An Oracle White Paper
March 2011

StorageTek SL3000 Modular Library System Analysis of Reliability and Availability

ORACLE

Executive Overview

To stay ahead of rapidly changing business conditions, organizations depend on fast and easy access to the information maintained in their corporate datacenters. Having a highly available system with 24x7 access to data is critical in meeting business demand. This document discusses Oracle's StorageTek SL3000 Modular Library System availability and the importance of hardware component redundancy for improved system availability.

Introduction

From a reliability standpoint, the StorageTek SL3000 builds upon technology from Oracle's highly successful and ground breaking StorageTek SL8500 Modular Library System. Oracle's StorageTek tape automation systems are well known in the industry as highly reliable products. However, data center operators are much less concerned with component reliability than with actual overall system availability. If a customer cannot backup or retrieve their data, it makes little difference whether the system is down for scheduled maintenance, a feature upgrade, or to replace a component. Knowing that the cost of downtime can be extremely expensive, the design goal of StorageTek libraries is to address major issues that affect downtime – reliability, availability and serviceability.

Today's libraries are highly complex systems, and no matter how reliable the design, there is always some exposure to downtime, whether scheduled or unscheduled. By improving the reliability of a system, availability is improved. However, reliability is limited by the current state of the technology, and a probability of failure exists that may be unacceptable in the 24x7 data center.

System availability can be vastly improved by added redundancy to the key components or sub-systems in a library. Redundancy adds a standby component that performs the function when the primary component fails. In reliability terms, a complex system like a library is called a series system, where a single failure in the series can result in the failure of the system.

When certain components or sub-systems have a higher risk of failure, a parallel stand-by component can dramatically increase the probability of success of the sub-system. This, in turn, improves the availability of the overall system.

Improvements in robotic and software design have increased the reliability three fold over the early StorageTek PowderHorn 9310, which was released in 1993. A 9310 library system has an availability of roughly 0.995, which includes scheduled maintenance time twice per year for code and hardware upgrades, break/fix activity, and required maintenance. The StorageTek L700, which was the predecessor to the SL3000, has an availability of 0.999, which includes scheduled downtime for code and hardware upgrades and break/fix activities. In contrast, current library systems with full redundancy such as redundant power, redundant robotics, and redundant electronics with non-disruptive serviceability have improved library availability to 0.99992 for the StorageTek SL3000 and 0.99996 for the StorageTek SL8500.

Redundancy and Availability

Oracle's StorageTek product line offers an improved level of redundancy over past products. Field data on past products show that 85 – 90% of library hardware is made up of three key sub-systems: robotics, control modules and power supplies.

The SL8500 was the first library product in the industry that offered redundancy on all three key sub-systems. Many components of the SL3000 are the same as those of the SL8500, including:

- Rail technology, robotic communications, and design
- Robotics – robots and scanner technology
- Hardware – cartridge access ports, arrays, fans, power supplies, operator panel, and more
- Firmware – library code base and the StorageTek Library Console software interface
- Library electronics, control cards, and cables

The SL3000 provides redundancy in the form of robotics, library electronics, power supplies, and control path connectivity. Thus the intent is not only to provide a highly reliable system, but a fully redundant system, meeting the ultimate goal of high availability to the customer. Two key add-ons for the availability of the SL3000 are redundant electronics and redundant robotics with access expansion modules (AEMs). Redundant electronics provides for automatic failover to a standby set of control cards in the event of an active control card failure. This failover is transparent to host applications. Utilizing redundant robotics with access expansion modules has two benefits: they provide capabilities to insert and eject massive amounts of cartridges and they also provide the capability for service engineers to non-disruptively service a downed robot through use of the AEM. This is done without taking down the system or interrupting the availability of the SL3000 library. Non-disruptive service is also available for the library electronics, power supplies, fans, and cartridge access ports increasing the operational reliability on SL3000. Overall, the availability of the SL3000 with full redundancy improves from 0.99983 to 0.99992. Table 1 equates availability to down time per year.

Table 1: Estimated Downtime per Year based on Availability

Availability	Estimated Downtime per Year
0.99	3.65 days
0.999	8.76 hours
0.9999	52.56 minutes
0.99999	5.26 minutes

There are several different types of parallel redundancy implemented in SL3000:

- Active parallel redundancy is where both components share the operational load. This lowers the duty cycle of both units improving the reliability of each. If one fails, the parallel unit assumes the full load until the other component is replaced.

- Standby parallel redundancy means the parallel component is passive, waiting to be switched on if the first unit fails. The standby component is assumed to have a "zero" failure rate in standby capacity.

- N+1 adds redundancy to a series of components, where the parallel standby component can replace any one of the "N" components.

- 2N adds redundancy to each of the "N" components in the series.

By adding redundancy to key sub-systems, the system availability is improved. The end result is that a failure of a parallel component in a redundant system has virtually no impact on the customer's ability to access data.

Major Components Impacting Availability

Robotics

Robotic technology used from the SL8500 coupled with improvements over time increase the reliability of the enterprise class library products. The SL3000 uses a two robot system. The reliability for a one robot system is 0.64. In other words it has a probability of 64% of lasting 5 years. In the SL3000 a 2nd robot functions as an active parallel redundancy. With this feature, both robots share the load under normal operating conditions, each having a 50% duty cycle. The reliability of both robots working together is 93%. This is an improvement of 29% over a single robot and is why it is implemented in the SL3000. If one robot fails, the other robot takes up the full load until a Customer Service Engineer (CSE) replaces the failed robot. The probability of the 2nd robot going down in the next 24-hour service period making the data unavailable to the customer or the host computer system is 0.0005.

