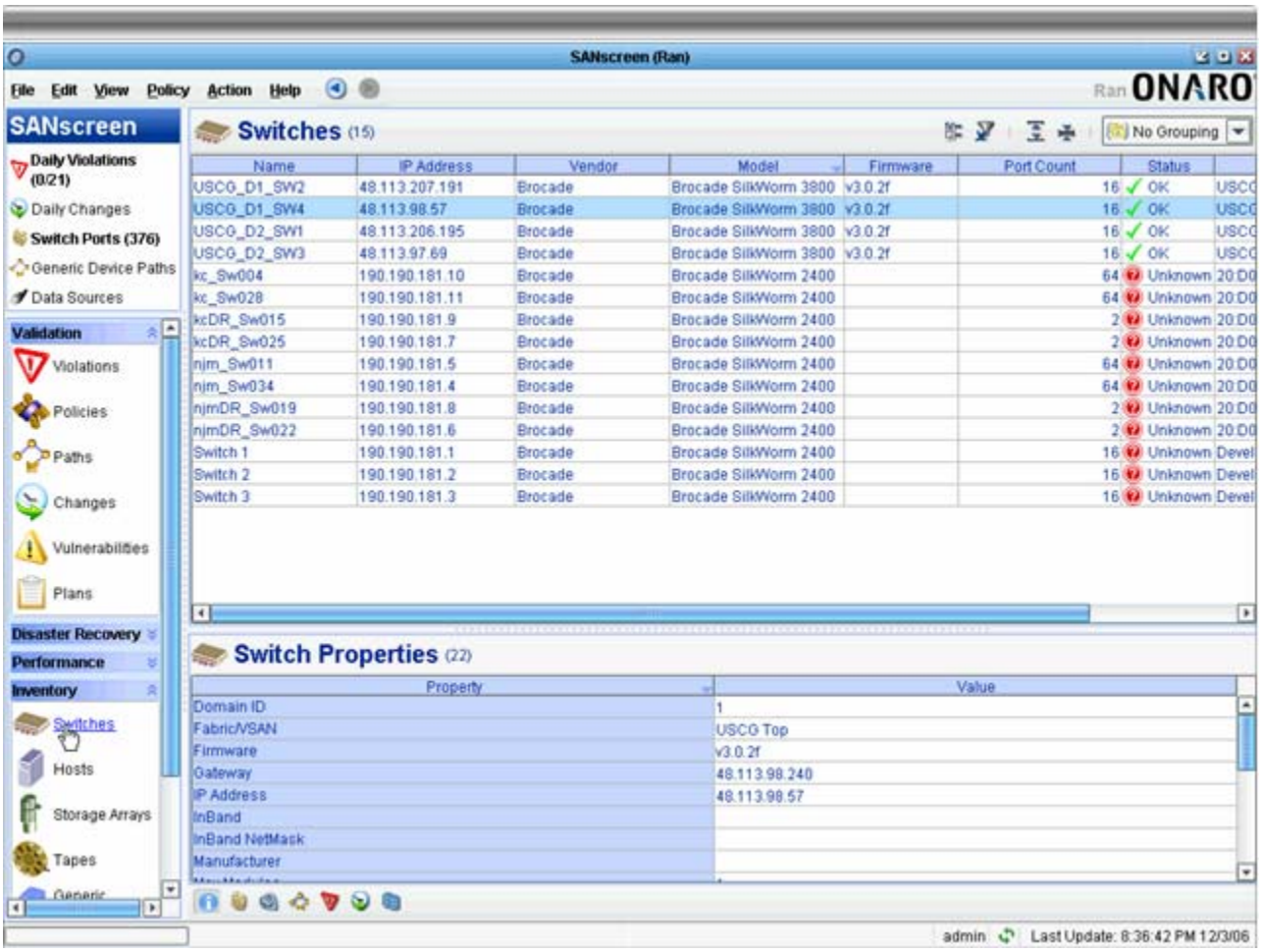
- **Service Intelligence Engine (SIE)** – This engine is a generic internal machine that allows rules to be applied to objects. Although the rules are clearly focused on the storage network infrastructure, the internal engine is very generic and could probably be used for other applications

- **What If Simulations –** The Service Intelligence Engine can apply rules to both What Is and What If scenarios. This becomes a very powerful tool for both change control and device migration because it lets the Administrator see what will happen if certain changes are made to the SAN infrastructure. It will list out all of the violations and allow the change team to work through a task list to avoid the problems before they actually happen.

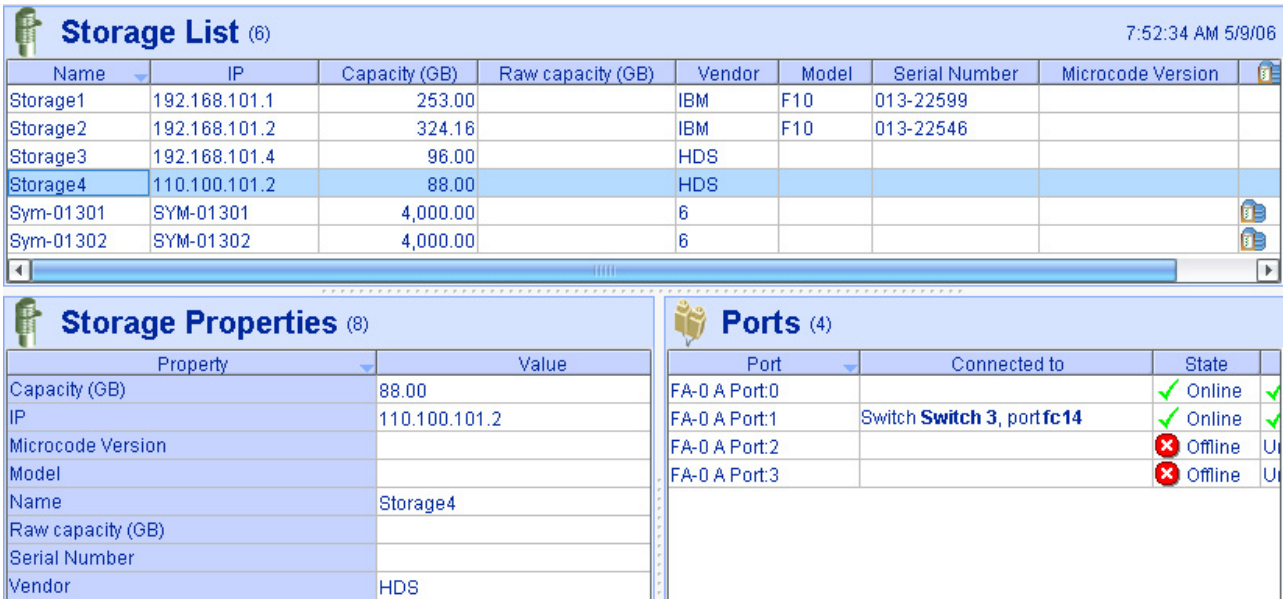
- **Migration Manager –** During device migration, say for example, replacing a switch or storage device, the change control process becomes extremely difficult because so many things are affected during the process. The built-in Migration Manager will automatically build a task list for each phase of the actual migration showing all of the violations caused by each major phase of the migration. The Administrator doesn't have to plan out a list of tasks at all because all of these get generated automatically along with the violations list they have caused. The device migration becomes complete when all tasks have been executed and all violation conditions have been fixed.

# SANscreen® Service Insight

This is really their baseline bread and butter product to discover the entire SAN infrastructure, both logical (e.g., zones, zone sets) and physical (servers, HBAs, switches, storage arrays, ports, etc.). Below is an example of the information **SANscreen Service Insight** collects from switches:



Below is an example of the information **SANscreen Service Insight** collects from storage arrays:



**Storage List** (6) 7:52:34 AM 5/9/06

| Name | IP | Capacity (GB) | Raw capacity (GB) | Vendor | Model | Serial Number | Microcode Version |
|---|---|---|---|---|---|---|---|
| Storage1 | 192.168.101.1 | 253.00 | | IBM | F10 | 013-22599 | |
| Storage2 | 192.168.101.2 | 324.16 | | IBM | F10 | 013-22546 | |
| Storage3 | 192.168.101.4 | 96.00 | | HDS | | | |
| Storage4 | 110.100.101.2 | 88.00 | | HDS | | | |
| Sym-01301 | SYM-01301 | 4,000.00 | | 6 | | | |
| Sym-01302 | SYM-01302 | 4,000.00 | | 6 | | | |

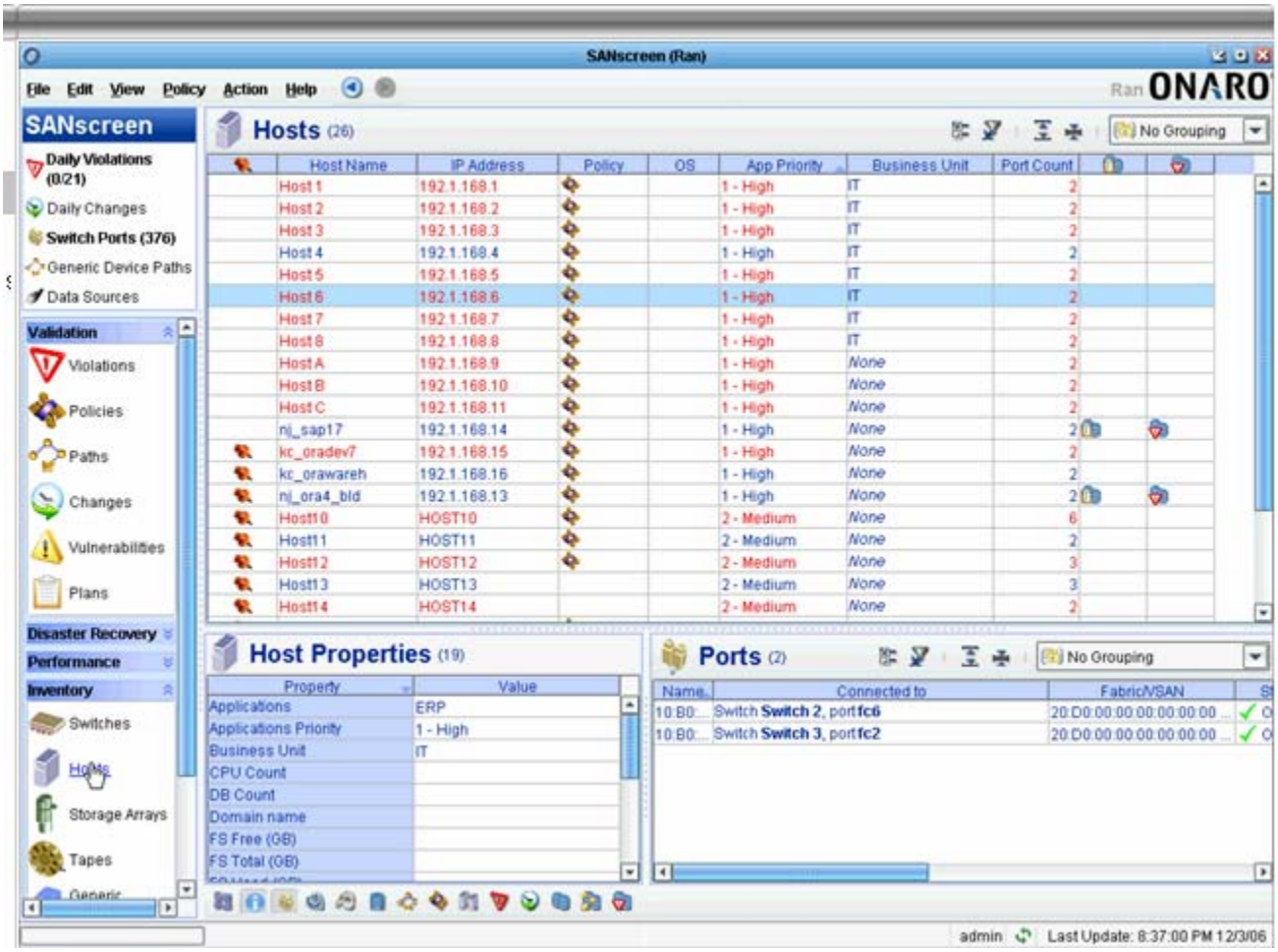
**Storage Properties** (8)

| Property | Value |
|---|---|
| Capacity (GB) | 88.00 |
| IP | 110.100.101.2 |
| Microcode Version | |
| Model | |
| Name | Storage4 |
| Raw capacity (GB) | |
| Serial Number | |
| Vendor | HDS |

**Ports** (4)

| Port | Connected to | State |
|---|---|---|
| FA-0 A Port:0 | | Online |
| FA-0 A Port:1 | Switch **Switch 3**, port **fc14** | Online |
| FA-0 A Port:2 | | Offline |
| FA-0 A Port:3 | | Offline |

**SANscreen Service Insight** will also collect the host and HBA information, and connect it to the SAN device-level information.

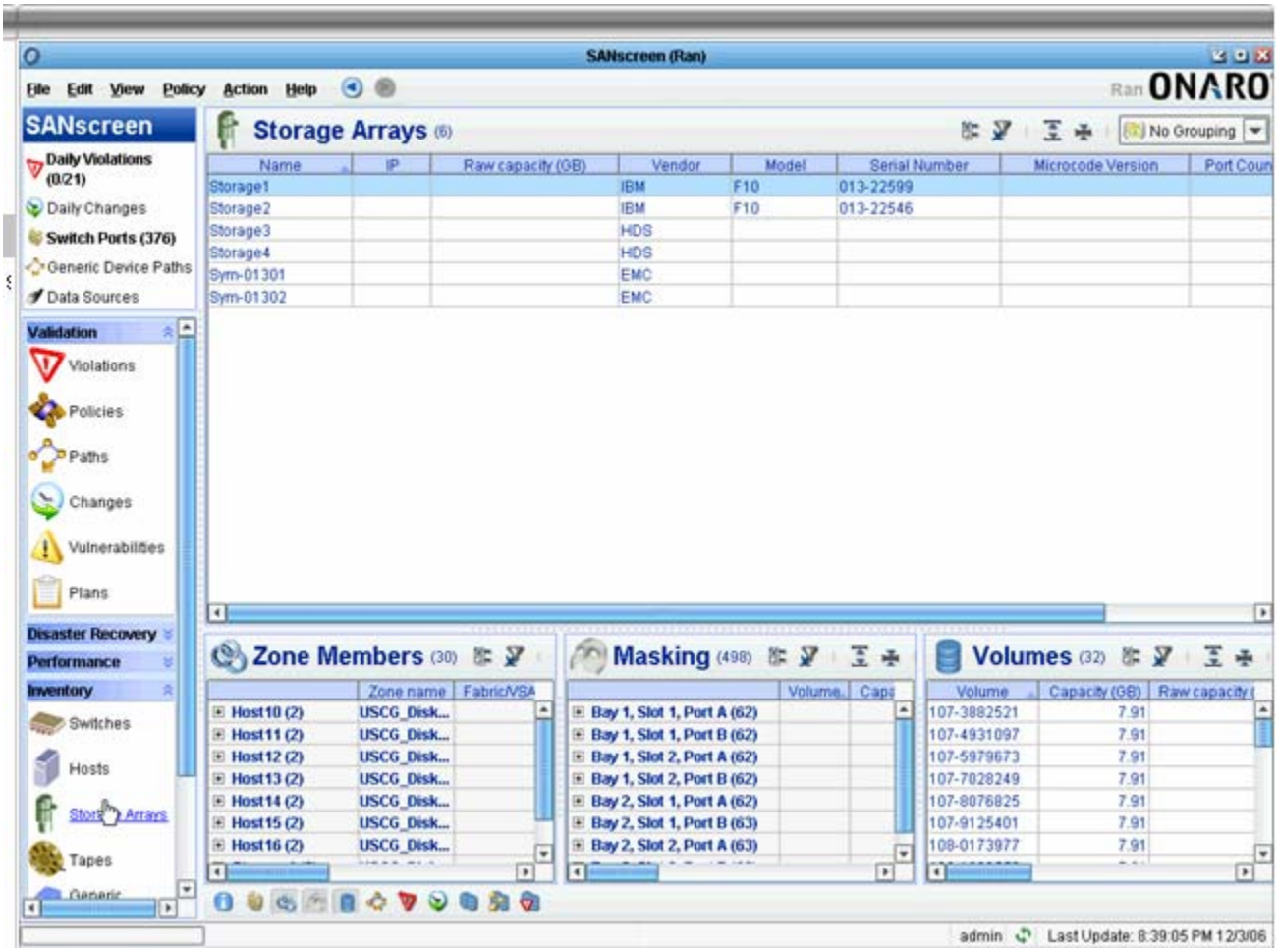



As you can see in the table above, there are columns associated with the host application in terms of the corporation business unit and the priority of the application. These would be manually set once by the installation, unless there was a business change.

There is another column that indicates there is a policy associated with this host. Definition of policies are shown later in this document.

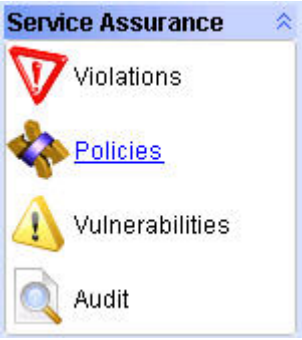
The navigation panel for all Onaro® functions appears to the left of the view screen. The navigation panel contains major group window boxes that expand when clicked on – the major groups are: **Inventory**, **Performance**, **Disaster Recovery**, **Validation**, and **Daily Violations**.

**SANscreen Service Insight** now takes all of this information and connects it into a full picture of the SAN with all of the connections (hosts, HBAs and ports, switches, switch ports, storage and storage ports, zones, zone sets, mapping and masking information) as shown below:

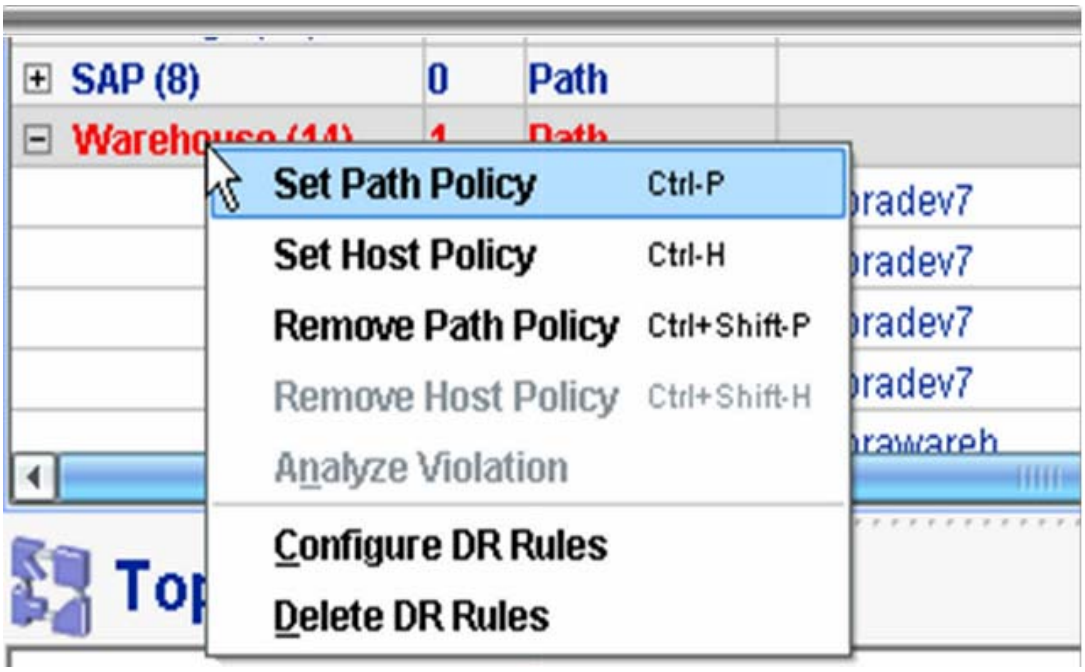



In the screen above, if you click on a particular storage array, **SANscreen Service Insight** will display the zoning, masking, and volume information for that array.