Access Expansion Modules

The Access Expansion Modules (AEM) provides improvements to the SL3000 by increasing scalability with 234 CAP slots for bulk load and unloads of cartridges. More importantly the AEMs increase availability of an SL3000 to service any downed robots without taking down the system in the robot parking zone for customers with a redundant robot system.

In average customer operations, a single AEM module has a reliability of .61 over five years. The loss of the AEM does not impact the SL3000 library other than CAP capabilities and making it possible to service a downed robot. For customers with two AEM modules, the duty cycle per AEM is reduced to 50%. The reliability of the AEMs increases to .84, up 23% for five years. For customers with two AEMs, if one AEM fails the other will be responsible for all activities until a CSE can fix the failed. The probably of the second AEM going down prior to the CSE fixing the failed is .0008.

Power Supplies

The SL3000 offers redundancy for the power supplies in a 2N+1 configuration providing full AC and DC redundancy with hot swappable power supplies. Under normal operation, one power supply is required for a minimum configuration of one robot and can power two robots. However, for customers requiring maximum reliability and availability of their library system a two robot system in a 2N configuration would require two power supplies. A 2N+1 configuration would require 3 power

supplies. A single power supply has a reliability of 0.84. A standby power supply redundancy or 2N+1 configuration predict a reliability of 0.975, or 13.5% improvement.

Control Cards

The library control cards, the HBCR and HBT are very reliable cards. These cards are based on the same control card technology in the SL8500. The reliability of these cards also allow for increased reliability and availability of the SL3000 system. The HBCR currently has 79% reliability over five years while the HBT is at 89%. The SL3000 also offers redundant library electronics, acting as a standby parallel system. The reliability of a redundant electronics HBCR/HBT card systems increases to 93% over the same 5 year period.

Code Upgrades and Scheduled Maintenance

Library availability is also affected by downtime associated to code upgrades and scheduled maintenance activities such as hardware upgrades. The SL3000 procedure for control software will allow the installation and distribution of new software versions to occur without customer operations interruption. Switching from one code version to the other (IPL) only takes a few minutes and with redundant electronics the switch is non-disruptive to host applications. SL3000's with direct-attach SMC connections may take longer to initialize after new microcode downloads. Also, the previous software version will be retained in the hardware elements for rapid re-activation in case undesirable behaviors are found in the new installation. The hardware redundancy allows for hardware upgrade and repair without library downtime.

Library Availability

The real improvement to the customer for StorageTek libraries can also be expressed in terms of availability. Assuming the same premium service level, library availability would go from 0.99983 for a basic SL3000 library system to 0.99992 for a fully redundant SL3000 library system. An availability of 0.99992 implies an average downtime of 43 minutes per year.

Table 2: Library System Availability

Library Configuration	Availability	Estimated Downtime per Year
PowderHorn 9310	0.995	43.8 Hours
L700	0.999	8.76 Hours
Basic SL3000	0.99983	1.5 Hours
Fully redundant SL3000 with 2N power, redundant robotics, redundant electronics, and two access expansion modules	0.99992	43.1 Minutes
Basic SL8500	0.99988	63 Minutes
Fully redundant SL8500 with 2N power, redundant robotics, and redundant electronics	0.99996	21 Minutes

Conclusion

Oracle's StorageTek SL3000 modular library system keeps risk at bay, with innovative technologies that have been proven in the most-demanding enterprise environments. Non-disruptive, on-the-fly replacement of robotics, library electronics, power supplies, and drives helps sustain 24x7 operations. Dedicated TCP/IP and/or Fibre-Channel library control paths with optional dual control path technology increase overall library availability. All of these advances bring the availability of a fully redundant SL3000 library to 0.99992, over a 10x improvement in availability over its predecessor, the L700.

StorageTek SL3000 Modular Library System
Analysis of Reliability and Availability
March 2011

Oracle Corporation
World Headquarters
500 Oracle Parkway
Redwood Shores, CA 94065
U.S.A.

Worldwide Inquiries:
Phone: +1.650.506.7000
Fax: +1.650.506.7200
oracle.com

Oracle is committed to developing practices and products that help protect the environment

Copyright © 2011, Oracle and/or its affiliates. All rights reserved. This document is provided for information purposes only and the contents hereof are subject to change without notice. This document is not warranted to be error-free, nor subject to any other warranties or conditions, whether expressed orally or implied in law, including implied warranties and conditions of merchantability or fitness for a particular purpose. We specifically disclaim any liability with respect to this document and no contractual obligations are formed either directly or indirectly by this document. This document may not be reproduced or transmitted in any form or by any means, electronic or mechanical, for any purpose, without our prior written permission.

Oracle and Java are registered trademarks of Oracle and/or its affiliates. Other names may be trademarks of their respective owners.

AMD, Opteron, the AMD logo, and the AMD Opteron logo are trademarks or registered trademarks of Advanced Micro Devices. Intel and Intel Xeon are trademarks or registered trademarks of Intel Corporation. All SPARC trademarks are used under license and are trademarks or registered trademarks of SPARC International, Inc. UNIX is a registered trademark licensed through X/Open Company, Ltd. 0311

SOFTWARE. HARDWARE. COMPLETE.