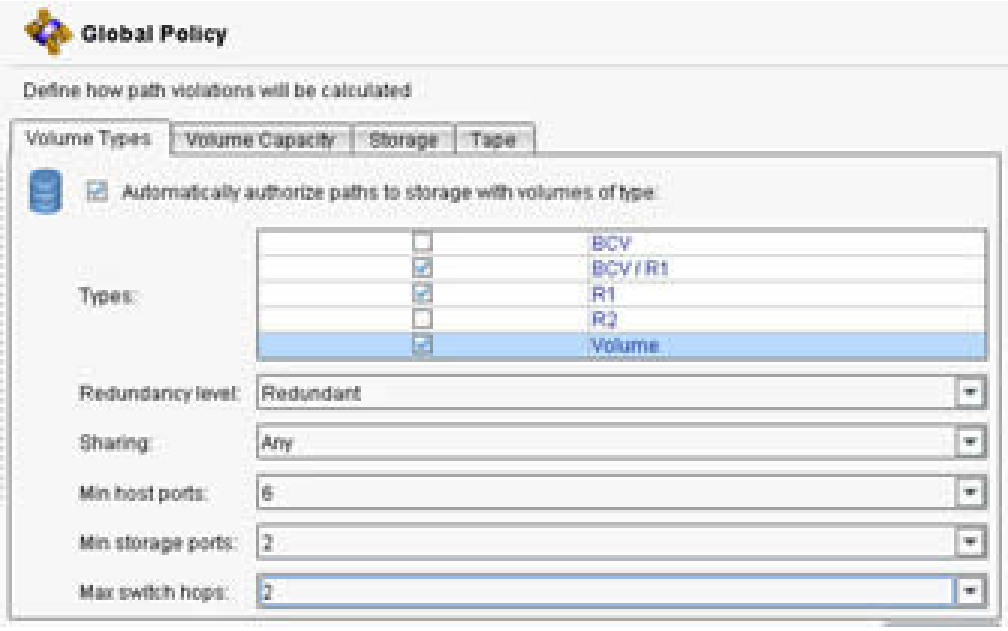
# SANscreen® Service Assurance




**SANscreen Service Assurance** (formerly **SANscreen Foundation**)brings in the notion of global, application, host, or path-based service policies



Customers can define global policies for the discovered SAN infrastructure via a GUI screen shown below

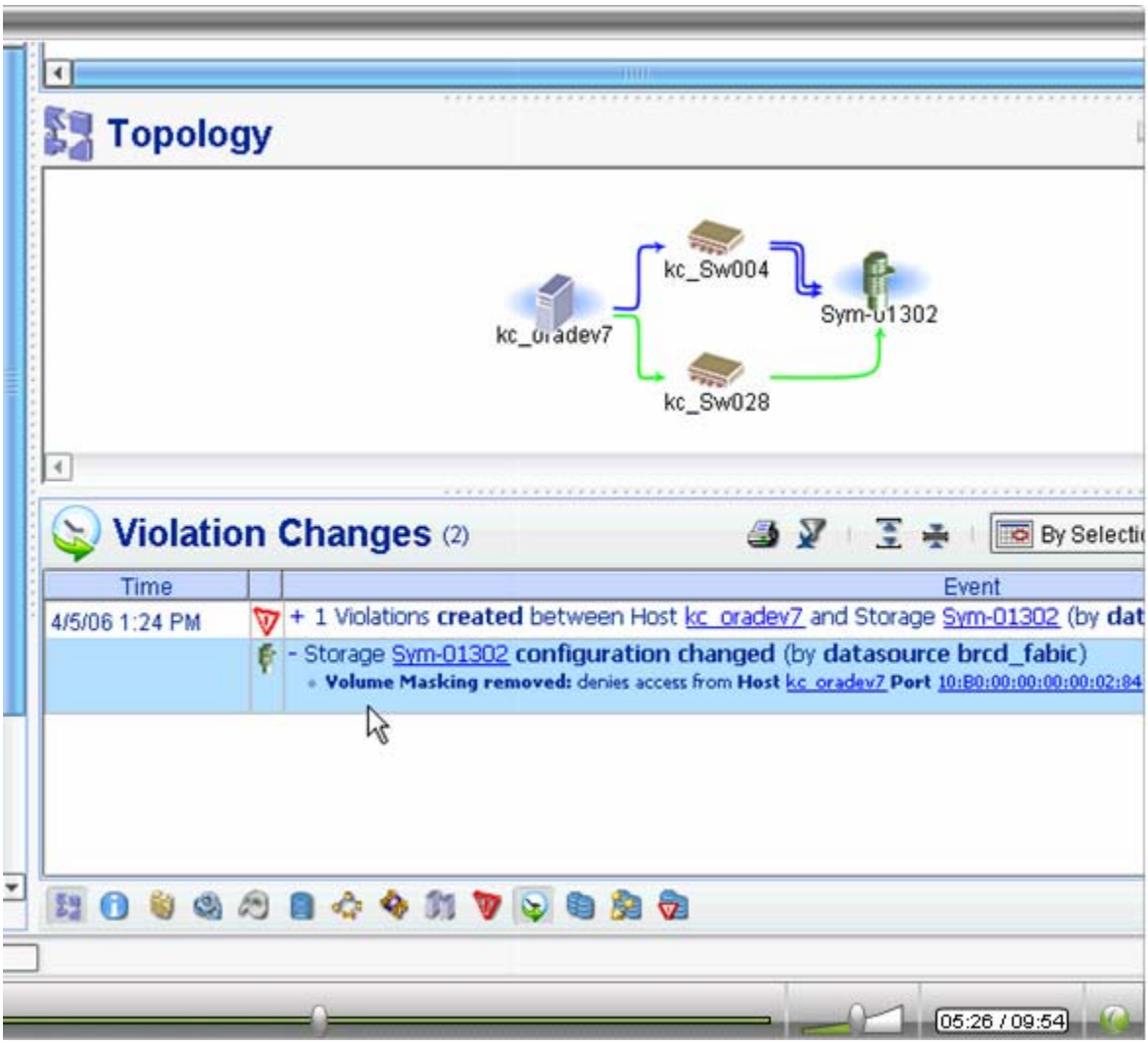



Internally, there is an SIE (Service Intelligence Engine) which processes the customer rules against the discovery data – this is a very generalized policy engine that matches policy rules against the monitored topology to expose infrastructure violations

In the scenario below, there is a high priority Warehouse path violation where there are supposed to be multiple access paths:

There is a corresponding topology view for this violation shown in the picture below. The green path from kc_oradev7 is fine but the blue path indicates that the path is zoned but the volume has not been masked properly. Since each change is logged, we can see that this violation was caused because the volume masking was removed previously.

The following table summarizes the process of taking a snapshot of a NetApp filer LUN mounted on a Windows 2000 host:



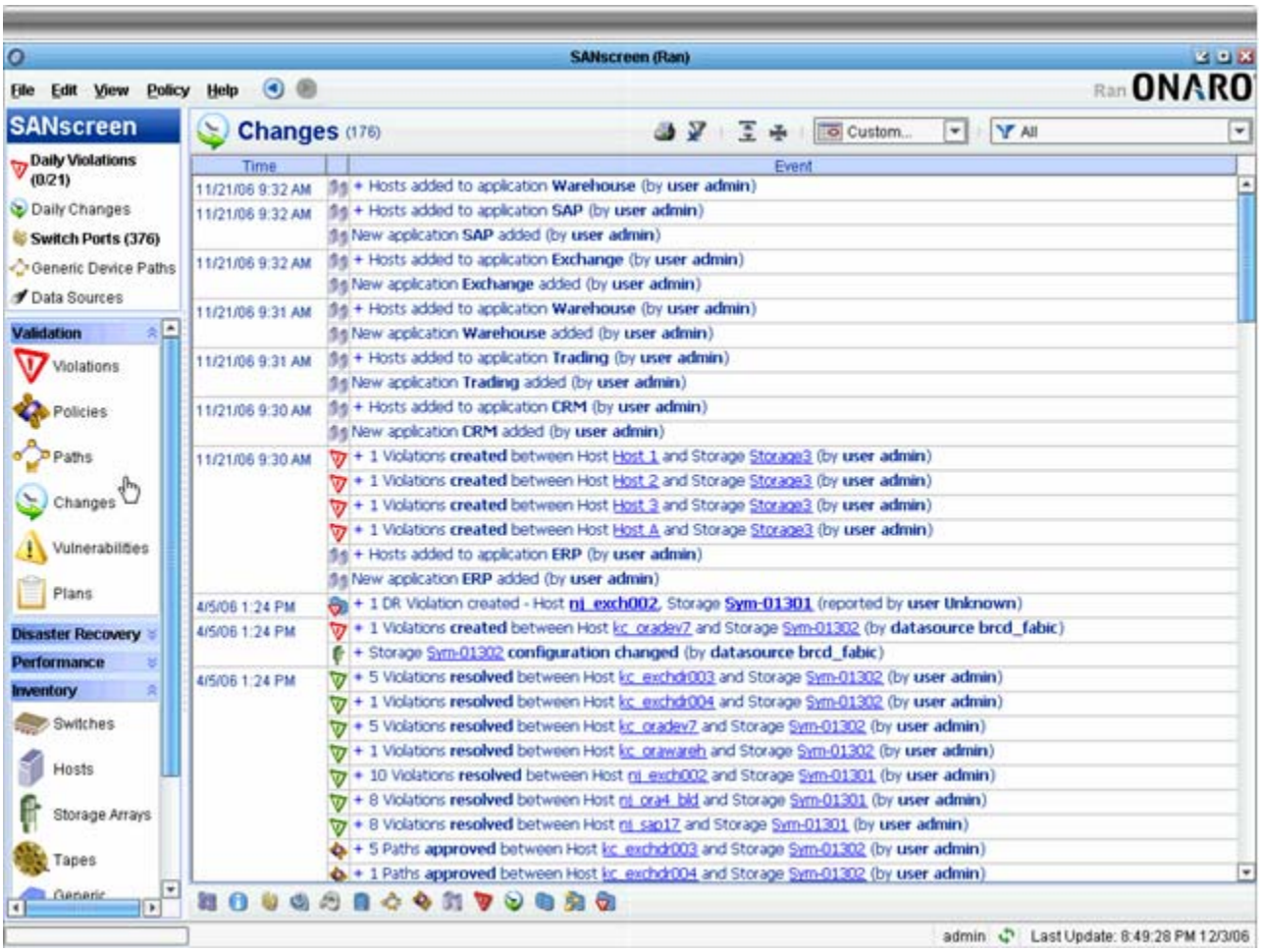

**SANscreen Service Assurance** will report on any violations for both existing configurations and "what-if" changes – things like:

- Too many ISL (Inter-switch links) jumps
- Orphan LUN conditions
- No parallel path to particular resources
- Single point of failure
- Missing zoning ports on host
- Etc.

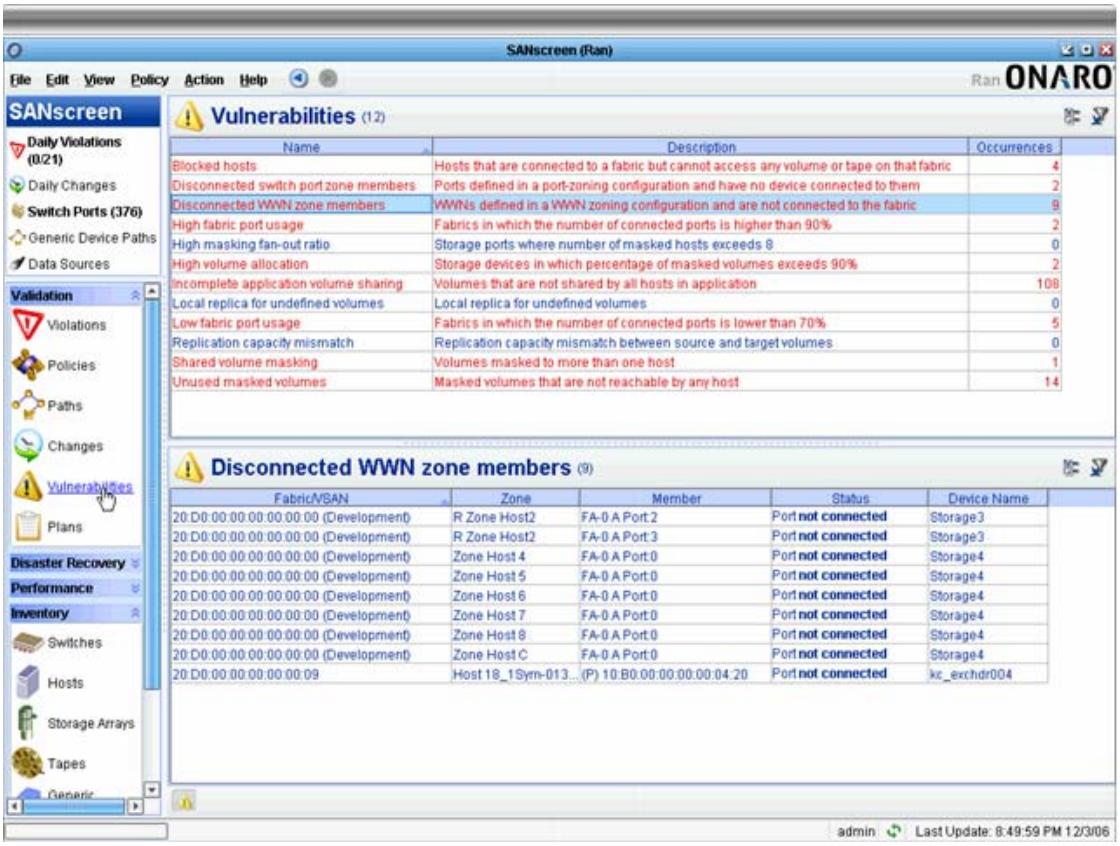
All changes are monitored and logged for a history of change control. This provides a robust audit and compliance mechanism for organizations

It will also make an assessment on the impact of that change to the service being delivered to the application

Below is an example screen shot from the **SANscreen Service Assurance** module displaying the change log:



**SANscreen Service Assurance** will also check for application vulnerabilities – these are not policy violations but they may impact the serviceability to applications within the infrastructure and should be looked into. Below is an example screen shot:

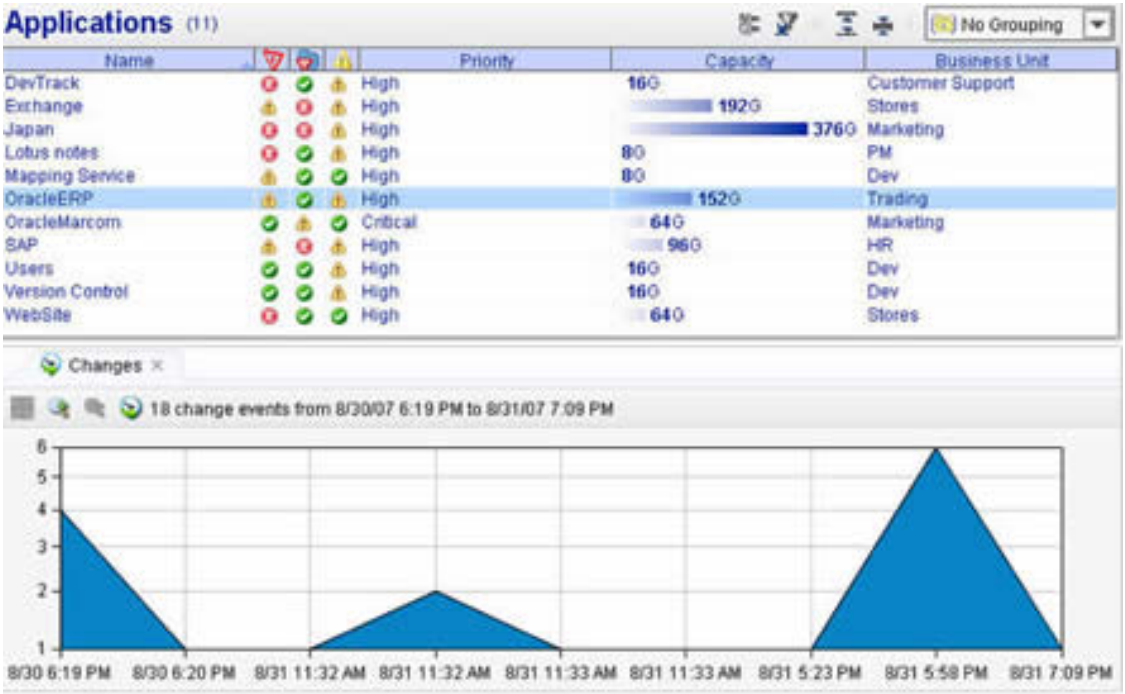



For each host or application, it reports on the services delivered to that application in terms of capacity assigned, access paths to that capacity, recoverability of the application in the event of a source volume failure, and performance of the storage environment.

Below is a screen shot example:

| | | | Host | Storage | Volume | Capacity (GB) | Host ports | Hops | Host Fabrics | | | DR Types | Since |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0 | 1 | Host17 | TAPE 3 | | 0 | 1 | 1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (10) | 0 | 10 | Host16 | Storage2 | | 79.06 | 2 | 1,1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (11) | 0 | 11 | Host15 | Storage1 | | 86.97 | 2 | 1,1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (13) | 0 | 13 | Host15 | Storage2 | | 102.78 | 2 | 1,1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (8) | 8 | 0 | Host14 | Storage1 | | 63.25 | 2 | 1,1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (7) | 0 | 7 | Host12 | Storage2 | | 55.34 | 2 | 1,1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (9) | 0 | 9 | Host11 | Storage2 | | 71.16 | 2 | 1,1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (1) | 0 | 1 | Host10 | TAPE 1 | | 0 | 1 | 1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (1) | 0 | 1 | Host10 | TAPE 2 | | 0 | 1 | 1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (1) | 0 | 1 | Host10 | TAPE 5 | | 0 | 1 | 1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (2) | 0 | 2 | Host10 | Storage2 | | 15.81 | 2 | 1,1 | | 0 | 0 | | 10/20/03 1:12 PM |
| (13) | 0 | 13 | Host10 | Storage1 | | 102.78 | 2 | 1,1, 2,1 | | 0 | 0 | | 10/20/03 1:12 PM |

Below is an example of the Application Dashboard which lists all of the applications along with indications of problems associated with their policy violations




| Name | Priority | Capacity | Business Unit |
|---|---|---|---|
| DevTrack | High | 16G | Customer Support |
| Exchange | High | 192G | Stores |
| Japan | High | 376G | Marketing |
| Lotus notes | High | 8G | PM |
| Mapping Service | High | 8G | Dev |
| OracleERP | High | 152G | Trading |
| OracleMarcom | Critical | 64G | Marketing |
| SAP | High | 96G | HR |
| Users | High | 16G | Dev |
| Version Control | High | 16G | Dev |
| WebSite | High | 64G | Stores |

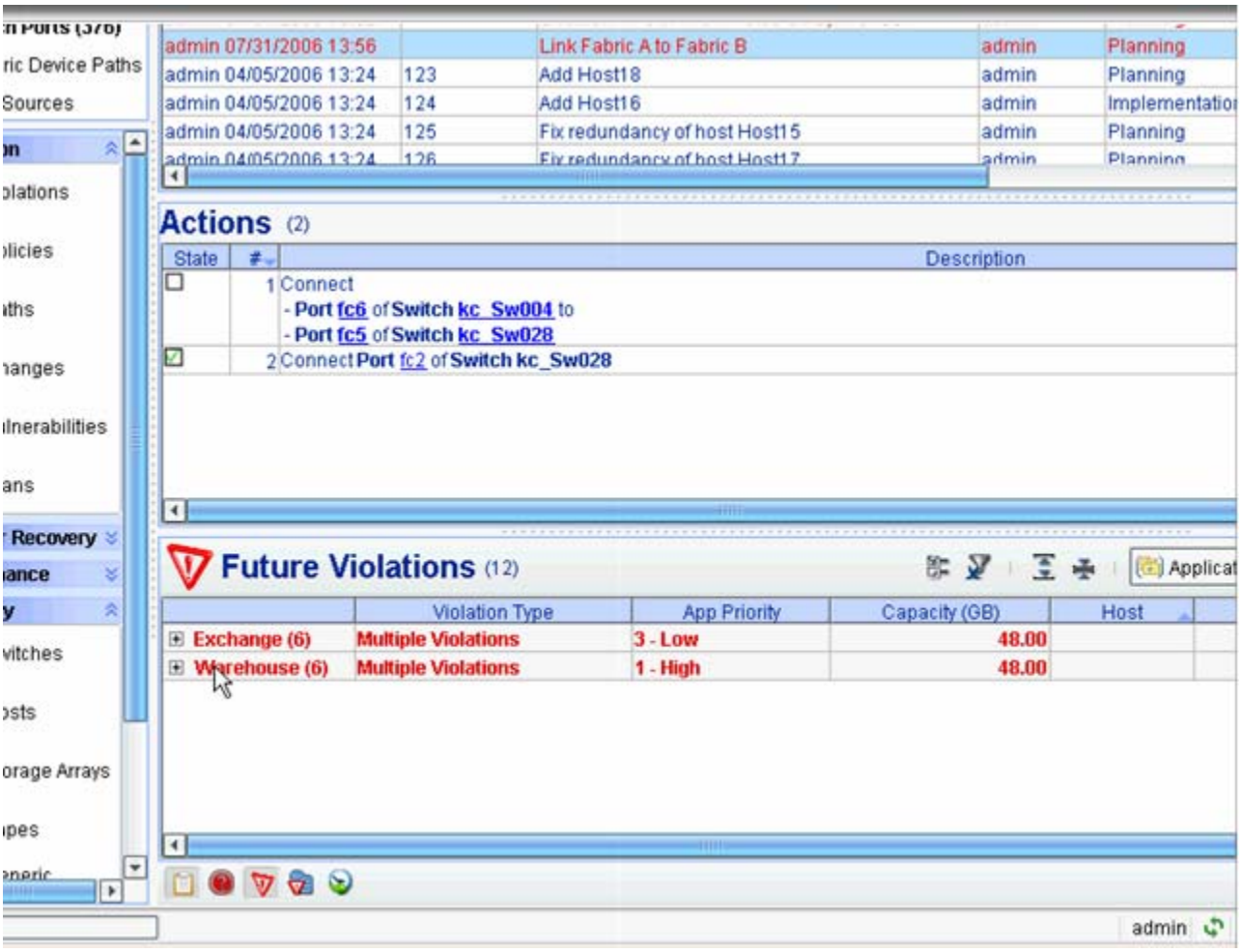
**SANscreen Service Assurance** also provides a Migration Manager function which helps the customer through one of the most disruptive configuration changes – migrating to new switches in an existing environment – because the monitoring is real time, it can be used to completely remove all policy violations related to the switch infrastructure

An example of this Migration Manager function is shown below:

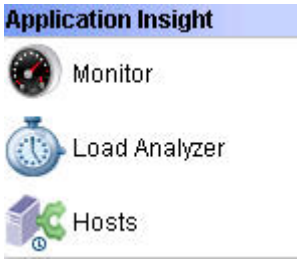
| | Impact | Migration Risk | Application |
|---|---|---|---|
| ⊟ Version Control (2) | Missing Active Host ... | Low | Version Control |
| | Switch Hop Count, Mi... | Low | Version Control |
| | Switch Hop Count, Mi... | Low | Version Control |
| ⊟ Lotus notes,Users (1) | Missing Active Host ... | Low | Lotus notes,Users |
| | Switch Hop Count, Mi... | Low | Lotus notes,Users |
| ⊟ SAP (4) | Missing Active Host ... | High | SAP |
| | | None | SAP |
| | | None | SAP |
| | Path outage | High | SAP |
| | Switch Hop Count, Mi... | Low | SAP |

**SANscreen Service Assurance** also provides customers with a “What If” functionality letting them build an ITIL Configuration Plan that they can use as a task list and also verify in advance using a simulation capability that the change will or won’t cause any system problems or break any installation rules.

An example of this screen is shown below where the simulation is showing that the proposed changes will cause future violations – this will let the change team step their way through the task list to complete the migration and remove all violations safely:



# SANscreen® Application Insight




This product tries to manage the application SLR (Service Level Requirements) by analyzing the storage tier assignments, load balancing across the storage infrastructure, and detecting infrastructure-related issues that would impact application performance and the fulfillment of the associated SLRs.

It lets the user monitor the existing traffic load in order to adjust the storage tier assignments. Sometimes applications are assigned a Tier 1 layer of storage when their actual traffic patterns indicate that the tier assignment was overkill.

The **SANscreen Application Insight** module uses a concept of “SAN access path” as the connection between the host application and its data on a storage device. The “access path” includes a set of logical and physical components necessary for the transfer of data from the host application to the storage device.

The **SANscreen Application Insight** module collects real time performance information for all components in the “access path” and ties this performance data to the host application. It keeps the raw data for seven (7) days and up to a year of it in histogram form. It keeps information for all host HBA ports, switch ports, and storage ports in the form of MBs transferred.

Having this information along with the entire SAN topology, the **SANscreen Application Insight** can show the actual load through all of the access paths in the SAN infrastructure. This helps the administrator identify both heavy and light loads in the infrastructure, including “access paths” with no loads.

The current list of switches supported are Cisco, Brocade, McData, and Qlogic.

In the rest of this section, we will walk through a typical analysis using the **SANscreen Application Insight** module in some example SAN environments.

The Onaro® development team is improving their code to support iSCSI blocks, and CIFS/NFS shares for Network Appliance devices. When this code is ready to GA, it will be added to this document.

Below is an example report showing the load for each host application as a percent on the SAN infrastructure:

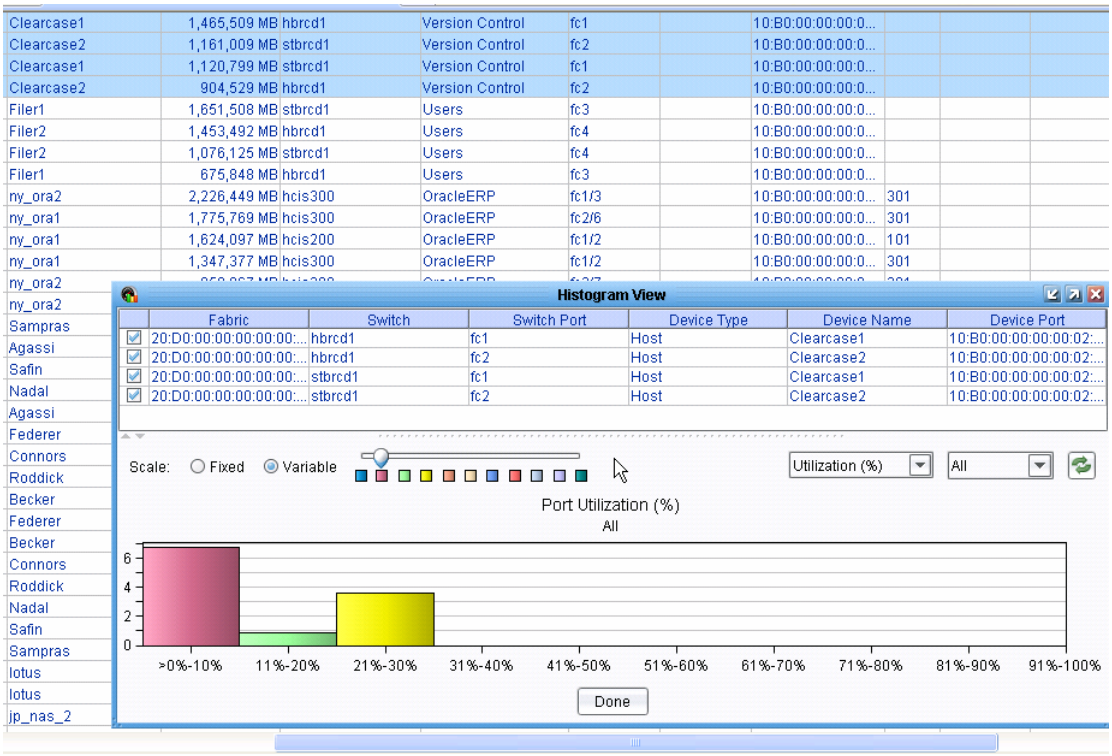
**Load Analyzer** (146) *Traffic Las...*

| | Value | Distribution |
|---|---|---|
| Host (74) | 100,646,579 MB | 50.0% |
| HP1_bm (1) | 0 MB | 0.0% |
| Linx_dev1 (1) | 0 MB | 0.0% |
| Linx_dev2 (1) | 0 MB | 0.0% |
| Becker (2) | 504,431 MB | 0.5% |
| kc_exchdr004 (1) | 1,437,630 MB | 1.4% |
| jp_nas_1 (2) | 1,678,729 MB | 1.7% |
| Federer (2) | 1,685,988 MB | 1.7% |
| Nas2Backup (2) | 1,720,943 MB | 1.7% |
| Roddick (2) | 1,800,382 MB | 1.8% |
| nj_exch002 (2) | 1,846,621 MB | 1.8% |
| lotus (2) | 1,949,944 MB | 1.9% |
| Connors (2) | 2,052,883 MB | 2.0% |
| nj_ora4_bld (2) | 2,093,613 MB | 2.1% |
| Nas1Backup (2) | 2,197,975 MB | 2.2% |
| kc_oradev7 (2) | 2,343,882 MB | 2.3% |
| kc_exchdr003 (2) | 2,443,041 MB | 2.4% |
| Nadal (2) | 2,495,446 MB | 2.5% |
| Safin (2) | 2,648,006 MB | 2.6% |
| my_prtTest1 (2) | 2,812,868 MB | 2.8% |
| Nas1test (2) | 2,968,687 MB | 2.9% |
| jp_nas_2 (4) | 2,973,315 MB | 3.0% |
| csNAS3 (2) | 3,006,899 MB | 3.0% |
| csNAS2 (2) | 3,012,075 MB | 3.0% |
| Clearcase1 (2) | 3,072,392 MB | 3.1% |
| Clearcase2 (2) | 3,242,791 MB | 3.2% |
| nj_sap17 (2) | 3,292,636 MB | 3.3% |
| my_ora2 (3) | 3,448,913 MB | 3.4% |
| Filer1 (2) | 3,480,280 MB | 3.5% |
| my_ora1 (3) | 3,543,485 MB | 3.5% |
| my_exch2 (3) | 3,641,656 MB | 3.6% |
| Filer2 (2) | 4,222,711 MB | 4.2% |

This same report can be used to identify idle and potentially “orphan” servers – see the screen shot below:

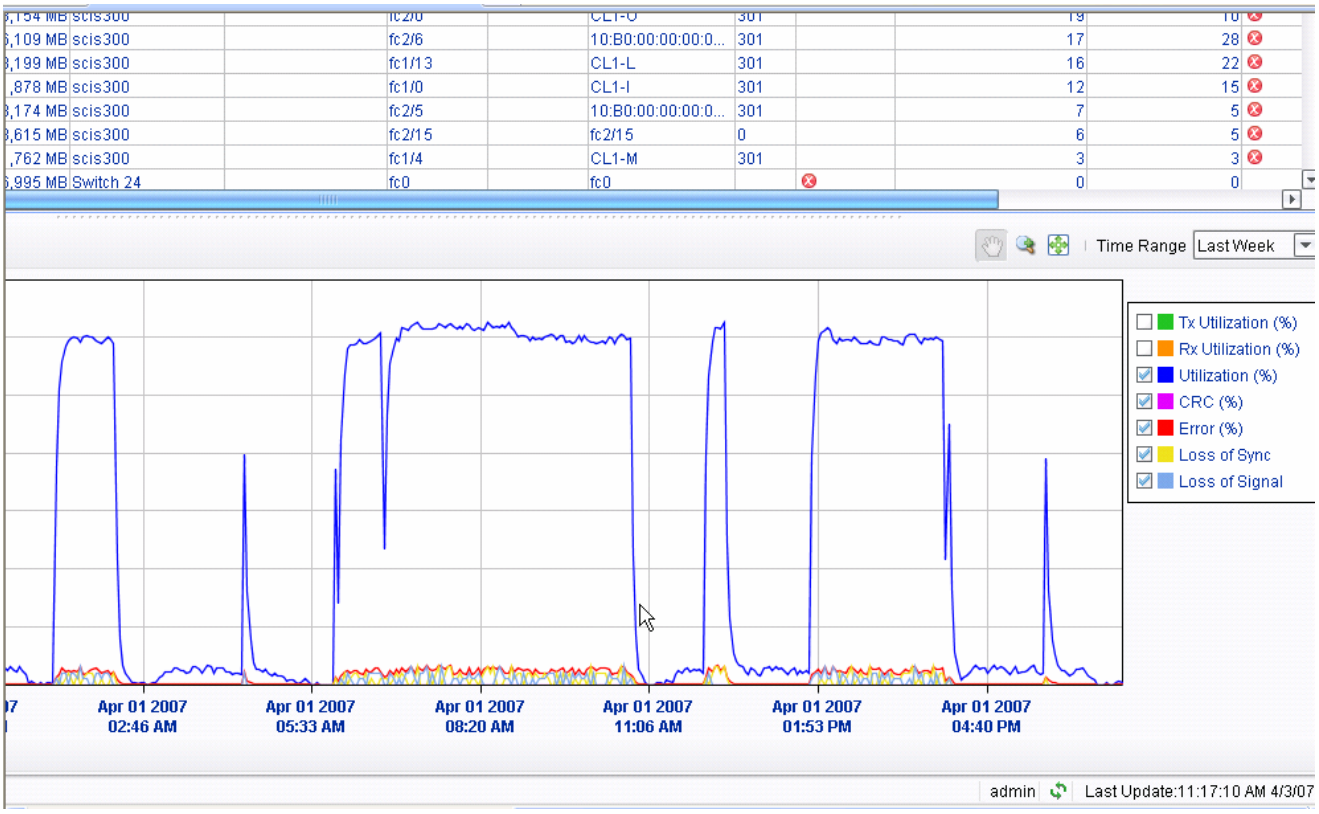
| | | |
|---|---|---|
| ⊟ Host (74) | 100,646,579 MB | 50.0% |
| ⊞ HP1_bm (1) | 0 MB | 0.0% |
| ⊞ Linx_dev1 (1) | 0 MB | 0.0% |
| ⊞ Linx_dev2 (1) | 0 MB | 0.0% |
| ⊞ Becker (2) | 504,431 MB | 0.5% |
| ⊞ kc_exchdr004 (1) | 1,437,630 MB | 1.4% |
| ⊞ jp_nas_1 (2) | 1,678,729 MB | 1.7% |
| ⊞ Federer (2) | 1,685,988 MB | 1.7% |

The **SANscreen Application Insight** module collects port performance information across all SAN ports for long periods of time. We can select a host application and focus in on its port utilization statistics over time as seen in the screen shot below:



This gives us an historical perspective on the load and typical port utilization over significant periods of time. **SANscreen Application Insight** also keeps track of the transmit (**Tx**) and receive (**Rx**) utilization breakdown plus common network errors such as **CRC** (Cyclic Redundancy Check) errors, loss of synchronization errors, loss of signal errors, etc.

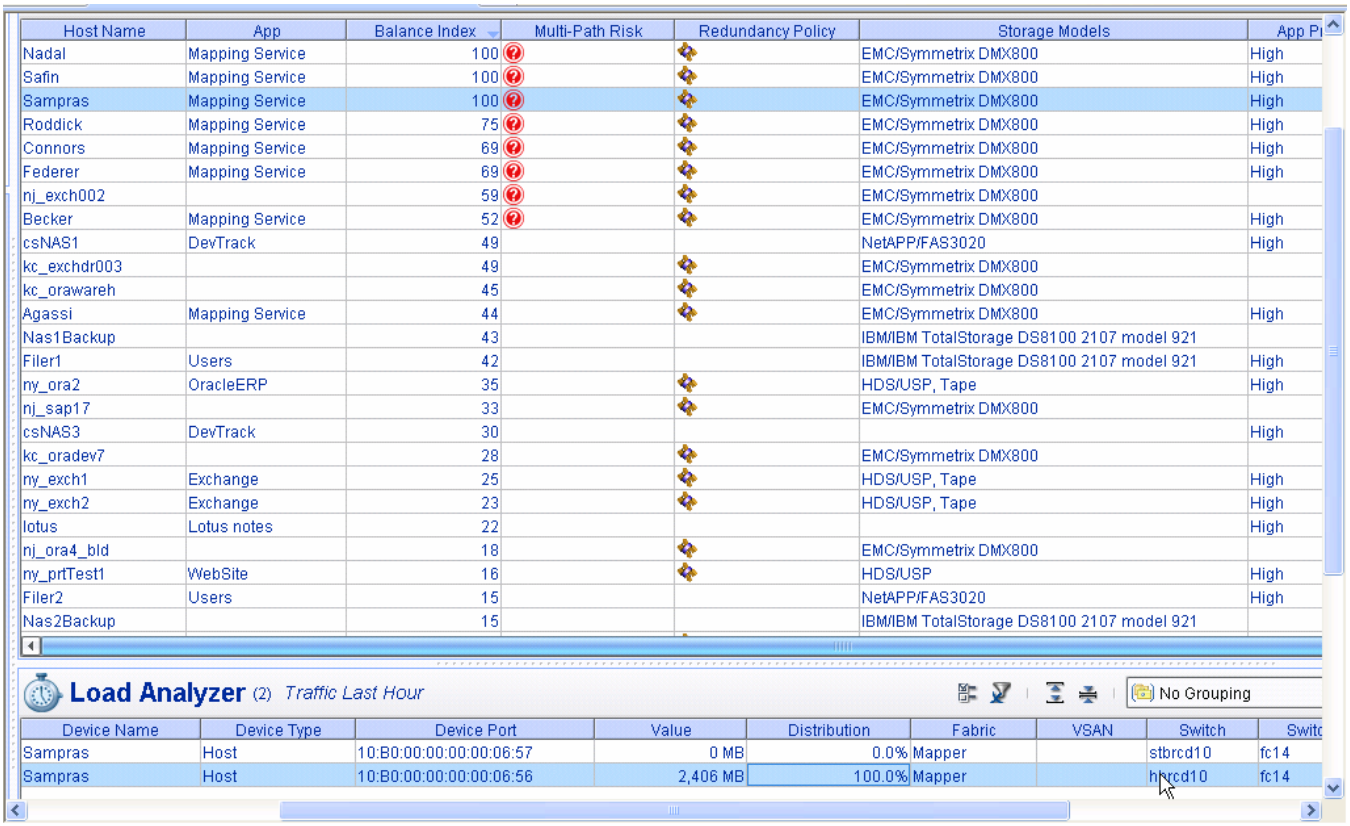
In the screen shot below, we can contrast these errors against the port utilization statistics to look for significant percents of errors that make impact application performance and throughput:




If we go back to the host application level, there is another useful area of analysis that can be done for the verification of multi-path working correctly. In the next example, we will find hosts that potentially have multi-path problems. The first step is to click on the “Multi-path Risk” column to identify all hosts that may be at risk. We can then filter out all non-EMC arrays to leave all of those EMC arrays that support active-active configurations. This leaves us with the host applications that feed into a Symmetrix array that requires multi-pathing to be operational.

We can first filter on only those Symmetrix arrays that require multi-pathing. The **SANscreen Application Insight** will create a balance index that indicates the split of traffic that it is actually seeing over the paths. We can then select the balance column to bring the highest balance percents to the top.

If we select an application with a balance percent of 100, we can see below in the Load Analyzer that 100% of the MB transferred is going through one switch and zero percent of the load is going through the second switch, indicating we have a severe multi-path violation:



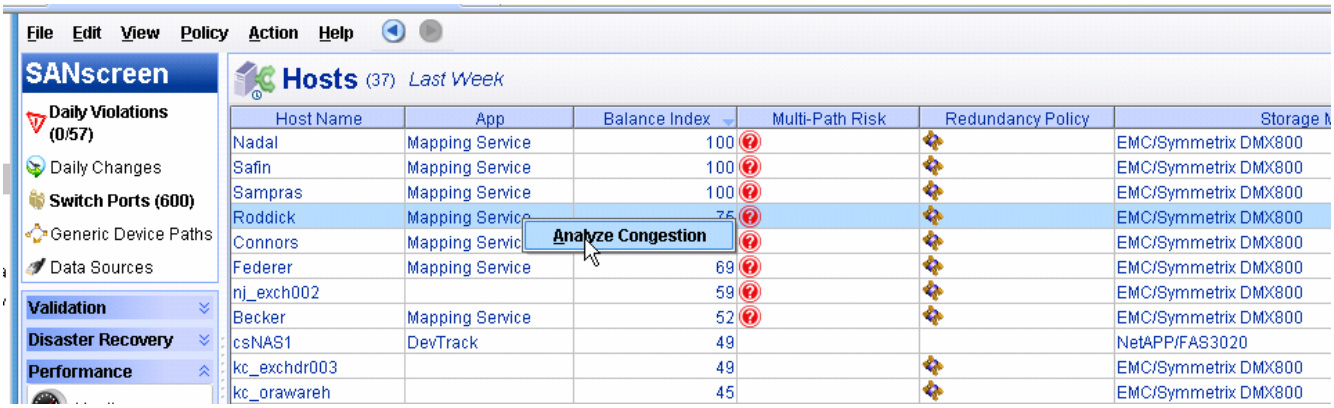
| Host Name | App | Balance Index | Multi-Path Risk | Redundancy Policy | Storage Models | App Pr |
|---|---|---|---|---|---|---|
| Nadal | Mapping Service | 100 | | | EMC/Symmetrix DMX800 | High |
| Safin | Mapping Service | 100 | | | EMC/Symmetrix DMX800 | High |
| Sampras | Mapping Service | 100 | | | EMC/Symmetrix DMX800 | High |
| Roddick | Mapping Service | 75 | | | EMC/Symmetrix DMX800 | High |
| Connors | Mapping Service | 69 | | | EMC/Symmetrix DMX800 | High |
| Federer | Mapping Service | 69 | | | EMC/Symmetrix DMX800 | High |
| nj_exch002 | | 59 | | | EMC/Symmetrix DMX800 | |
| Becker | Mapping Service | 52 | | | EMC/Symmetrix DMX800 | High |
| csNAS1 | DevTrack | 49 | | | NetAPP/FAS3020 | High |
| kc_exchdr003 | | 49 | | | EMC/Symmetrix DMX800 | |
| kc_orawareh | | 45 | | | EMC/Symmetrix DMX800 | |
| Agassi | Mapping Service | 44 | | | EMC/Symmetrix DMX800 | High |
| Nas1Backup | | 43 | | | IBM/IBM TotalStorage DS8100 2107 model 921 | |
| Filer1 | Users | 42 | | | IBM/IBM TotalStorage DS8100 2107 model 921 | High |
| ny_ora2 | OracleERP | 35 | | | HDS/USP, Tape | High |
| nj_sap17 | | 33 | | | EMC/Symmetrix DMX800 | |
| csNAS3 | DevTrack | 30 | | | | High |
| kc_oradev7 | | 28 | | | EMC/Symmetrix DMX800 | |
| ny_exch1 | Exchange | 25 | | | HDS/USP, Tape | High |
| ny_exch2 | Exchange | 23 | | | HDS/USP, Tape | High |
| lotus | Lotus notes | 22 | | | | High |
| nj_ora4_bld | | 18 | | | EMC/Symmetrix DMX800 | |
| ny_prtTest1 | WebSite | 16 | | | HDS/USP | High |
| Filer2 | Users | 15 | | | NetAPP/FAS3020 | High |
| Nas2Backup | | 15 | | | IBM/IBM TotalStorage DS8100 2107 model 921 | |

Load Analyzer (2) *Traffic Last Hour*

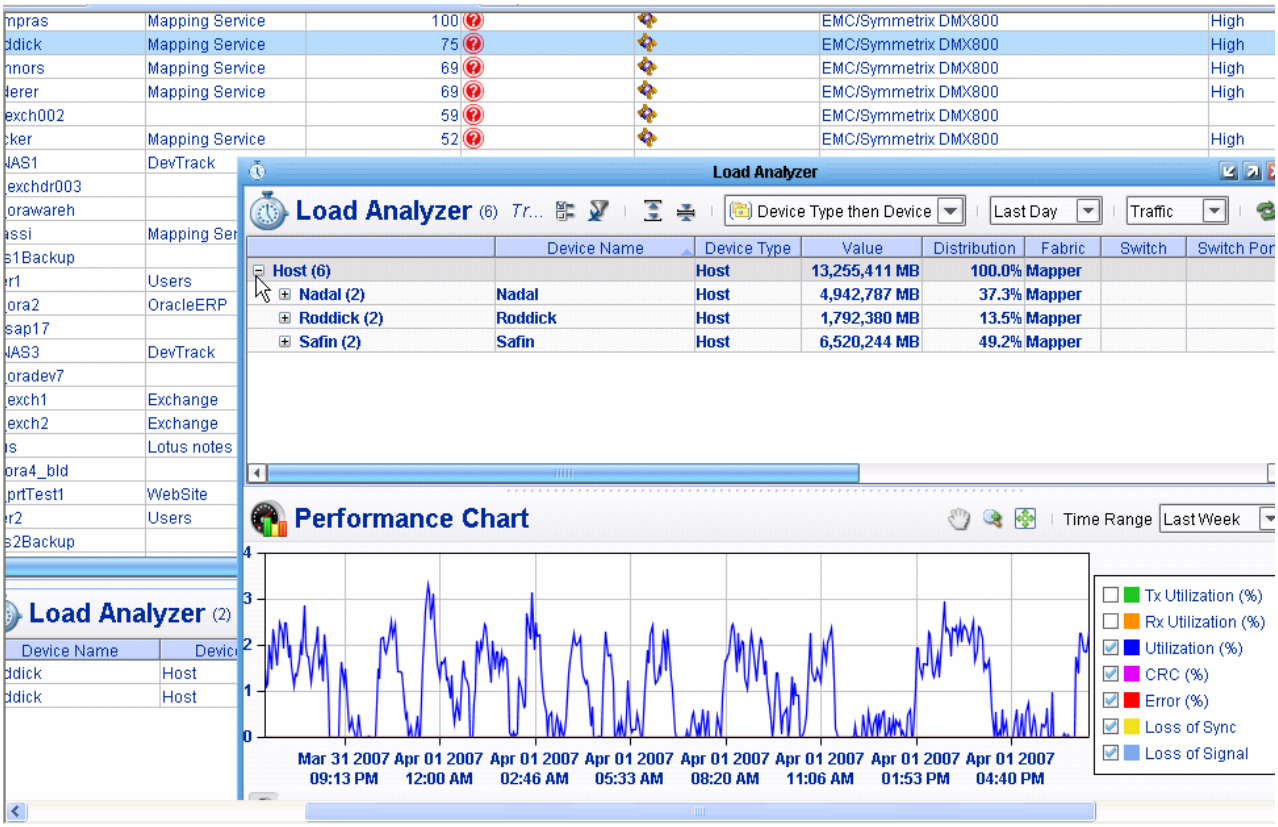
No Grouping

| Device Name | Device Type | Device Port | Value | Distribution | Fabric | VSAN | Switch | Switc |
|---|---|---|---|---|---|---|---|---|
| Sampras | Host | 10:B0:00:00:00:00:06:57 | 0 MB | 0.0% | Mapper | | stbrcd10 | fc14 |
| Sampras | Host | 10:B0:00:00:00:00:06:56 | 2,406 MB | 100.0% | Mapper | | hbrcd10 | fc14 |

From this same screen we can also analyze any “host congestion” problems (hosts that are dominating the traffic at switch ports causing application problems on other hosts sharing that same switch port.
To look for “host congestion”, right-click on the host above and select **Analyze Congestion** to see all of the hosts competing for that same storage port.



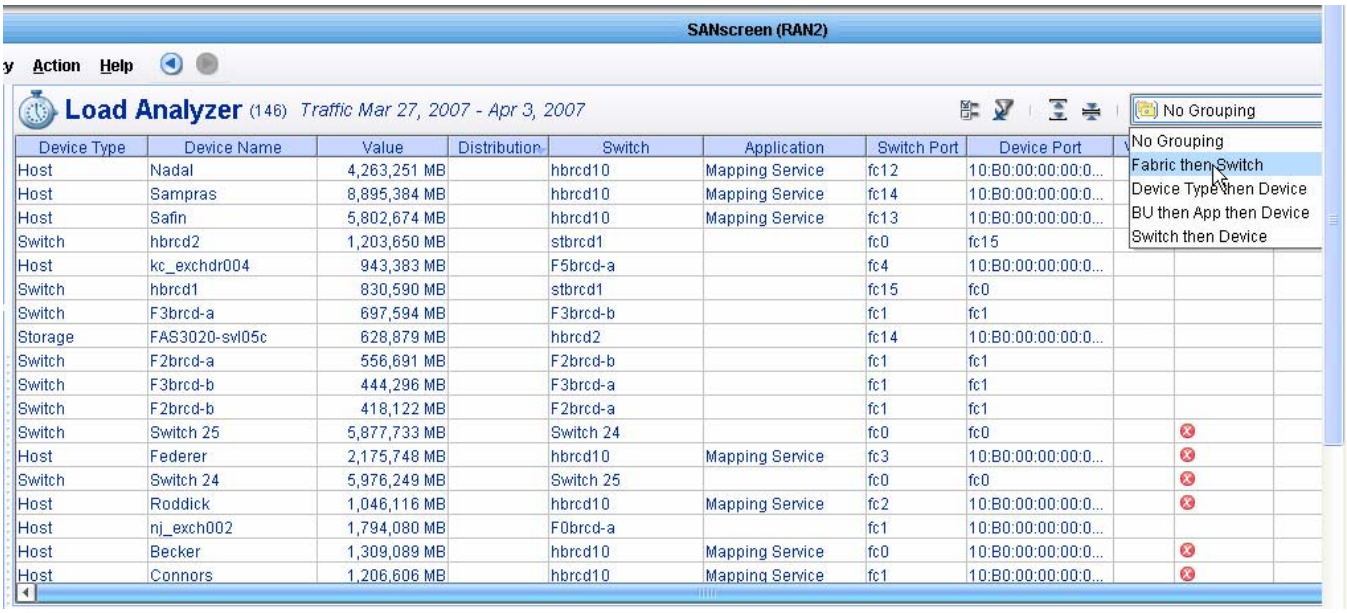

In the screen shot below, we see the breakdown of the port utilization over time and total MB transferred percent for each host sharing that SAN switch port:



This provides great input into choosing the ideal location for storage provisioned to a given server. The first task in this process is the storage selection process is the selection of the correct fabric – the screen shot below shows an example of this report:

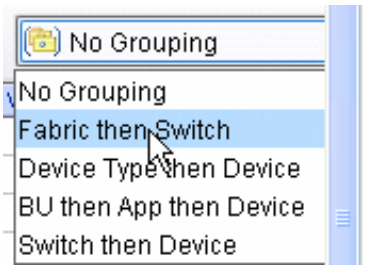
| | Value | Distribution |
|---|---|---|
| Development (29) | 44,262,234 MB | 22.0% |
| VSAN0301 (32) | 40,138,565 MB | 19.9% |
| VSAN0101 (24) | 28,703,615 MB | 14.3% |
| Mapper (16) | 26,808,632 MB | 13.3% |
| 20:D0:00:00:00:00:00:23 (4) | 17,314,203 MB | 8.6% |
| (8) | 11,116,283 MB | 5.5% |
| 20:D0:00:00:00:00:00:20 (5) | 7,856,307 MB | 3.9% |
| 20:D0:00:00:00:00:00:19 (6) | 6,729,439 MB | 3.3% |
| 20:D0:00:00:00:00:00:14 (4) | 5,501,138 MB | 2.7% |
| 20:D0:00:00:00:00:00:17 (4) | 4,806,492 MB | 2.4% |
| 20:D0:00:00:00:00:00:15 (4) | 4,432,282 MB | 2.2% |
| 20:D0:00:00:00:00:00:13 (4) | 3,636,500 MB | 1.8% |
| 20:D0:00:00:00:00:00:25 (2) | 0 MB | 0.0% |
| 20:D0:00:00:00:00:00:27 (2) | 0 MB | 0.0% |
| 20:D0:00:00:00:00:00:29 (2) | 0 MB | 0.0% |

The **Load Analyzer** function is one of the most powerful tools in the **SANscreen Application Insight** because it lets you look at the entire storage network for problems, load balancing, improved resource utilization, and better capacity planning. In the screen shot below, it shows the utilization for all resources.

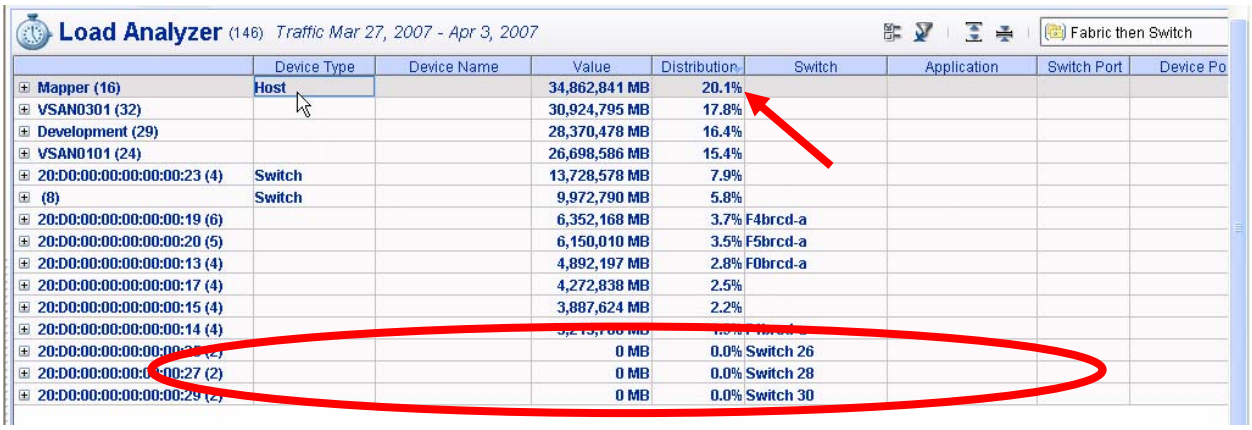



| Device Type | Device Name | Value | Distribution | Switch | Application | Switch Port | Device Port |
|---|---|---|---|---|---|---|---|
| Host | Nadal | 4,263,251 MB | | hbrcd10 | Mapping Service | fc12 | 10:B0:00:00:00:0... |
| Host | Sampras | 8,895,384 MB | | hbrcd10 | Mapping Service | fc14 | 10:B0:00:00:00:0... |
| Host | Safin | 5,802,674 MB | | hbrcd10 | Mapping Service | fc13 | 10:B0:00:00:00:0... |
| Switch | hbrcd2 | 1,203,650 MB | | stbrcd1 | | fc0 | fc15 |
| Host | kc_exchdr004 | 943,383 MB | | F5brcd-a | | fc4 | 10:B0:00:00:00:0... |
| Switch | hbrcd1 | 830,590 MB | | stbrcd1 | | fc15 | fc0 |
| Switch | F3brcd-a | 697,594 MB | | F3brcd-b | | fc1 | fc1 |
| Storage | FAS3020-svl05c | 628,879 MB | | hbrcd2 | | fc14 | 10:B0:00:00:00:0... |
| Switch | F2brcd-a | 556,691 MB | | F2brcd-b | | fc1 | fc1 |
| Switch | F3brcd-b | 444,296 MB | | F3brcd-a | | fc1 | fc1 |
| Switch | F2brcd-b | 418,122 MB | | F2brcd-a | | fc1 | fc1 |
| Switch | Switch 25 | 5,877,733 MB | | Switch 24 | | fc0 | fc0 |
| Host | Federer | 2,175,748 MB | | hbrcd10 | Mapping Service | fc3 | 10:B0:00:00:00:0... |
| Switch | Switch 24 | 5,976,249 MB | | Switch 25 | | fc0 | fc0 |
| Host | Roddick | 1,046,116 MB | | hbrcd10 | Mapping Service | fc2 | 10:B0:00:00:00:0... |
| Host | nj_exch002 | 1,794,080 MB | | F0brcd-a | | fc1 | 10:B0:00:00:00:0... |
| Host | Becker | 1,309,089 MB | | hbrcd10 | Mapping Service | fc0 | 10:B0:00:00:00:0... |
| Host | Connors | 1,206,606 MB | | hbrcd10 | Mapping Service | fc1 | 10:B0:00:00:00:0... |

Notice the box in the upper right was set for **No Grouping**. If we open up the list box as shown below, we can change the focus to fabrics, device types, business unit-application or switches:

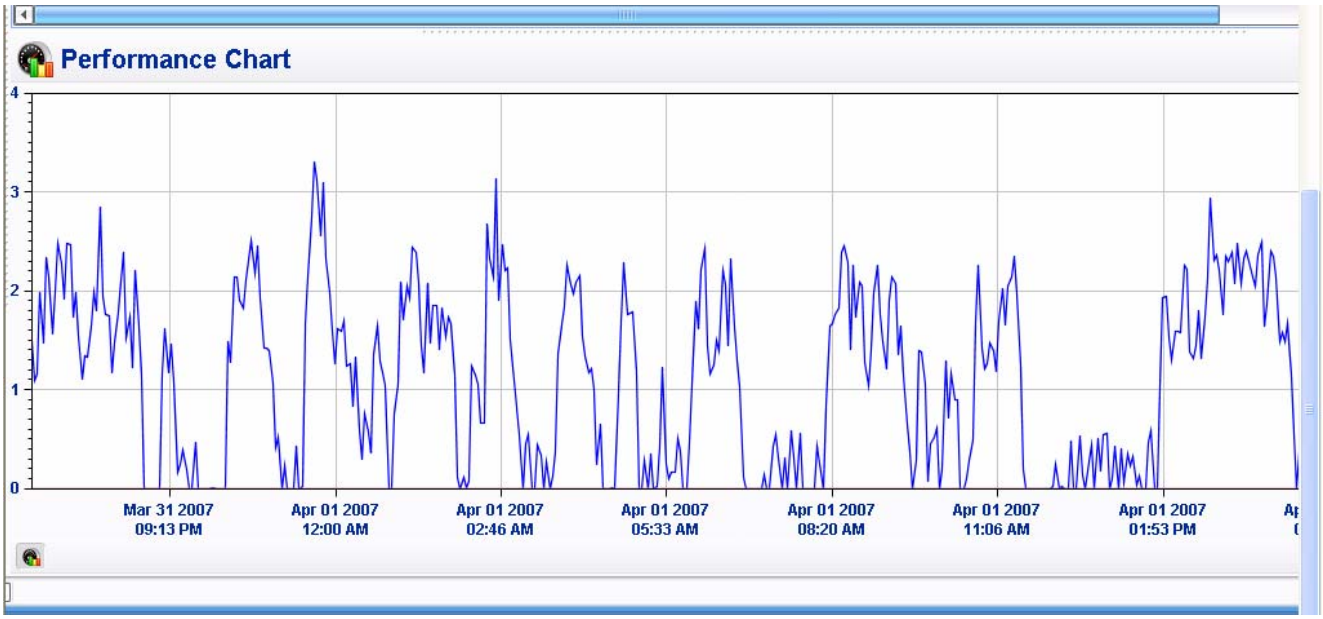



Let's take a look at the **Fabric then Switch** display:

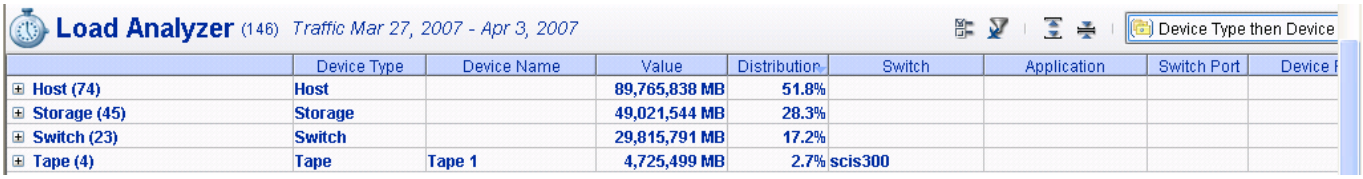



| | Device Type | Device Name | Value | Distribution | Switch | Application | Switch Port | Device Po |
|---|---|---|---|---|---|---|---|---|
| Mapper (16) | Host | | 34,862,841 MB | 20.1% | | | | |
| VSAN0301 (32) | | | 30,924,795 MB | 17.8% | | | | |
| Development (29) | | | 28,370,478 MB | 16.4% | | | | |
| VSAN0101 (24) | | | 26,698,586 MB | 15.4% | | | | |
| 20:D0:00:00:00:00:00:23 (4) | Switch | | 13,728,578 MB | 7.9% | | | | |
| (8) | Switch | | 9,972,790 MB | 5.8% | | | | |
| 20:D0:00:00:00:00:00:19 (6) | | | 6,352,168 MB | 3.7% | F4brcd-a | | | |
| 20:D0:00:00:00:00:00:20 (5) | | | 6,150,010 MB | 3.5% | F5brcd-a | | | |
| 20:D0:00:00:00:00:00:13 (4) | | | 4,892,197 MB | 2.8% | F0brcd-a | | | |
| 20:D0:00:00:00:00:00:17 (4) | | | 4,272,838 MB | 2.5% | | | | |
| 20:D0:00:00:00:00:00:15 (4) | | | 3,887,624 MB | 2.2% | | | | |
| 20:D0:00:00:00:00:00:14 (4) | | | [illegible] | [illegible] | [illegible] | | | |
| 20:D0:00:00:00:00:00:[illegible] (2) | | | 0 MB | 0.0% | Switch 26 | | | |
| 20:D0:00:00:00:00:00:27 (2) | | | 0 MB | 0.0% | Switch 28 | | | |
| 20:D0:00:00:00:00:00:29 (2) | | | 0 MB | 0.0% | Switch 30 | | | |

Not only can we find the fabrics that are totally unused but if we click on the busiest fabric, we can see the traffic distribution over time. Both of these views help us to do better load balancing to achieve better utilization in the storage network.

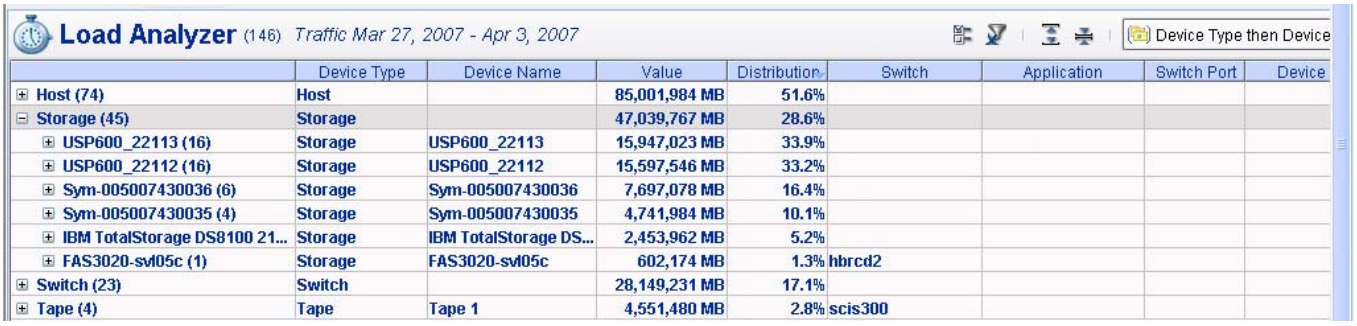



If we change the grouping to **Device Type then Device**, we see the following screen shot:



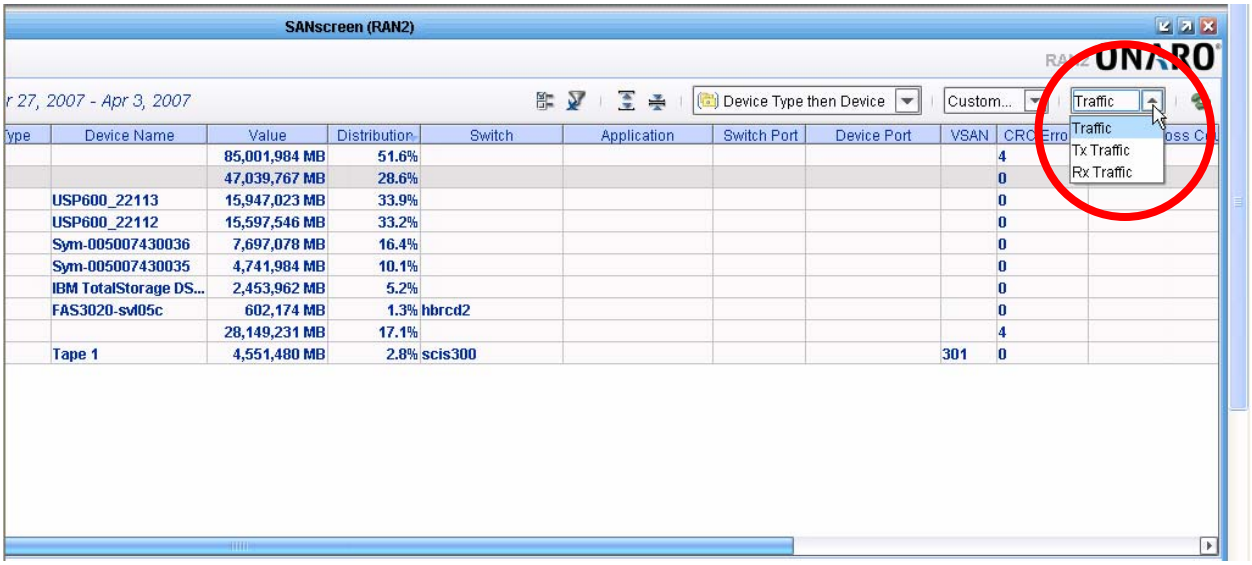

| | Device Type | Device Name | Value | Distribution | Switch | Application | Switch Port | Device I |
|---|---|---|---|---|---|---|---|---|
| Host (74) | Host | | 89,765,838 MB | 51.8% | | | | |
| Storage (45) | Storage | | 49,021,544 MB | 28.3% | | | | |
| Switch (23) | Switch | | 29,815,791 MB | 17.2% | | | | |
| Tape (4) | Tape | Tape 1 | 4,725,499 MB | 2.7% | scis300 | | | |

We can open up the "+" to see the high to low utilization for all devices in that group. In the screen shot below, we have clicked on the "+" to open it up to all of the storage arrays. These will be listed from high to low in terms of traffic utilization.




| | Device Type | Device Name | Value | Distribution | Switch | Application | Switch Port | Device |
|---|---|---|---|---|---|---|---|---|
| Host (74) | Host | | 85,001,984 MB | 51.6% | | | | |
| Storage (45) | Storage | | 47,039,767 MB | 28.6% | | | | |
| USP600_22113 (16) | Storage | USP600_22113 | 15,947,023 MB | 33.9% | | | | |
| USP600_22112 (16) | Storage | USP600_22112 | 15,597,546 MB | 33.2% | | | | |
| Sym-005007430036 (6) | Storage | Sym-005007430036 | 7,697,078 MB | 16.4% | | | | |
| Sym-005007430035 (4) | Storage | Sym-005007430035 | 4,741,984 MB | 10.1% | | | | |
| IBM TotalStorage DS8100 21... | Storage | IBM TotalStorage DS... | 2,453,962 MB | 5.2% | | | | |
| FAS3020-svl05c (1) | Storage | FAS3020-svl05c | 602,174 MB | 1.3% | hbrcd2 | | | |
| Switch (23) | Switch | | 28,149,231 MB | 17.1% | | | | |
| Tape (4) | Tape | Tape 1 | 4,551,480 MB | 2.8% | scis300 | | | |

Not only can we see the total traffic utilization, but we can find the arrays with the most read or write traffic by clicking on the proper control shown below:

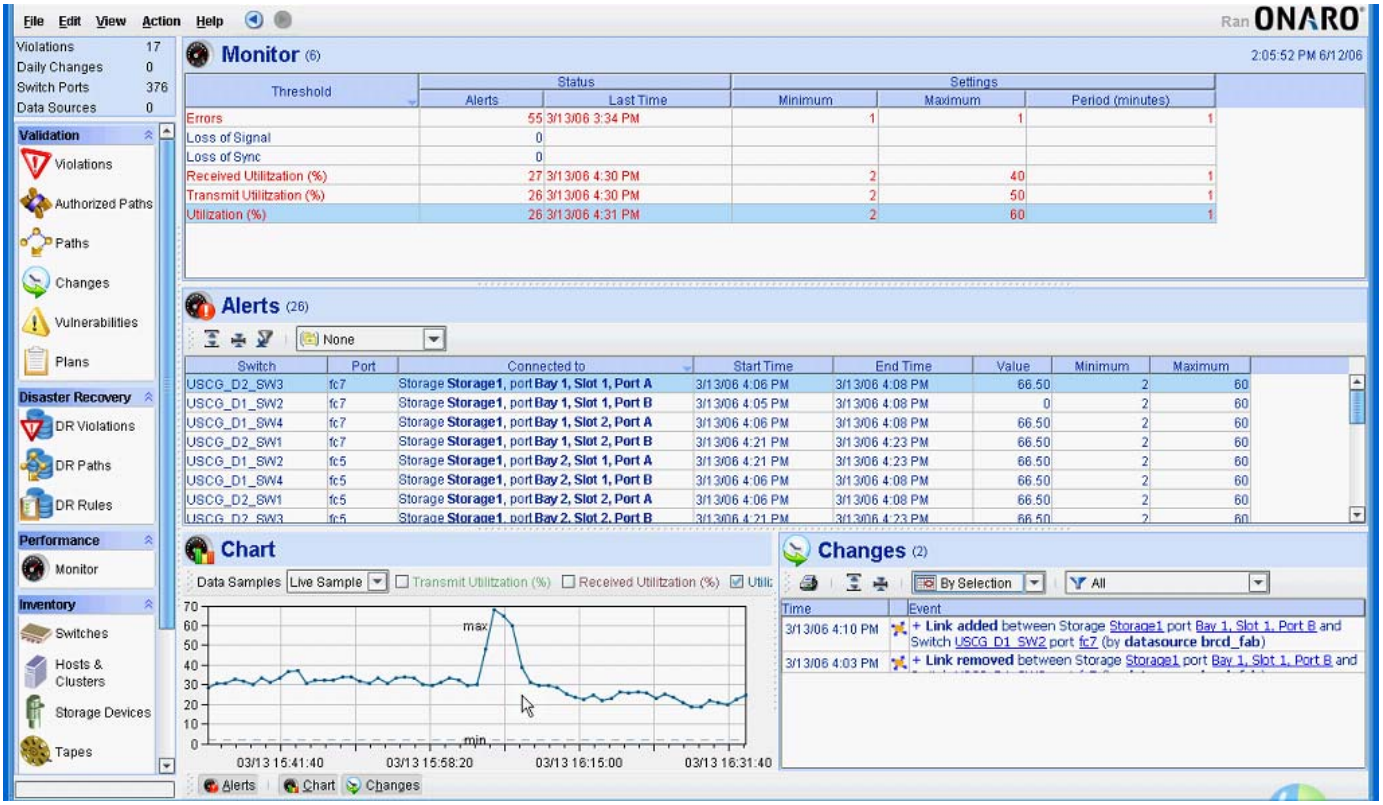



| Device Name | Value | Distribution | Switch | Application | Switch Port | Device Port | VSAN | CRC Erro | Loss C |
|---|---|---|---|---|---|---|---|---|---|
| | 85,001,984 MB | 51.6% | | | | | | 4 | |
| | 47,039,767 MB | 28.6% | | | | | | 0 | |
| USP600_22113 | 15,947,023 MB | 33.9% | | | | | | 0 | |
| USP600_22112 | 15,597,546 MB | 33.2% | | | | | | 0 | |
| Sym-005007430036 | 7,697,078 MB | 16.4% | | | | | | 0 | |
| Sym-005007430035 | 4,741,984 MB | 10.1% | | | | | | 0 | |
| IBM TotalStorage DS... | 2,453,962 MB | 5.2% | | | | | | 0 | |
| FAS3020-svl05c | 602,174 MB | 1.3% | hbrcd2 | | | | | 0 | |
| | 28,149,231 MB | 17.1% | | | | | | 4 | |
| Tape 1 | 4,551,480 MB | 2.8% | scis300 | | | | 301 | 0 | |

To see the breakdown by write traffic, you would click the Tx Traffic option and click the Rx Traffic option for the traffic utilization by reads.

Using the **SANscreen Application Insight** module, the administrator can set alert conditions, which include min and max threshold values, monitoring frequency, and what is to be monitored. Not only will an alert be sent to the administrator (if he/she chooses) but these alert conditions will be monitored over time. The administrator can click on the alert condition to see the recent history and then chart it over time.

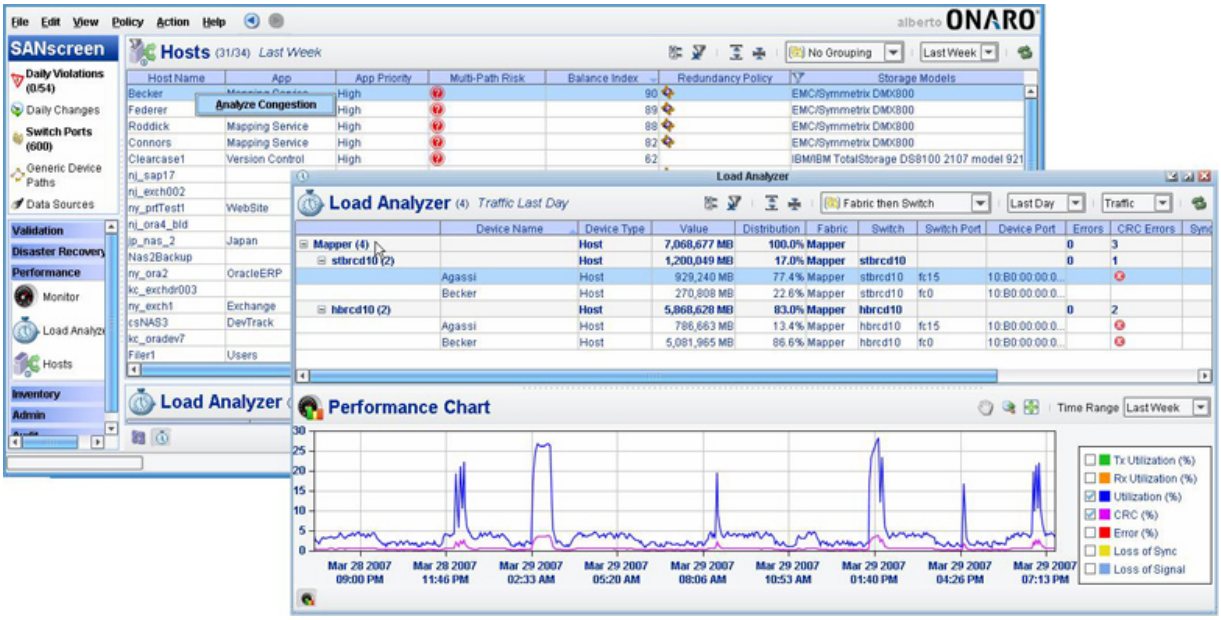
In the screen shot below, there is an alert set for storage port utilization. By clicking on the alert, we can see the list of events where the threshold was exceeded and we can chart that particular storage port to see the period of time where it spiked. Because all changes are logged, we can view the change log and determine that the link was removed for another port on that array, thus greatly increasing the load on this port.



The **SANscreen Application Insight** module can also identify application performance issues after the provisioning has been done for existing applications that need monitoring – there are several performance impact conditions it can detect:

- Multi-path hosts that have unbalanced traffic over the redundant ports
- Congestion along the data path to the storage volumes at the switch or array port
- Unbalanced host traffic causing congestion over the switch ports
- Long term monitoring of fabric can show historical window issues and trending of congestion over time

An example of a typical application performance analysis report is shown below:

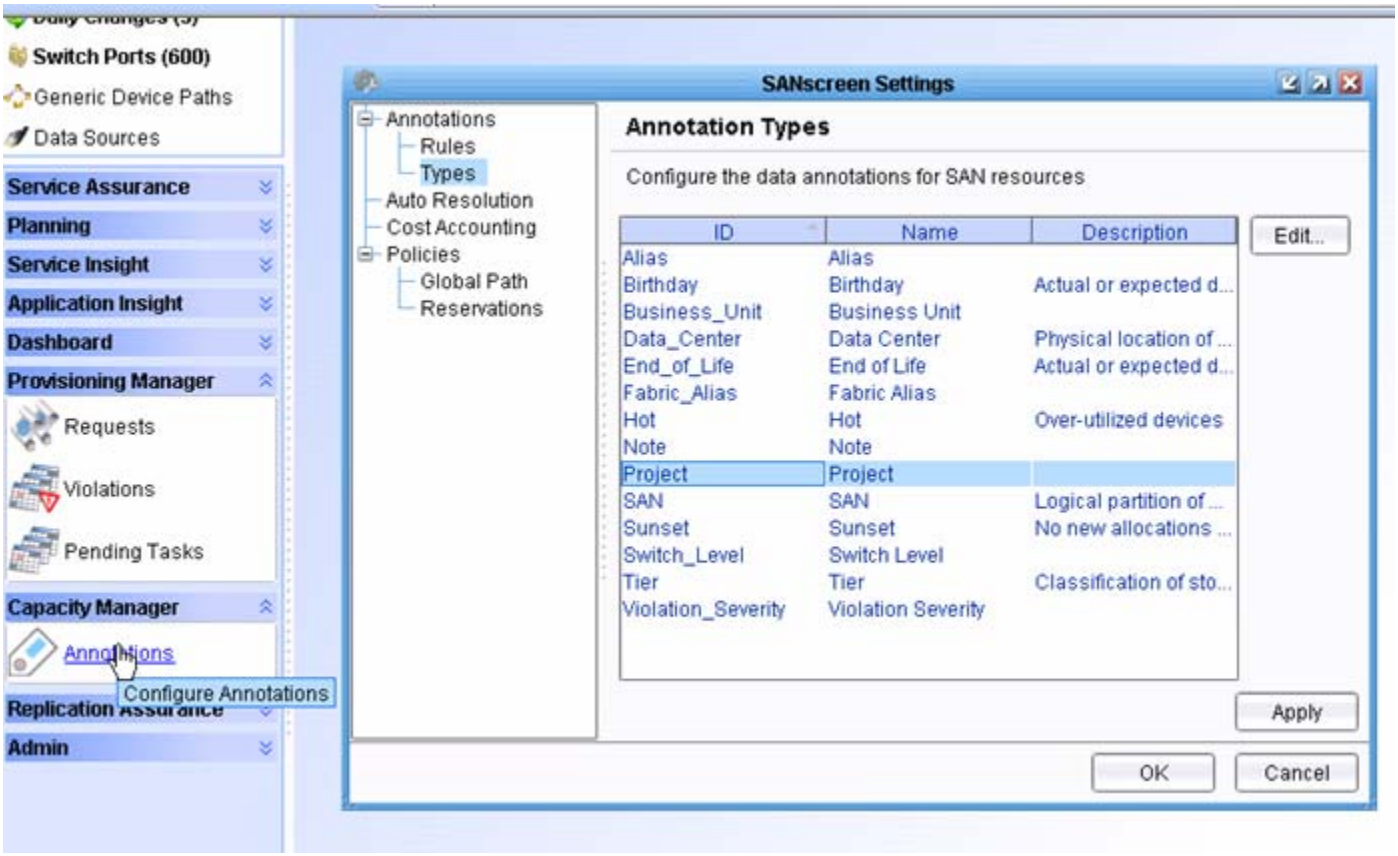



The **SANscreen Application Insight** module is a key module of the **SANscreen®** product suite for monitoring, load balancing, problem determination, capacity planning, and system utilization efficiency.

# SANscreen® Capacity Manager

The **SANscreen Capacity Manager** module will let the customer manage the storage resources by giving the ability to tag the storage with various “Annotations” that can be amalgamated into reports for storage tiers, business units, projects, and even chargeback.

The following screen shot displays the various annotations that can be tagged to the storage for reporting purposes. Typically, this is done initially and only needs to be changed as other things change (e.g., storage costs, storage tier re-assignments, business units, etc.).




The user can also change the basic annotation tags above to something more meaningful to the business needs – for example, to change the “Sunset” annotation above to “Lease Expiration”. Once the annotations are established, they can be applied to the discovered assets in order to produce reports based on annotation groupings such a geographical location, business unit, storage tier, etc. The following sections will illustrate some of the possible reports that can be generated.

In the following report, the storage utilization is reported on a storage tier basis and on a geographical basis based on the annotation tags associated with the storage:

# Storage Utilization Report

**Summary:**

| | Boston | London | Tampa |
|---|---|---|---|
| Tier 1-Gold Storage GB Available: | 0 | 7808 | 7008 |
| Tier 2-Silver Storage GB | 3888 | 176 | 736 |
| Tier 3-Bronze Storage GB Available: | 0 | 0 | 0 |
| Uncategorized Storage GB | 0 | 0 | 0 |
| Total Capacity: | 4832 | 8192 | 8320 |
| Capacity: | 960 | 224 | 464 |
| Status: | Green | Green | Green |

**Detailed Report:**

**Boston**

| Frame | Vendor | Model | Tier | # of volumes | Total Storage | Storage Allocated | Storage Available | Utilization Allocated | Status |
|---|---|---|---|---|---|---|---|---|---|
| Sym-050074300310 | EMC | Symmetrix DMX800 | | | 16 | 16 | 0 | 100.00% | Red |
| | | | Tier 1-Gold | 1 | 16 | 16 | 0 | 100.00% | Red |
| Sym-050074300311 | EMC | Symmetrix DMX800 | | | 16 | 16 | 0 | 100.00% | Red |
| | | | Tier 1-Gold | 1 | 16 | 16 | 0 | 100.00% | Red |
| USP600_22112 | HDS | USP | | | 2400 | 512 | 1888 | 21.33% | Green |
| | | | Tier 2-Silver | 150 | 2400 | 512 | 1904 | 21.33% | Green |
| USP600_22113 | HDS | USP | | | 2400 | 416 | 1984 | 17.33% | Green |
| | | | Tier 2-Silver | 150 | 2400 | 416 | 1984 | 17.33% | Green |

**London**

| Frame | Vendor | Model | Tier | # of volumes | Total Storage | Storage Allocated | Storage Available | Utilization Allocated | Status |
|---|---|---|---|---|---|---|---|---|---|
| Sym-005007430036 | EMC | Symmetrix DMX800 | | | 8000 | 176 | 7824 | 2.20% | Green |
| | | | Tier 1-Gold | 487 | 7792 | 144 | 7648 | 1.85% | Green |
| | | | Tier 2-Silver | 13 | 208 | 32 | 176 | 15.38% | Green |
| Sym-005007430037 | EMC | Symmetrix DMX800 | | | 160 | 16 | 144 | 50.00% | Yellow |
| | | | Tier 1-Gold | 10 | 160 | 16 | 160 | 10.00% | Green |
| Sym-005007430038 | EMC | Symmetrix DMX800 | | | 16 | 16 | 0 | 100.00% | Red |
| | | | Tier 1-Gold | 1 | 16 | 16 | 0 | 100.00% | Red |
| Sym-005007430039 | EMC | Symmetrix DMX800 | | | 16 | 16 | 0 | 100.00% | Red |

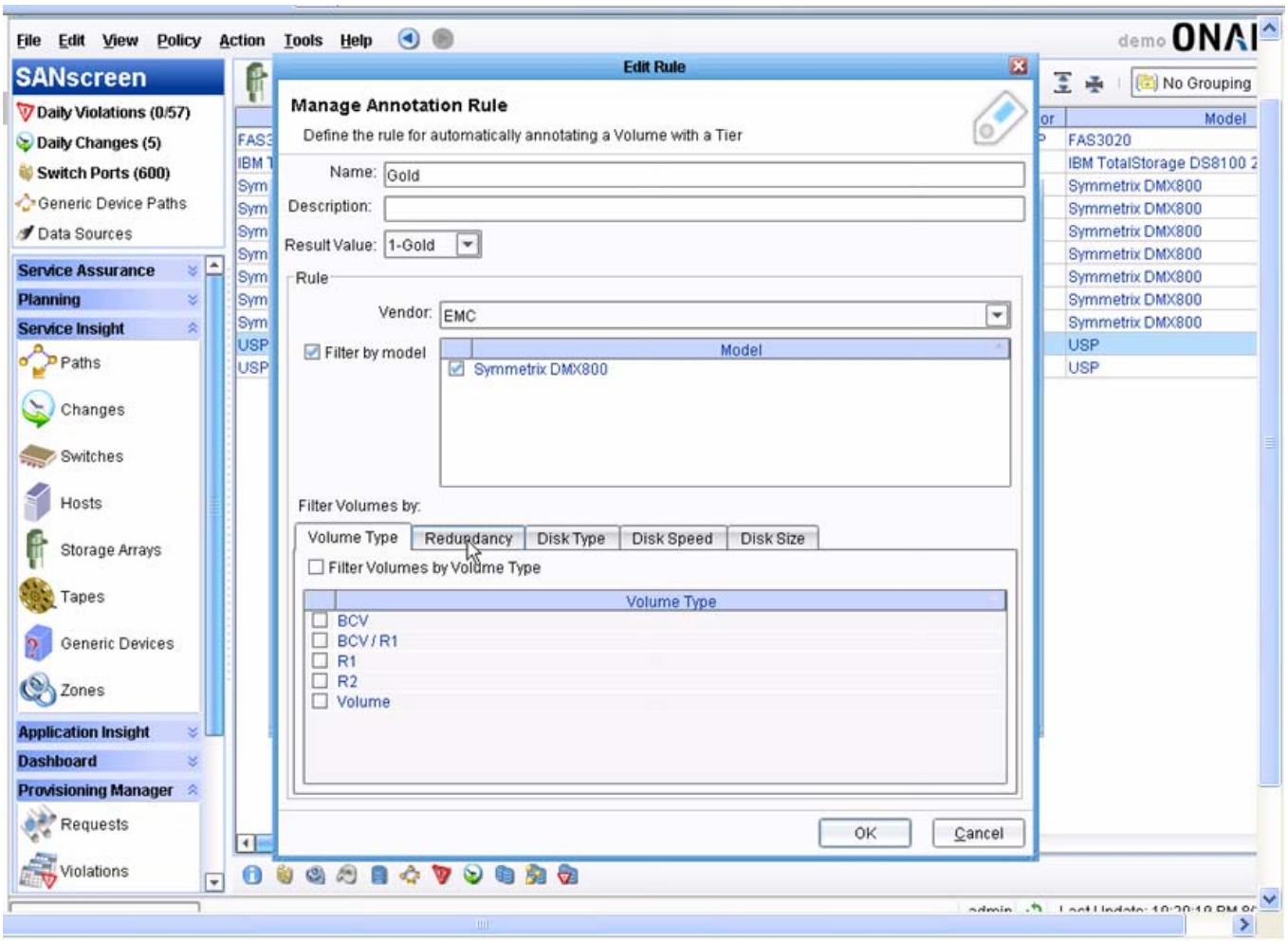
Fabric Report | Storage Report

Ready

Notice in the above report that even the geographical report has a breakdown has a sub-breakdown of the capacity utilization by tier within that geographical region. The tier levels are also broken down by the actual array in that tier so that the administrator can still manage storage at the array level as well as the tier level. Again, the tagging of resources causes the **SANscreen Capacity Manager** to preserve the meta data with the resources and be able to apply them to the various reports.

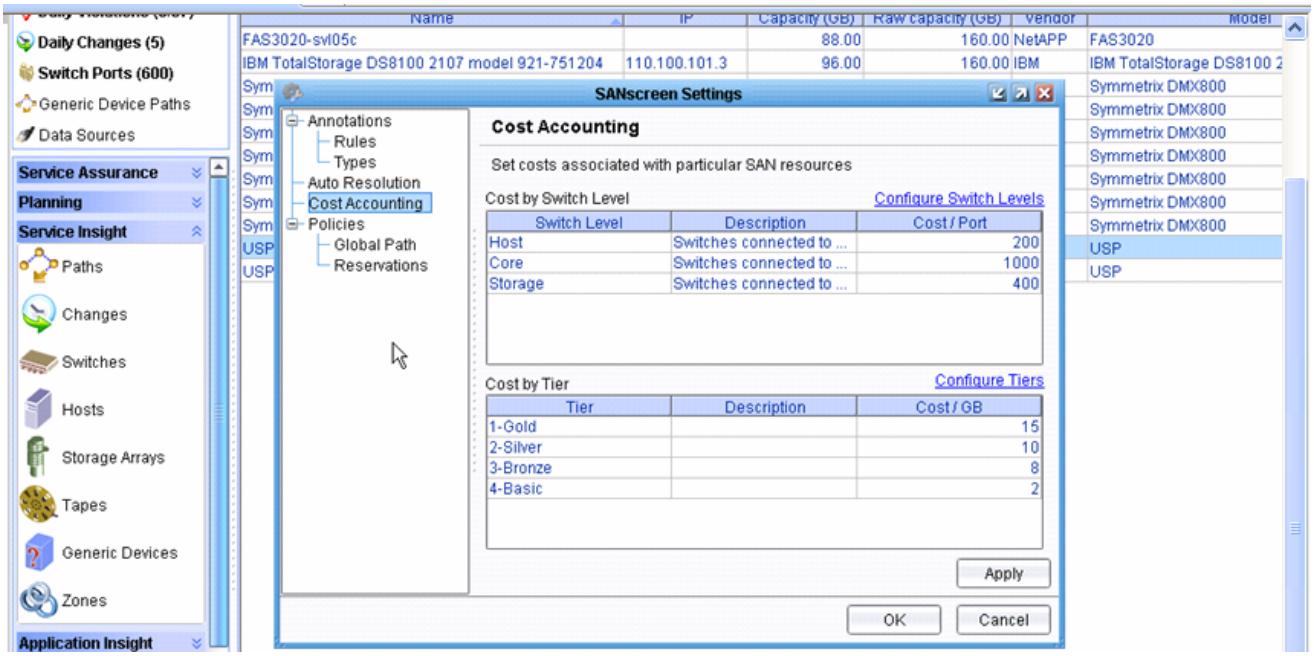
One other point in the report above, the colors of red, yellow, and green are based on user-specified threshold values which will cause the color to show up in reports and also to generate alerts that are specified by the user.

In the screen shot below, you can use **SANscreen Capacity Manager** to define storage tiers by vendor model, Volume type, volume redundancy, disk type, disk speed or disk size.




By classifying the storage tiers, it makes it easier to manage the provisioning process and the storage capacity planning process because both processes can be done on a tiered basis.

The **SANscreen Capacity Manager** also allows the user to input cost numbers for the tiers of storage and also the cost per switch port, host port, and storage port. This feature allows customers to understand the total cost of their SAN environments. However, since **SANscreen Capacity Manager** keeps track of port usage by MB transfer statistics by host application, and the amount of storage capacity for that host application, it can actually generate chargeback numbers based on real usage of the SAN capacity.




Below is an example of a possible chargeback summary that can be generated using the annotation tags and the cost numbers:

## Chargeback Summary

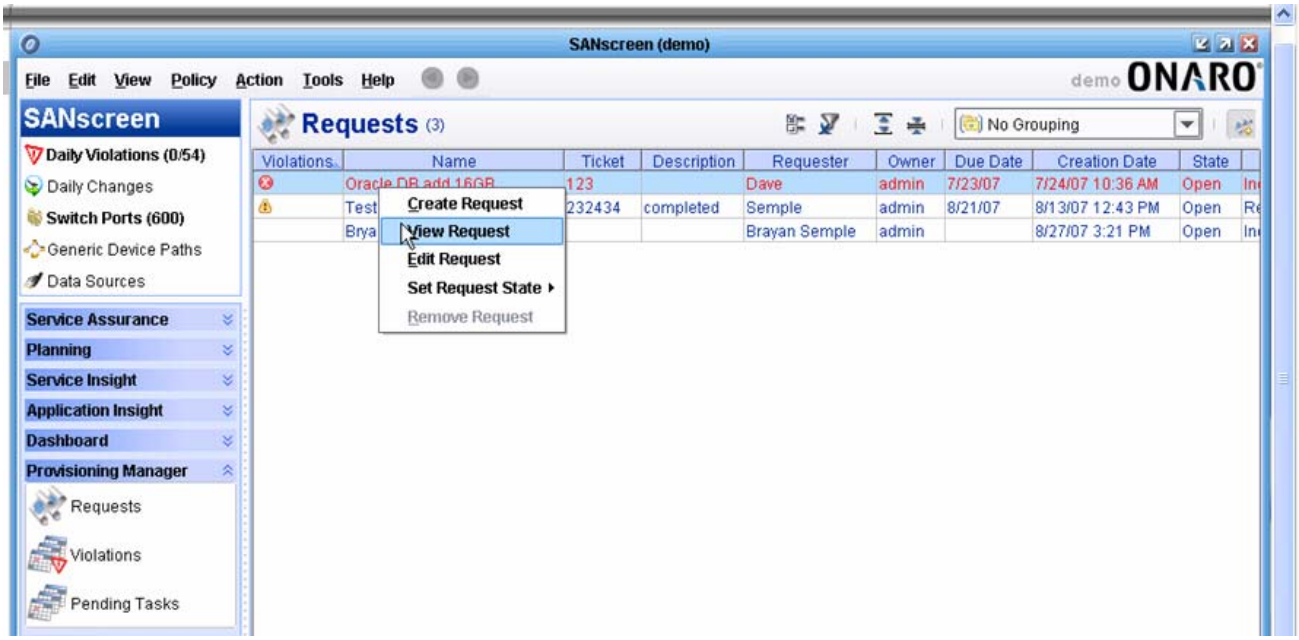
| Tier | Cost (1GB) |
|---|---|
| 2-Silver | $10 |
| 3-Bronze | $8 |
| 1-Gold | $15 |

| | 2-Silver | | 3-Bronze | | 1-Gold | | Total | |
|---|---|---|---|---|---|---|---|---|
| Business Unit | Capacity | Cost | Capacity | Cost | Capacity | Cost | Capacity | Cost |
| Dev | 0 | $0 | 8 | $64 | 32 | $480 | 40 | $544 |
| Customer Support | 0 | $0 | 16 | $128 | 0 | $0 | 16 | $128 |
| Trading | 112 | $1,120 | 0 | $0 | 0 | $0 | 112 | $1,120 |
| Stores | 64 | $640 | 0 | $0 | 0 | $0 | 64 | $640 |
| Marketing | 184 | $1,840 | 0 | $0 | 0 | $0 | 184 | $1,840 |
| Legal | 112 | $1,120 | 0 | $0 | 0 | $0 | 112 | $1,120 |
| **Total** | **472** | **$4,720** | **24** | **$192** | **32** | **$480** | **528** | **$5,392** |

# SANscreen® Provisioning Manager

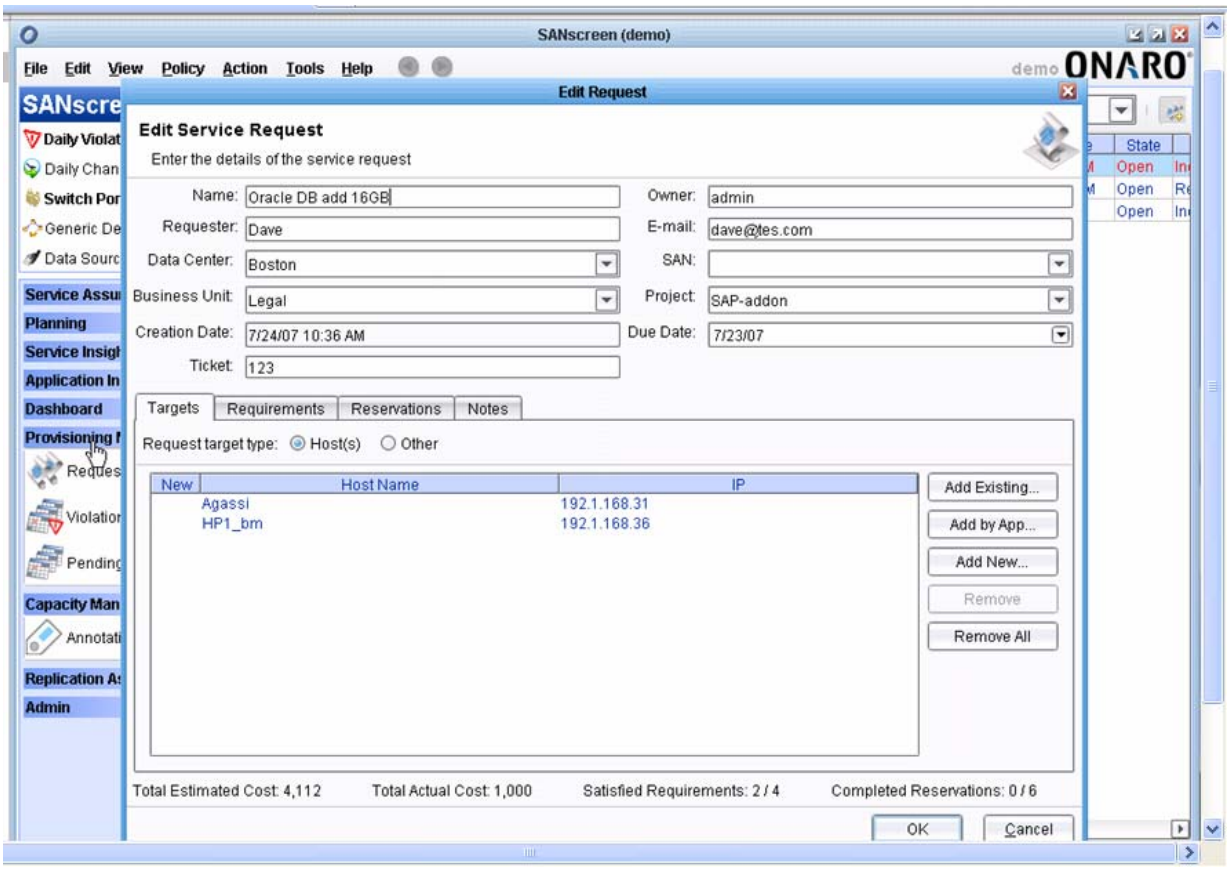
The **SANscreen Provisioning Manager** module claims to be able to accelerate the application provisioning process by simplification of the process through a reservation system and better forecasting tools.

The screen below shows all of the current provisioning requests that are currently in the request queue, along with their current status and any associated violations.

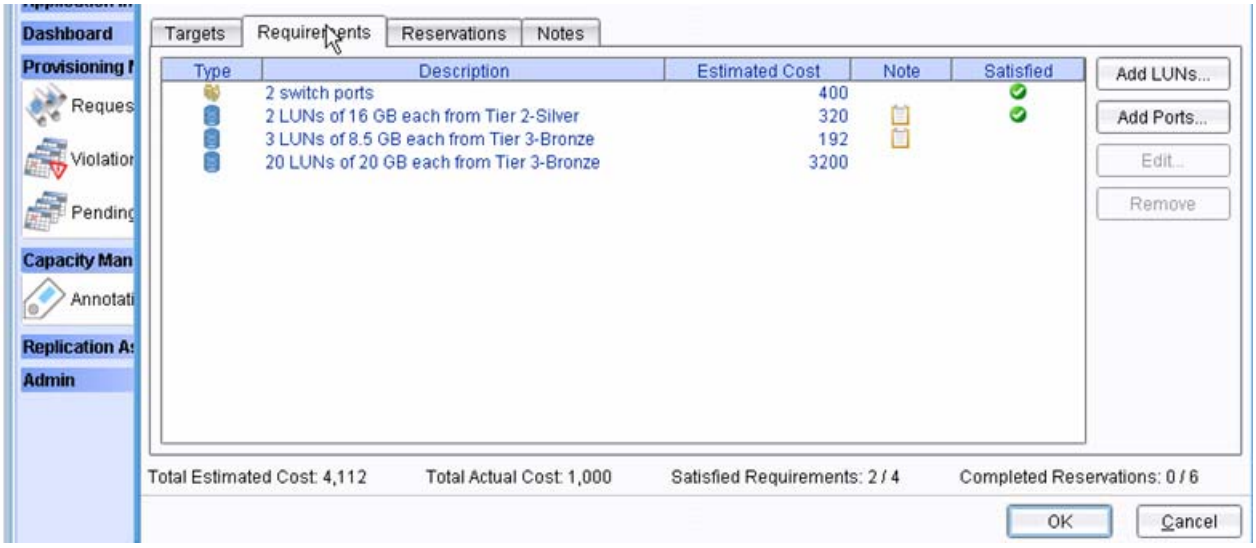



The end user can make a request either through the Onaro® UI panel or it can be done with a web portal that uses the Onaro® API and possibly ties into the local customer ticketing system. This panel lets the administrator see what requests are pending, and the status of each request. Based on these user requests, the administrator can build the pending task list to satisfy the request. As tasks are implemented, the **SANscreen Provisioning Manager** would monitor any violations caused by the changes created through execution of the task list. When the task list is completed, and there are no major violations, then the provisioning request is satisfied.

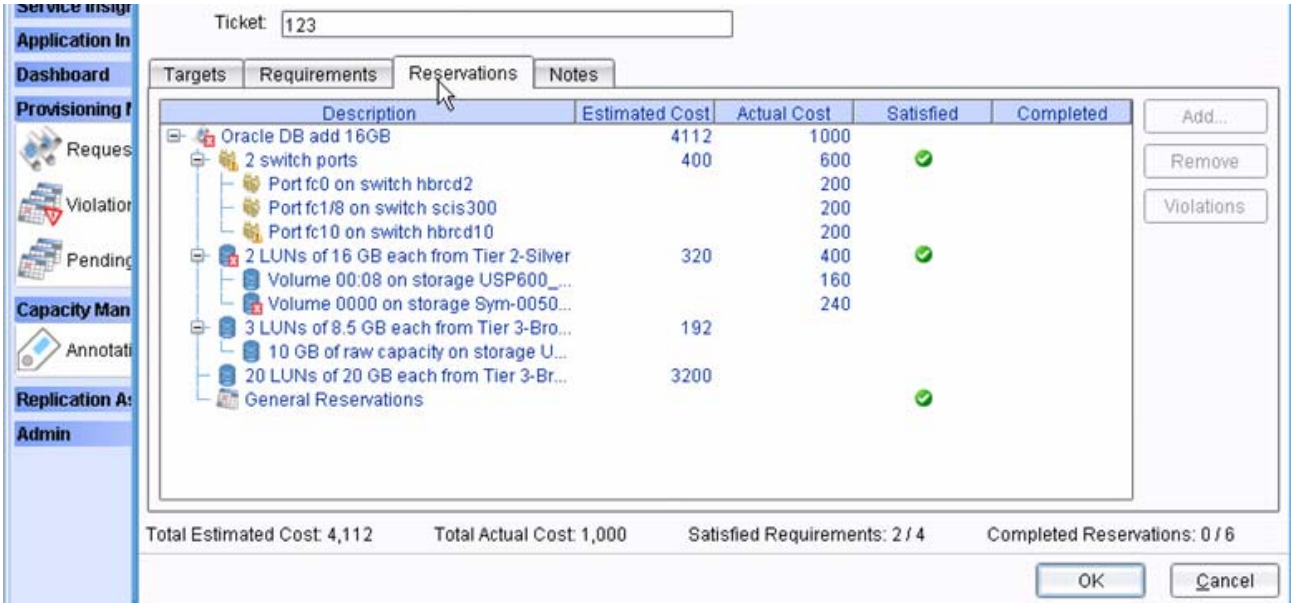
The following information would get filled in by the requestor (end user) – at the bottom of this request, there are a list of hosts making the provisioning request.



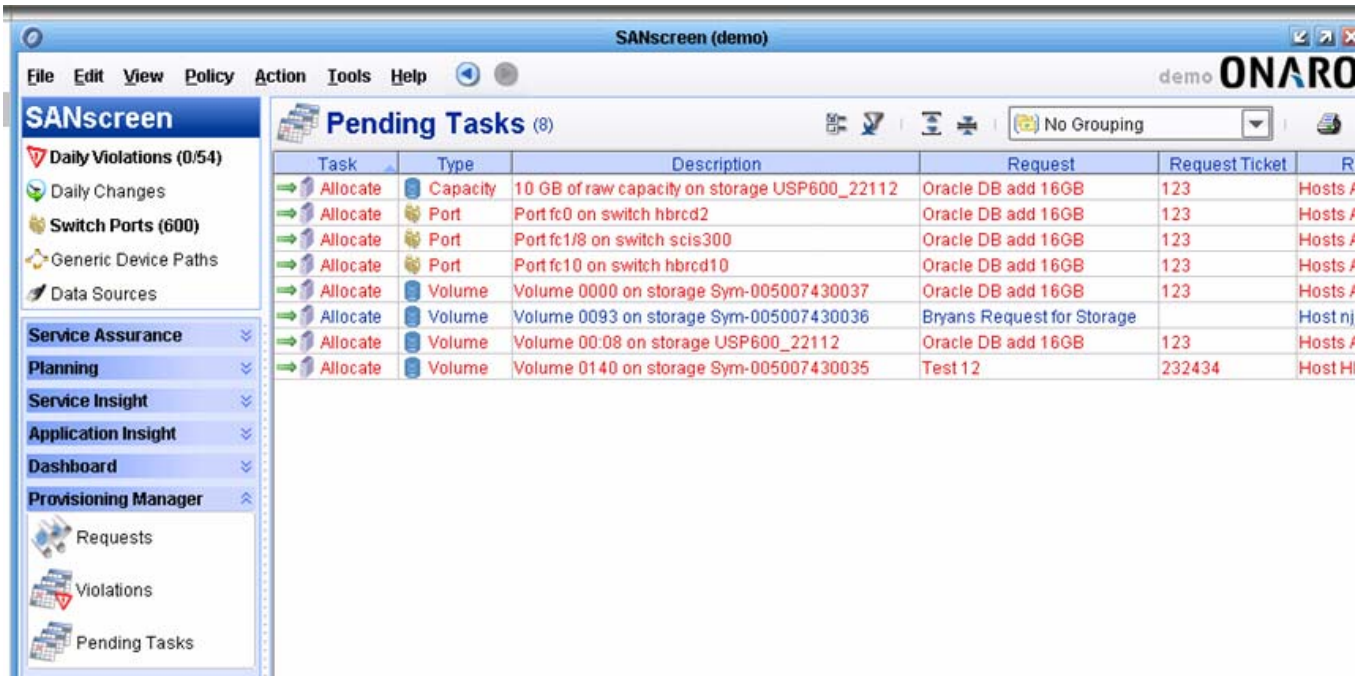
The end user would also fill out the Requirements tab above as shown below (notice the estimated cost below based on the port cost and storage costs specified by the Administrator:




Once the request targets and requirements are entered by the user, the Administrator can try to satisfy the request by reserving certain equipment. This doesn't actually hook up the equipment. It simply reserves it from being taken by someone else. An example of the reservations tab is shown below:

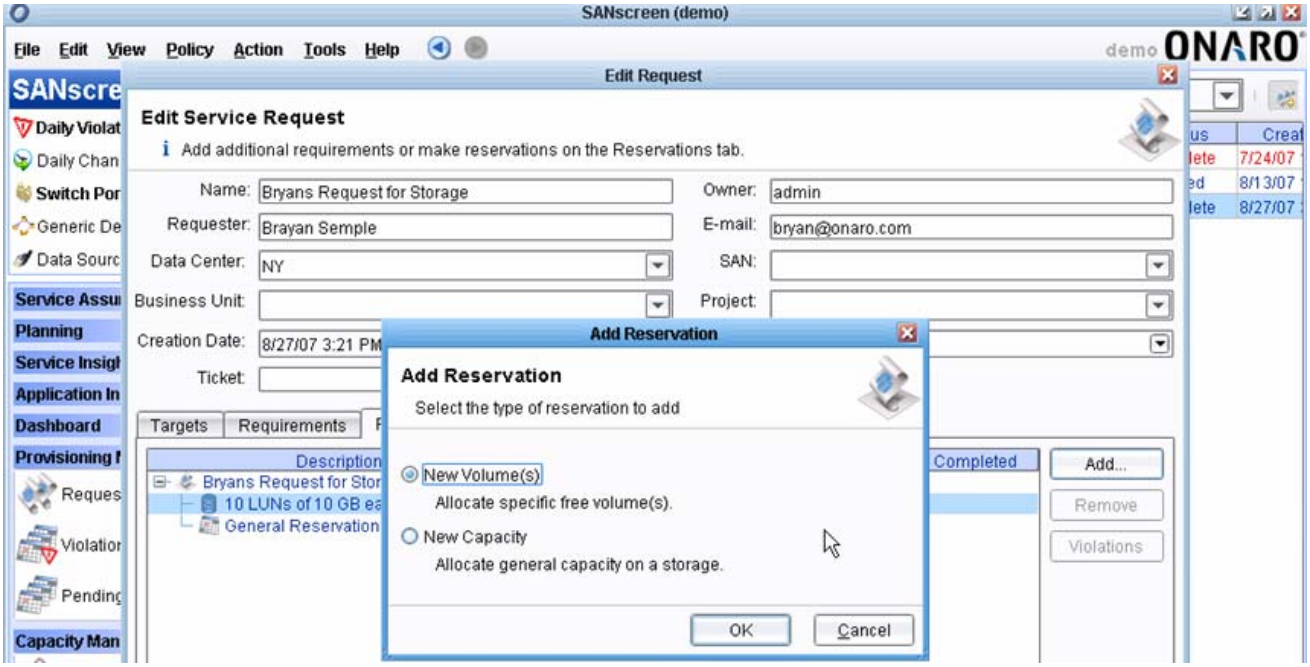


At some point after the reservations for the equipment are made, the Administrator needs to go through the Pending Task List to actually implement the plan automatically generated by the reservation process. The list of pending tasks for a given reservation is shown below:




Reservations can also be cancelled if they are no longer needed. The **SANscreen Provisioning Manager** will automatically return all resources, including all resources that have be partially implemented (e.g., LUNs that have already been masked to hosts). For the implementation of requests, the **SANscreen Provisioning Manager** will only show those resources that potentially can satisfy the request based on the data center, host, switches, zoning rules, tier of storage, etc.

Below is an example of a pending request to be satisfied:




A new volume request for the 10 LUNs requested above would bring up a choice of either selecting New Volumes or New Capacity. If the LUNs have already been carved up on the storage array, then New Volumes can be selected. If not, the New Capacity button can be selected to reserve the capacity until the LUNs are eventually carved out. After selecting New Volumes above, the following list of resources are displayed:

These arrays were automatically selected by **SANscreen Provisioning Manager** because they were the only possible candidates that could satisfy the requirements of the request.

# SANscreen® VM Insight

The introduction of server virtualization technology greatly impacts the SAN architecture model. Normally, in non-VM environments, SAN zoning and masking rules assume that each HBA or HBA group sits in front of one and only one host OS. In VM environments, there are multiple host OSes running in virtual machines all sharing the actual HBAs on the real ESX server.

This means that to really understand path and performance utilization, one needs to be able to tie the real storage network infrastructure to the VM hosts through the server virtualization layer. Furthermore, it needs to understand the breakdown of the CPU cycles given and used by each of the virtual servers since that could dramatically add to the performance impact on applications running on those virtual servers. Currently, over 2/3 of all ESX servers are connected to network storage. This means that the problem is not coming – it is already here.

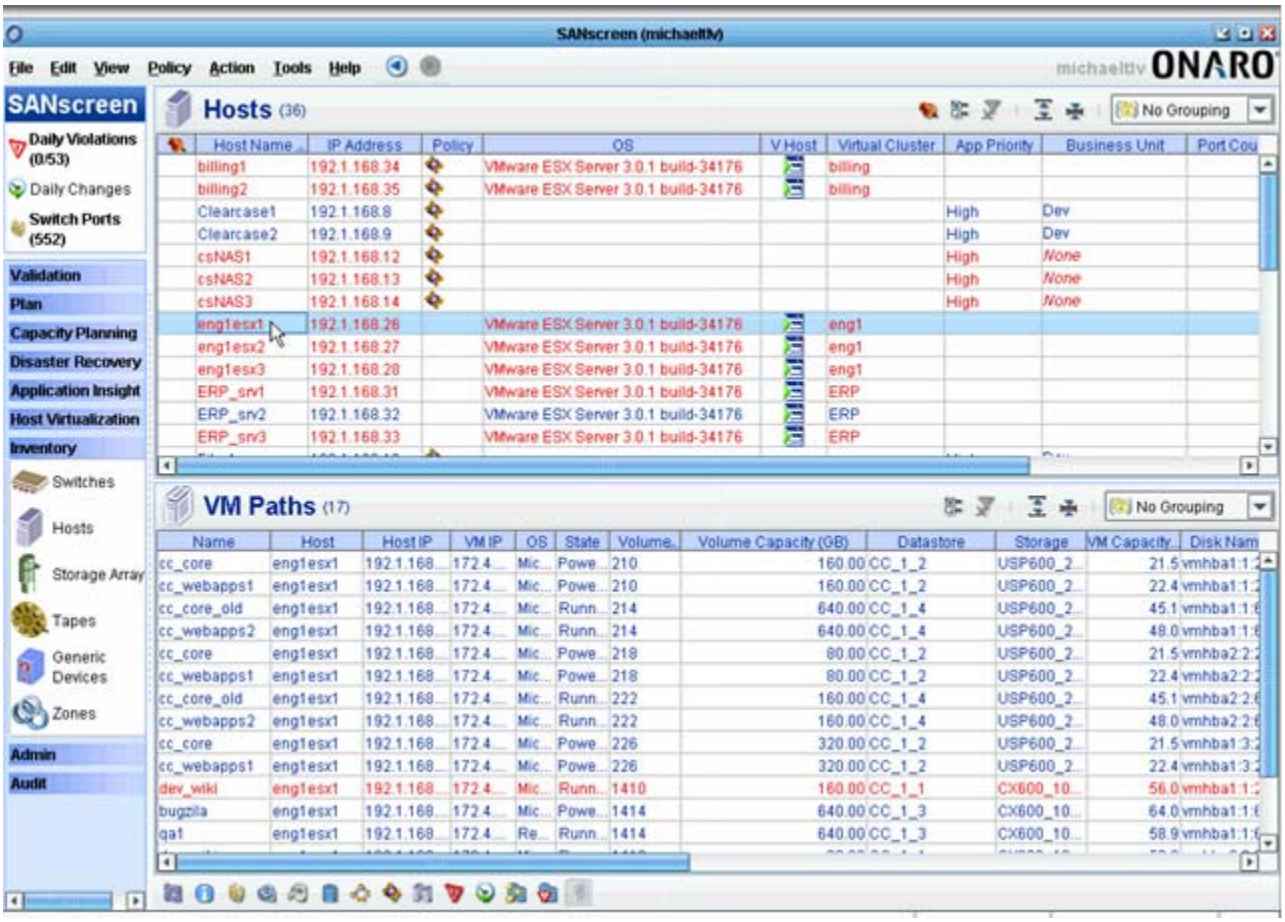
The **SANscreen VM Insight** module claims to be able to leverage its in-depth knowledge of the storage network infrastructure and its policies and policy engine to the VMWare information to extend the **SANscreen** technology to the host virtualization layer. Furthermore, it intends to provide a focal point to both the VM server management team and the storage network team to give a single system view of the resources.

When **SANscreen VM Insight** encounters a VMWare ESX Servers, it will talk to VMWare Virtual Center to get a list of all virtual hosts running on that ESX machine. It also acquires statistics about those virtual machines as well as the internal virtualized paths of those VMs. All of this is done in an agent-less fashion like the rest of the **SANscreen®** suite of products

The real power of the **SANscreen VM Insight** module is first and foremost, the inner knowledge of the storage network infrastructure, the paths, annotation tags, cost numbers, business units, rules, policies, traffic monitoring, violations, capacity planning, and the internal rules engine. This inner strength gets leveraged by applying the inner knowledge of the VMWare environment to the rest of the **SANscreen®** infrastructure.

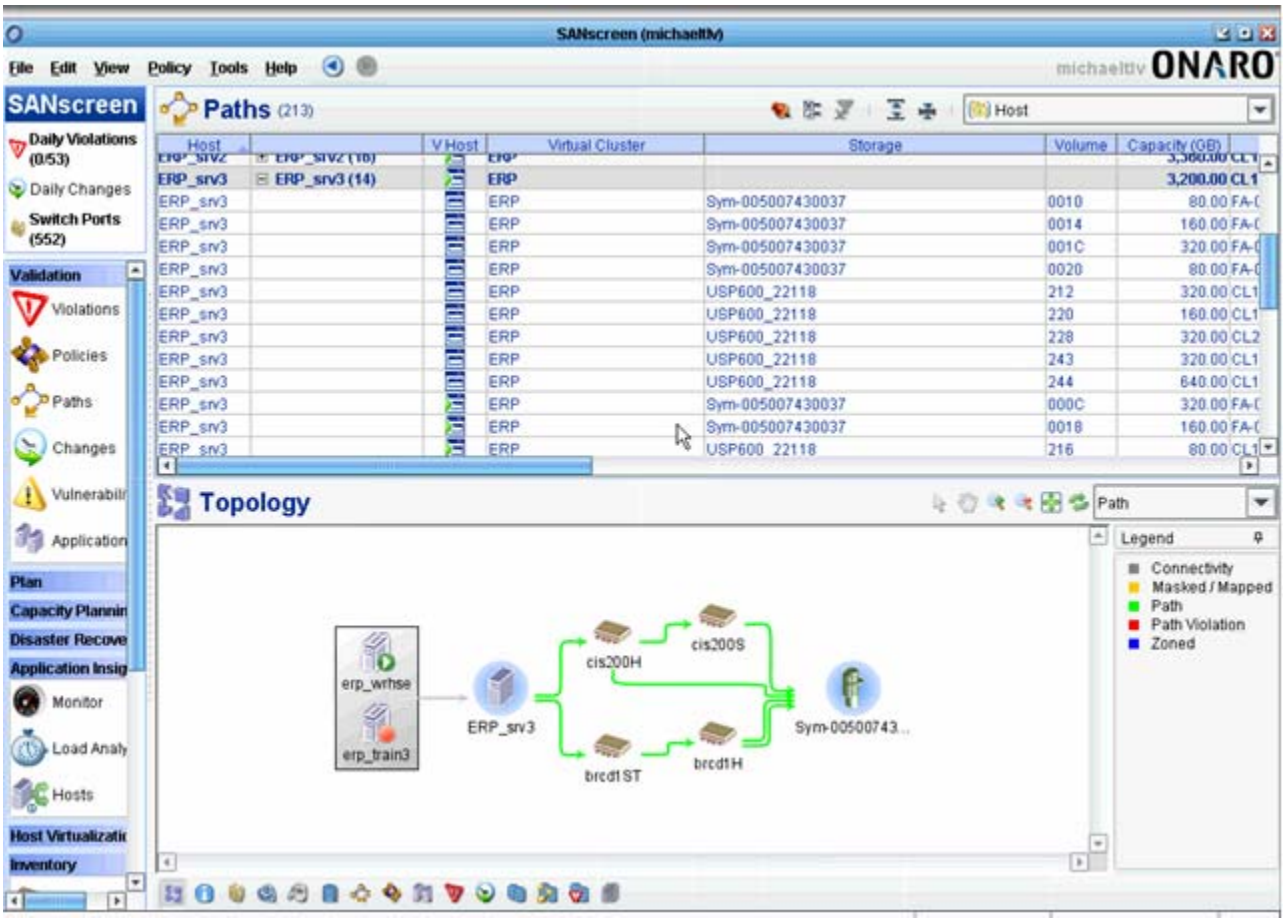
This means that all of the **SANscreen®** modules end up being energized for all of their built-in functionality to the virtualized world of the VMWare ESX server and all of its virtual host machines. The bottom line is that the customer gets all of the **SANscreen®**functionality applied to VM environments plus some new functionality just for VMWare.

In the screen shot below, displays the list of all hosts as it normally does. It also identifies any VMWare ESX servers it discovers. If we click on the ESX Server, it will display all of the virtual hosts inside:




As you can see in the picture above, **SANscreen VM Insight** not only sees all of the virtual machines for this ESX server but also all of the volumes, paths, capacity etc. as well as the storage array and the associated disks on that array. This translates to all **SANscreen®** functionality can now be tied directly to VM environments using VMWare ESX servers.

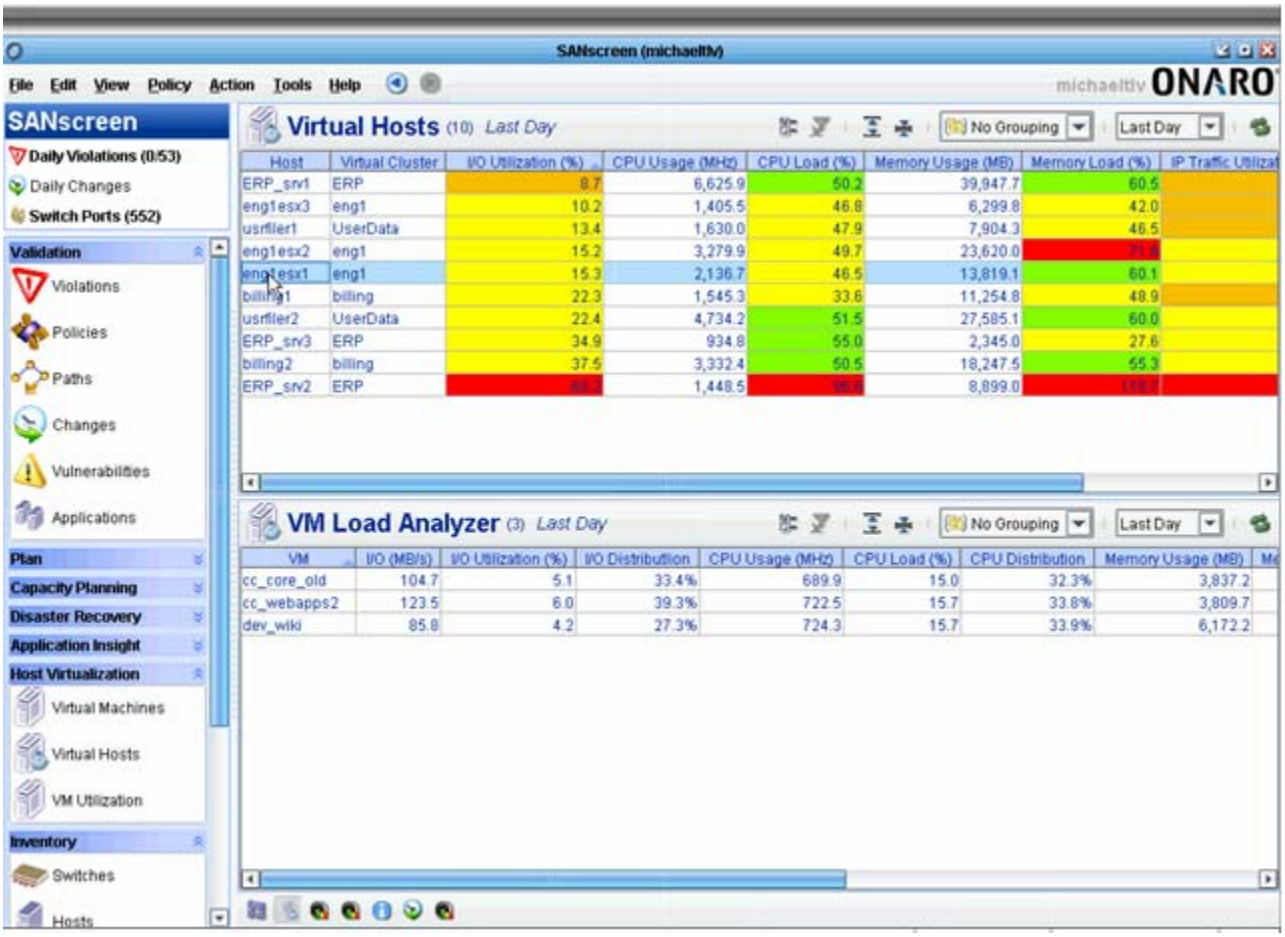
In the screen shot below, the **Topology** view shows an ESX server called ERP_sv3. This server has two virtual servers seen to the left of it called erp_wrhse and erp_train3. The green paths indicate the real physical connections through the storage network down to the EMC Symmetrix device, Sym-005007430037. The Paths view shows all of the volumes from the end storage array back to the VMWare virtual servers.




Again, because **SANscreen VM Insight** has all of the connections, annotations, etc. then it has the full power to monitor, show alerts and violations, provide the load data for performance tuning, load balancing, and capacity planning as it does in the non-virtual world.

In the screen shot below, the Virtual Hosts section shows all of the ESX servers discovered. They are color-coded because of how utilized they are with respect to the threshold settings put in by the Administrator (red > 65%, orange < 10%, yellow between 10 % and 50% and green between 50% and 65%). This display shows the roll-up utilization numbers at the ESX server level (I/O utilization, CPU Load, memory load, IP traffic utilization. Etc. These are the physical utilization numbers.

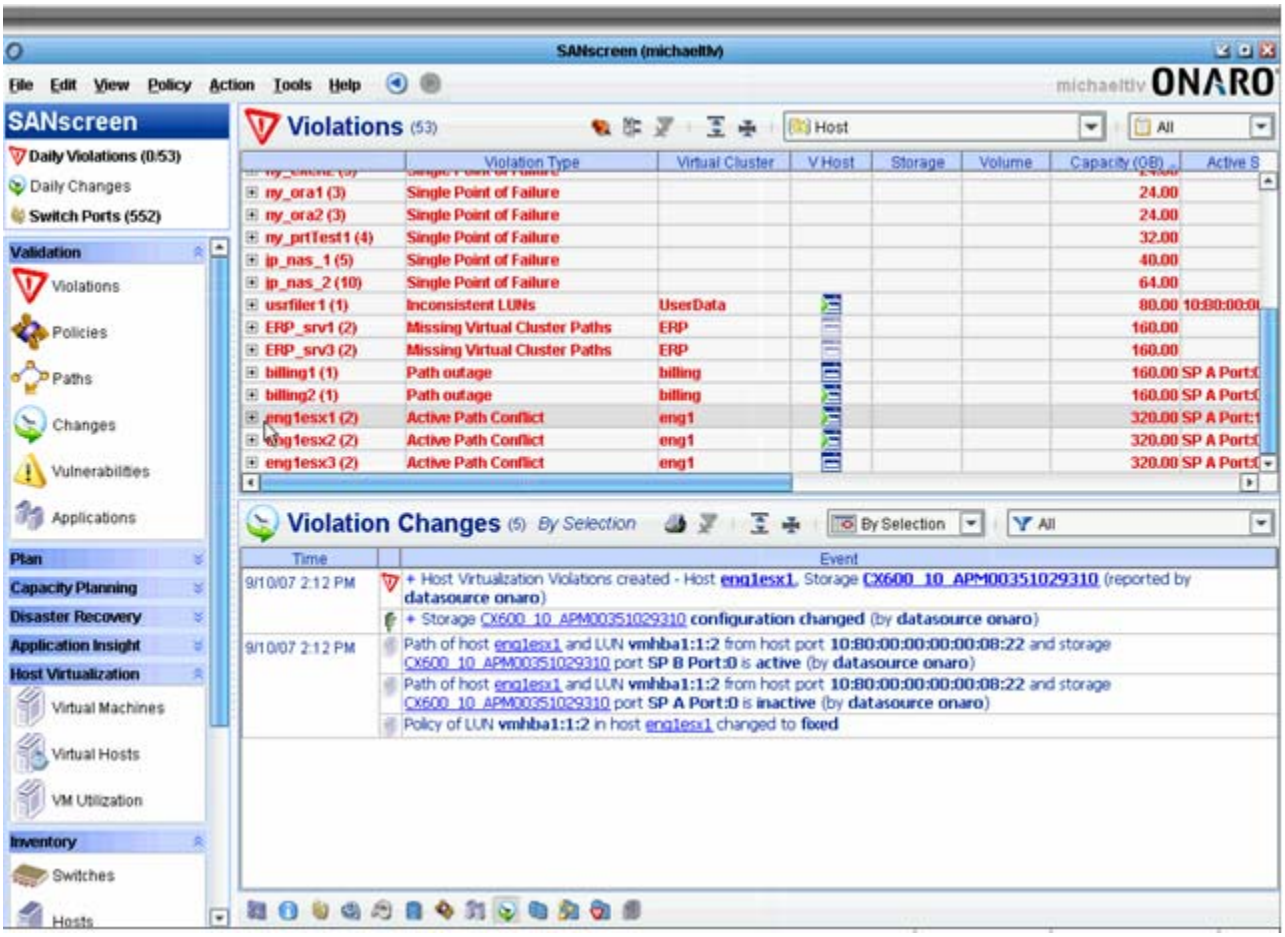
If we click on the eng1essx1 ESX server, we can see the breakdown of all the virtual servers in terms of loads, utilization, I/O traffic, etc.



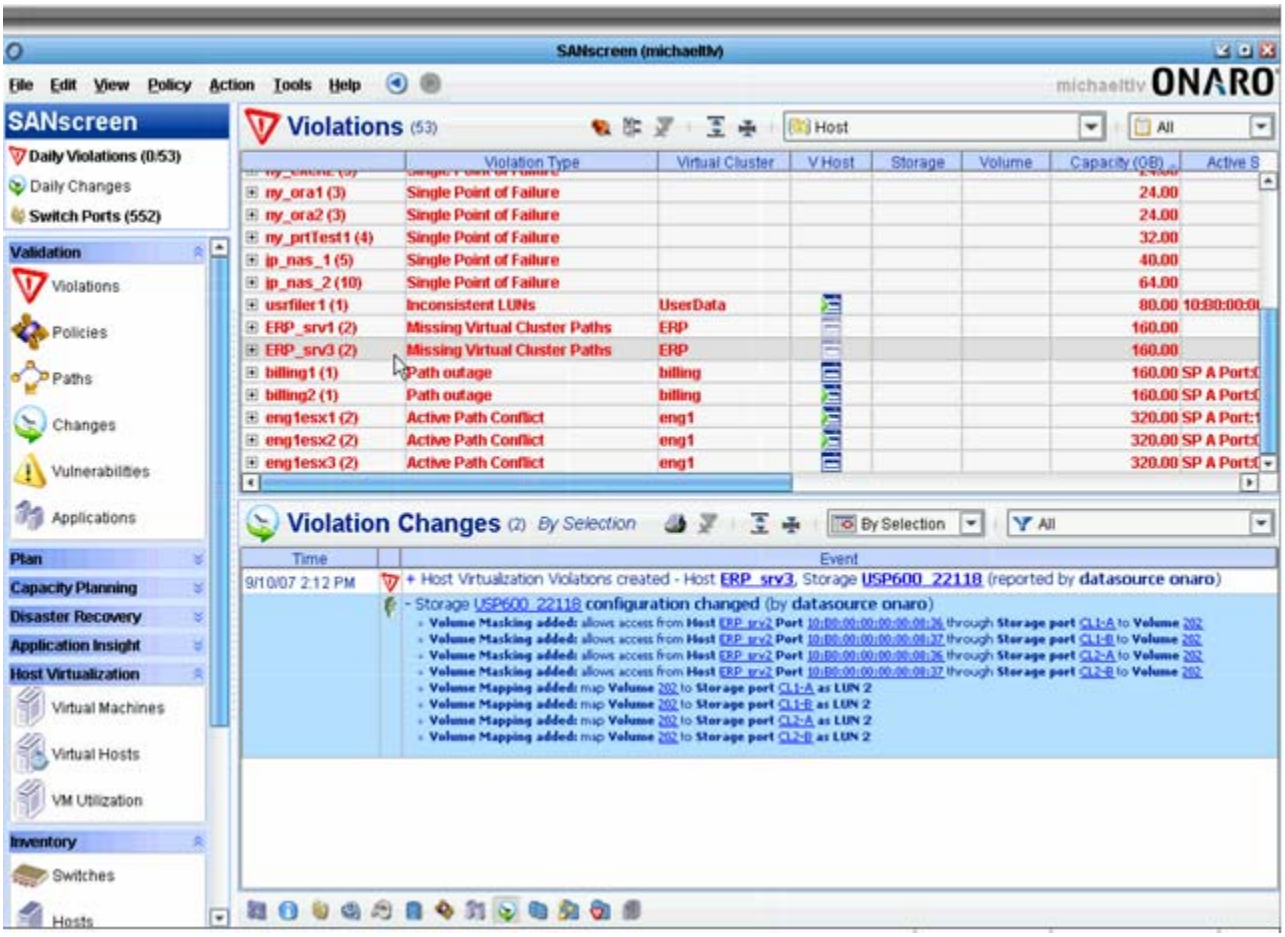
Because **SANscreen VM Insight** can merge all of the **SANscreen®** statistics with the performance statistics from the VMWare Virtual Center, the administrator is able to see the entire load end to end from the ESX Server, all of the virtual servers down through the volumes they are connected to and down through the entire SAN infrastructure. This is where the real power of the **SANscreen VM Insight** module lies.

The **SANscreen VM Insight** module can also identify **Violations** associated with the VMWare setup and the SAN infrastructure. Some violations are due to a mismatch to the policy set up by the Administrator – for example, the **Single Point of Failure** violations because the policy associated with those paths stated that the path must not have a single point of failure. An Inconsistent LUN condition occurs when a given volume is exposed using different LUN numbers to different servers within a virtual cluster.

Other violations such as **Path Outage** indicate a real failure condition that will cause a real outage. Some VMWare violations don't necessarily cause a failure but they certainly will impact performance issues. The **Active Path Conflict** is one of those types of **Violations**. There is a case in an ESX Server that could cause path thrashing - this happens when one server accesses LUN1 on Service Processor A in a storage array but a second server accesses LUN1 through Service Processor B on the same storage array. This would cause path thrashing because the SP ownership (due to the ESX sending commands to the array) for that LUN1.

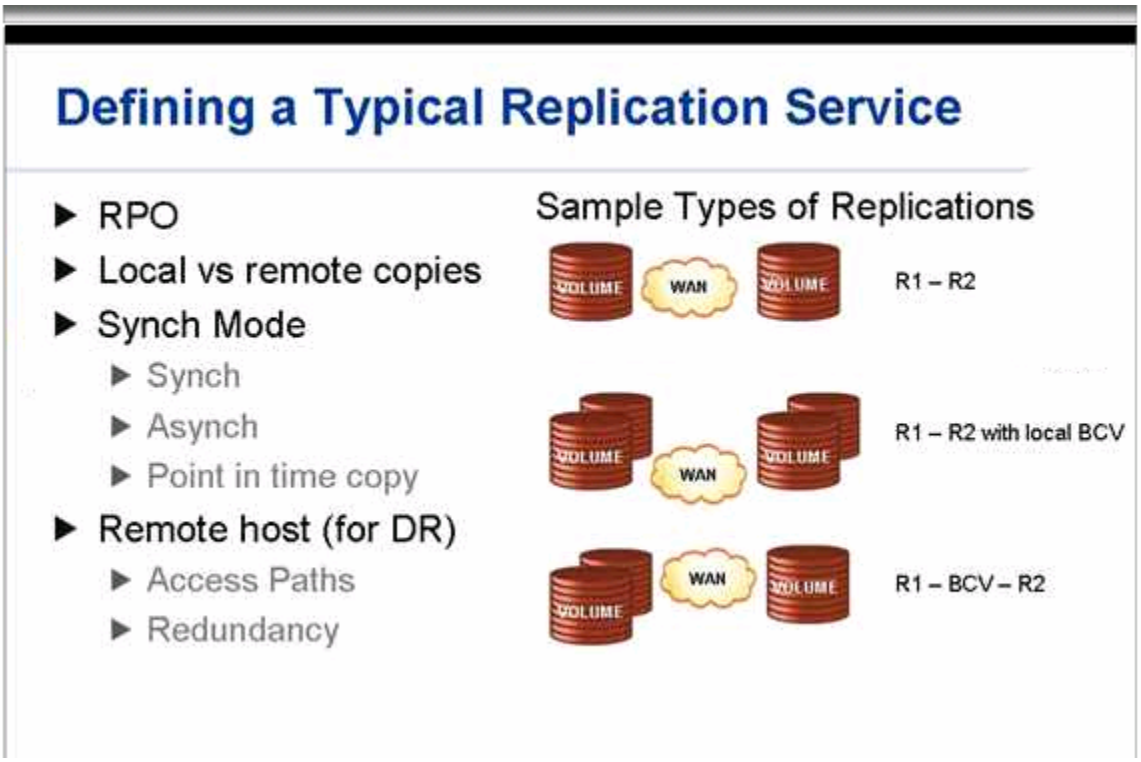


In an ESX Server farm, all of the ESX Servers need to be able to access all of the volumes to allow virtual servers to move freely to other ESX Servers within the VM Cluster (e.g., using VM Motion). The **SANscreen VM Insight** module detects this type of condition and marks it as a **Missing Virtual Cluster Path** violation. Since all changes are monitored by the SANscreen product suite, we can see what caused the problem in the **Violation Changes** section below. The volumes were masked to ERP_srv2 but the Administrator neglected to mask the to ERP_srv1 and ERP_srv3.

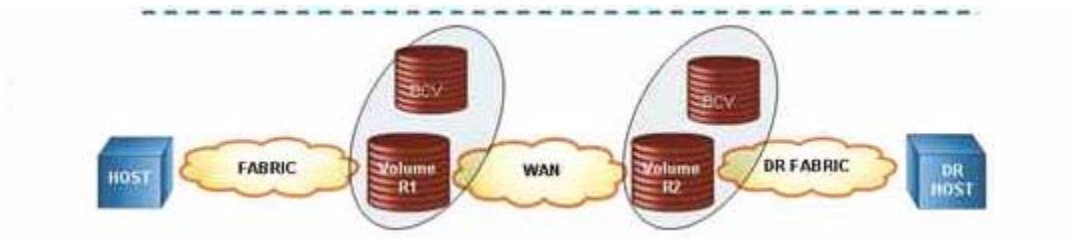


# SANscreen® Replication Assurance

This product validates, from a storage infrastructure point-of-view, that the RPO (Recovery Point Objective) for a given application can be met. This is really the monitoring of configuration, device failures, pathing issues, and other infrastructure issues that might impact application recovery. It is not monitoring the backup and/or disaster/recovery process, software, etc. – just the infrastructure to support it.

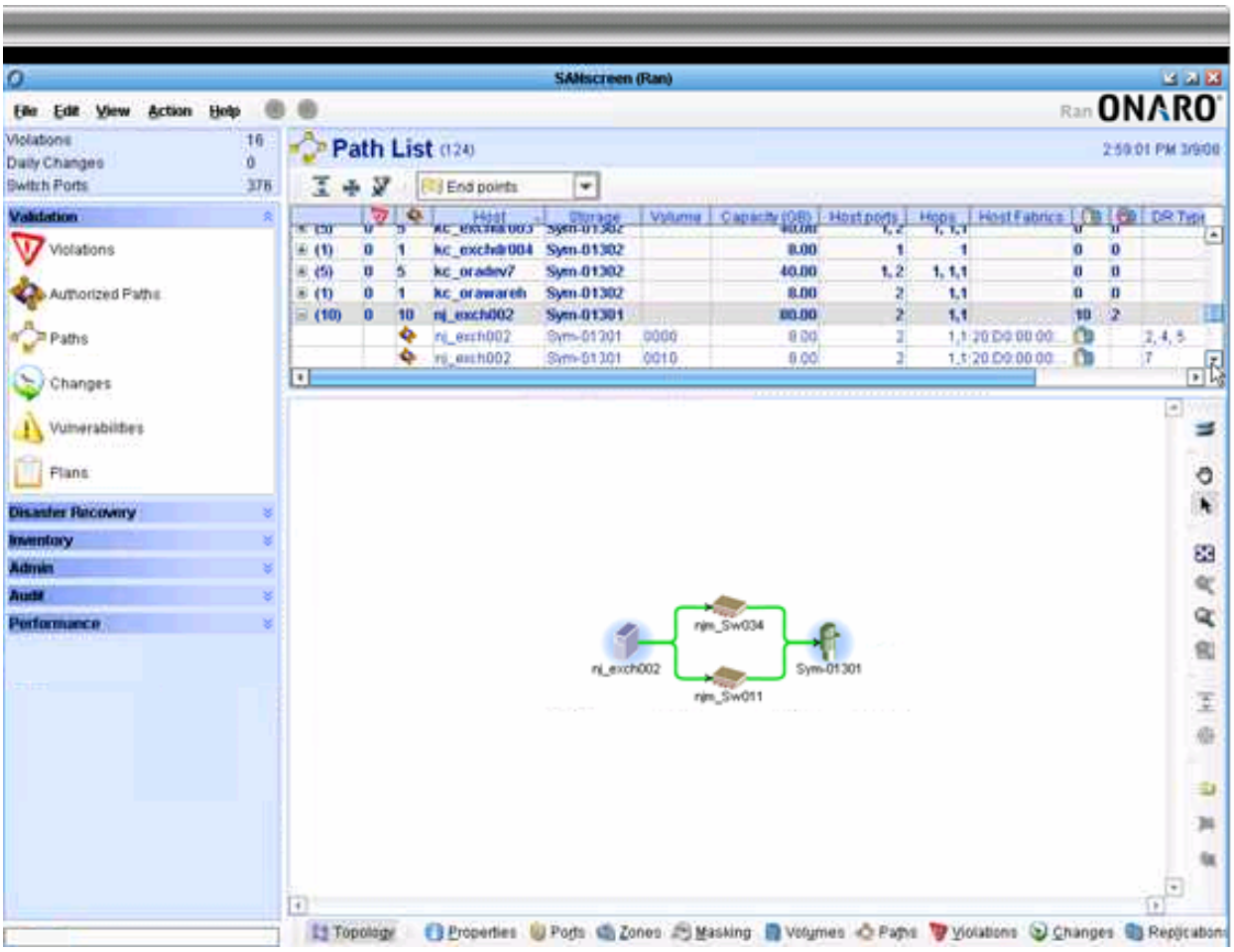


There are many types of replication services in the industry today, the examples above are very EMC-centric, especially with the use of R1, R2, and BCV (Business Continuity Volumes). However, there is a generic requirement to specify the RPO (Recovery Point Objectives) for the applications as to whether or not there will be local copies, remote copies, synchronization levels, a remote host, the access paths and the redundancy requirements. Below is a picture that shows the possible end-to-end process:




The actual setup for this is usually done by storage-centric tools. The **SANscreen Replication Assurance** module is built to handle the entire process.

Below is an example of an Exchange application showing all of the storage objects and the path connections, basically a dual path connection from the host server thru 2 switches:




**SANscreen Replication Assurance** has the ability of discovering all of the remote connections in order to piece the entire topology of the disaster/recovery environment from the application shown above to the edge switches in the local data center across the WAN to other edge switches connect to a remote array used for d/r purposes and any host connections at the host site.

By having the knowledge of this topology and the policy rules to define alert conditions to the internal rules engine in **SANscreen**, the **SANscreen Replication Assurance** module can easily show any violations within the d/r infrastructure that would impact the RPO objectives.

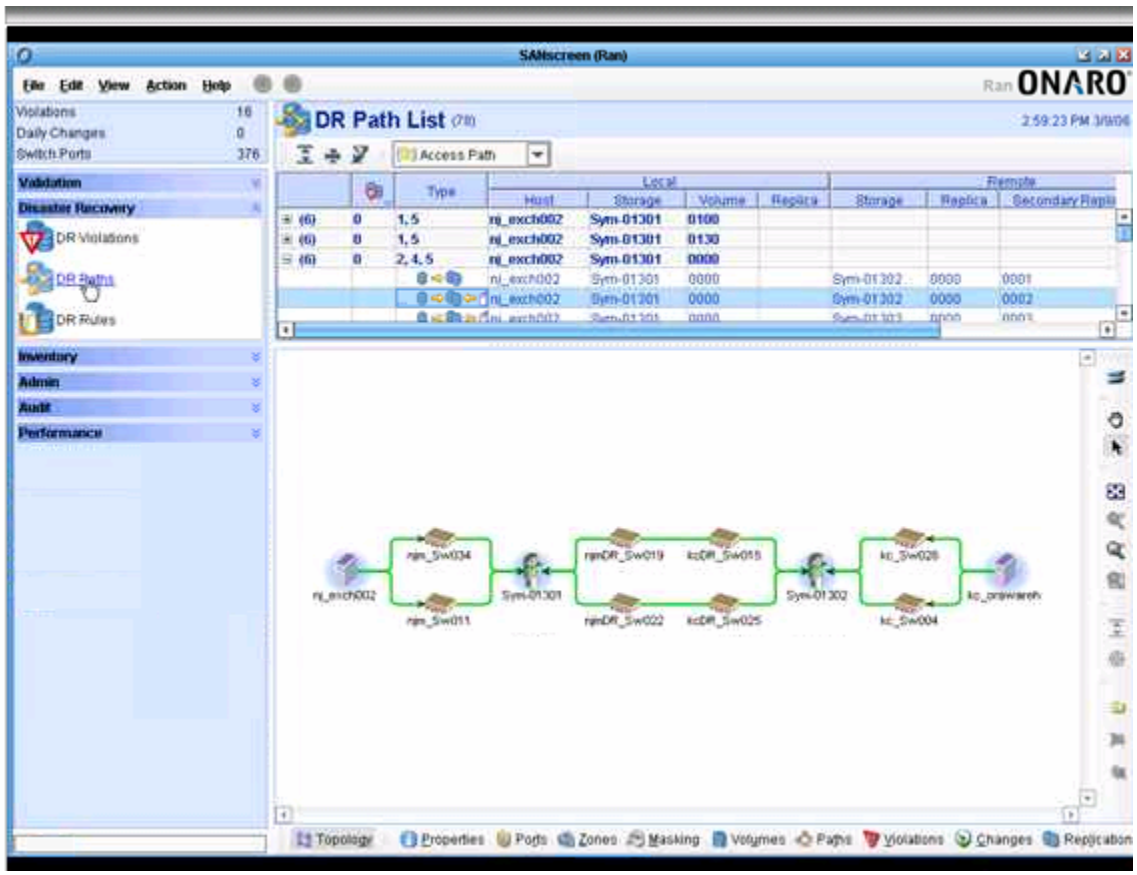
To define these d/r policies, there is a rules wizard that lets you set the following:

- Synchronization level (Synchronous, Semi-Synchronous, Copy, Asynchronous)
- Redundancy level (None, Redundant, No-Single-Point-Of-Failure)
- Minimum number of storage ports/Maximum number of ISL hops

In addition to the policy rules above, there are rules associated with the remote d/r paths to set the following policy attributes:

- Redundancy level (None, Redundant, No-Single-Point-Of-Failure)
- Minimum number of remote host ports/Maximum number of ISL hops

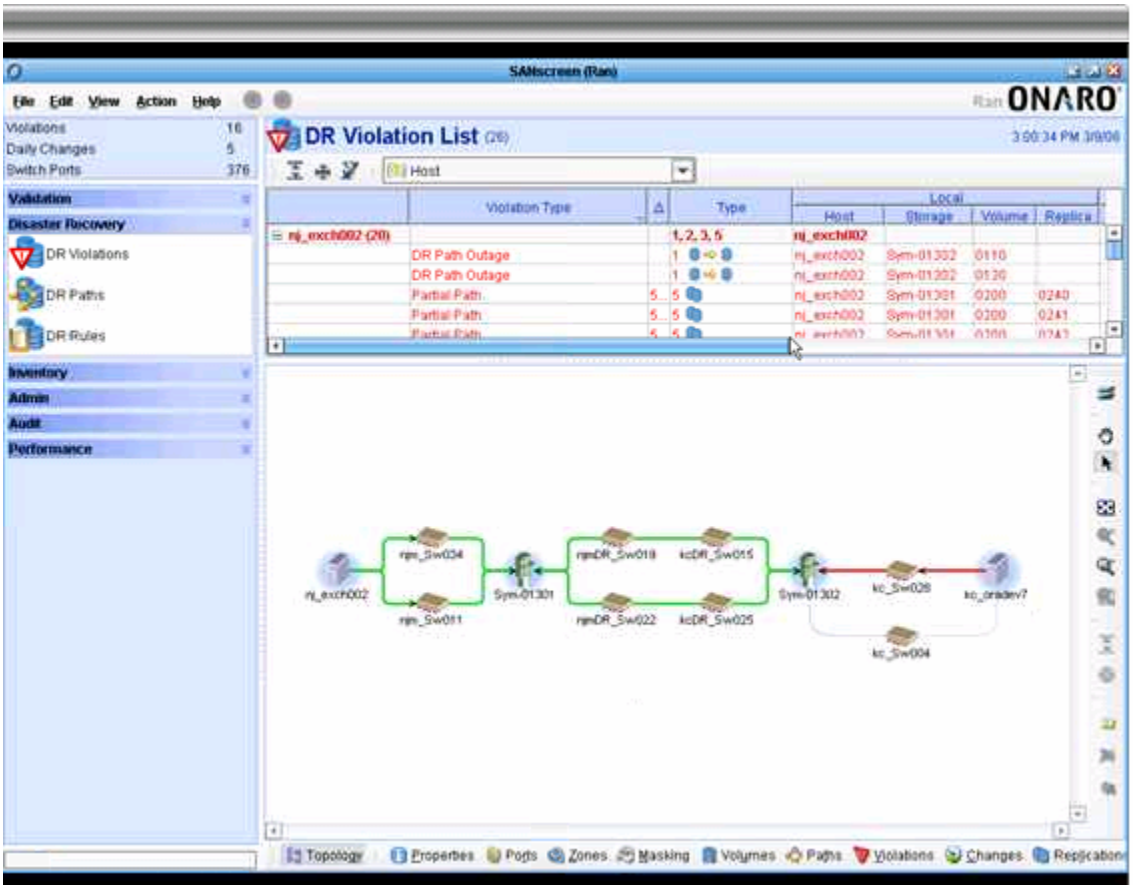
If we click on the DR paths for this application, **SANscreen Recovery Assurance** will show us all of the redundancy paths for this application below:



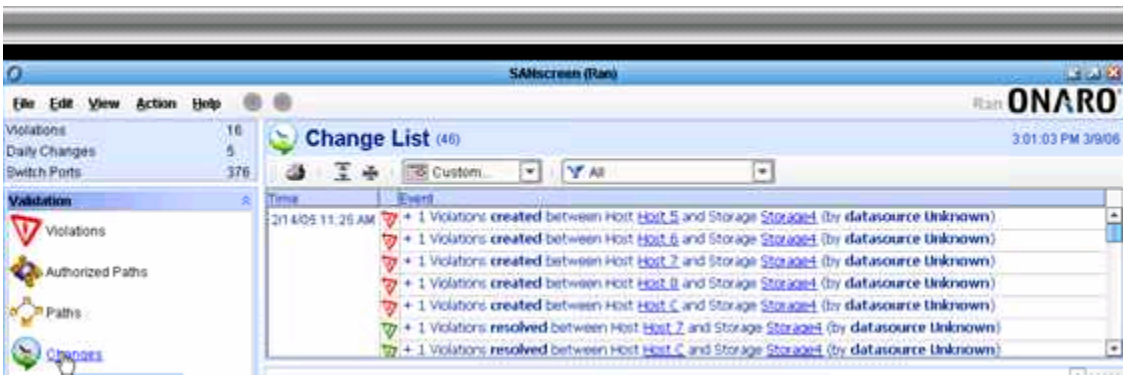
The above chart shows that the Exchange application has redundant paths to an EMC Symmetrix array which is connected to a redundant pair of edge switches that go across the WAN to another redundant pair of edge switches connected to a remote EMC Symmetrix array, which is also redundantly connected to a set of switches at the remote site and they are connected to a remote host.

Because **SANscreen Recovery Assurance** has this extensive topology knowledge about the application infrastructure and the policy rules defined by the customer, it is able to easily discover infrastructure violations.

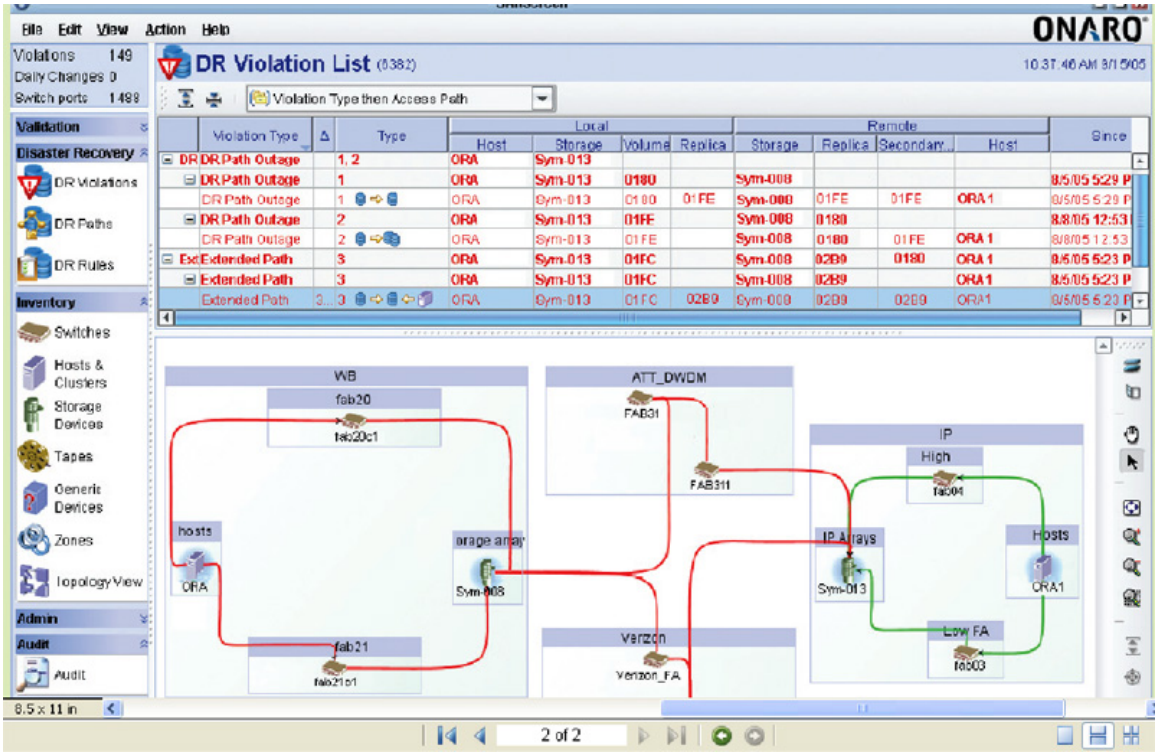
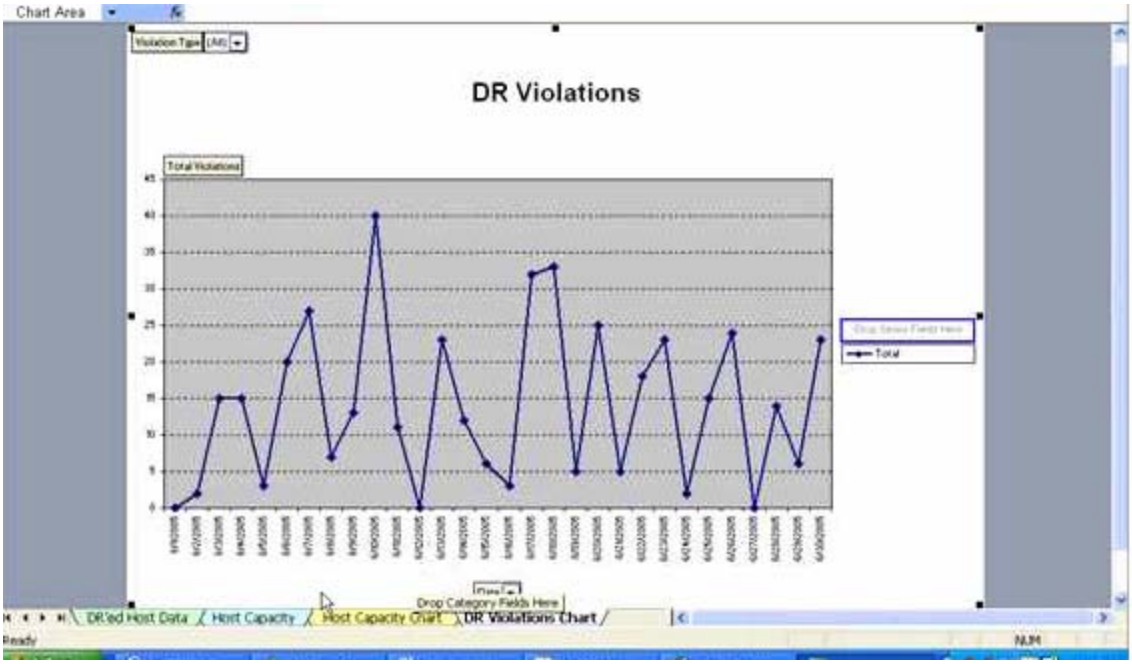
If we click on the **DR Violations** button, we see the following screen:



The result is a set of redundant path violations shown above in red, including on the topology screen between the remote Symmetrix array and the remote host. Also, since all changes are monitored, we can see the entire log of changes that caused the problems in the screen shot below:




Below is an example screen shot of a much more complicated d/r application with all of its associated violations:



Because these violations are also tracked over time, they can be shown graphically over any monitoring period in order to see improvement trends or lack of them: