Linux* and High-Availability Computing
Clustering Solutions for e-Business Today

Setting up an automatic failover database for Oracle8i on Linux*
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Introduction

As the Internet continues to become part of mainstream culture, Web site downtime has become a significant issue. People who didn’t own a computer a few years ago have become dedicated online communicators, shoppers, auction-goers and retailers. This has heightened the expectations for reliability in the online world, where even a few seconds delay can cause customers to take their clicks elsewhere.

Web site unavailability or sluggishness is one symptom of a matter of widening importance: continuous or highly available computing. A system of interdependent Web components functions only if all the components work properly and are available all the time (24 hours a day, seven days a week). Any server technology for Web-based content access must perform at the highest levels, be available continuously and have great scalability features. This is because of the nearly unplannable spikes in concurrent access that must, nonetheless, result in reasonable performance.

Oracle 8i, Oracle’s Internet-enabled database, is a premier heavyweight relational database for business use. Linux, which has enjoyed an explosive adoption rate since 1998, is a complete multiuser, multitasking operating system known for its flexibility, scalability, reliability and low cost. Linux is also clearly the fastest-growing platform supporting Oracle8i Server:

Recent improvements in Linux functionality, along with industry collaborative initiatives spearheaded by Intel, are dramatically improving the availability results customers are achieving with Intel® Architecture. A growing offering of affordable, industry-standard operating systems, clustering and middleware provide high availability on Intel Architecture. There is increasing evidence of this today as eToys and others successfully use Linux for high-availability, 24 X 7, and high-volume e-Business scenarios. Deploying Intel Architecture-based servers provides your business with agility through a breadth of products, performance leadership, price/performance leadership and choice.

This paper talks about many of the issues regarding high availability as they relate to Oracle8i on Linux servers and how to set up an automated standby database for Oracle8i on a Linux server to maximize uptime.

The tests referenced here were conducted by Intel® Solution Services. The Intel Solution Services program enables Solution Providers, ISVs, OEMs and Web integrators to work directly with Intel to develop e-Business solutions on Intel Architecture. Companies will work in Intel Solution Center or via on-site consulting to develop Internet technologies, application frameworks and solution sets that will give clients a time-to-market advantage when leveraging emerging technologies to build more robust relationships with their customers.

Key Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>DBMS</td>
<td>Database Management System: a software system that facilitates the creation and maintenance and use of an electronic database</td>
</tr>
<tr>
<td>HTML</td>
<td>Hypertext Markup Language</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ISV</td>
<td>Independent Software Vendor (not a hardware manufacturer)</td>
</tr>
<tr>
<td>JDBC</td>
<td>Java Database Connectivity</td>
</tr>
<tr>
<td>NIST</td>
<td>National Institute of Standards and Technology</td>
</tr>
<tr>
<td>ODBC</td>
<td>Open Database Connectivity, a standard for accessing different database systems</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>OLTP</td>
<td>Online Transaction Processing</td>
</tr>
<tr>
<td>OMG</td>
<td>Object Management Group, a consortium aimed at setting standards in object-oriented programming</td>
</tr>
<tr>
<td>OPS</td>
<td>Oracle Parallel Server</td>
</tr>
<tr>
<td>ORB</td>
<td>Object Request Broker, part of the OMG standard</td>
</tr>
<tr>
<td>RAID</td>
<td>Redundant Arrays of Independent Disks (originally “redundant arrays of inexpensive disks”)</td>
</tr>
<tr>
<td>SMP</td>
<td>Symmetric Multiprocessing</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language, an industry-standard language for creating, updating and querying relational database management systems</td>
</tr>
<tr>
<td>SQLJ</td>
<td>Structured Query Language for Java</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterruptible Power Supply</td>
</tr>
</tbody>
</table>
Linux Overview

Linux is a UNIX® work-alike operating system created by Linus Torvalds and a motivated and active group of programmers who united via the Internet. Thanks to years of source code fine-tuning by this group of dedicated volunteers, Linux has achieved enterprise-class reliability, ease of administration and outstanding performance. In just a few years, Linux has evolved from a fast-growing upstart in the server market into a well-respected system trusted to run mission-critical applications in networks (where it resides on 25 percent or more servers) and on desktops. While the number of Linux users is difficult to pin down since the software can be downloaded from the Internet for free, estimates are at least 5 million to 8 million users, and those numbers are growing at a breathtaking pace (212 percent in 1998). Linux delivers more speed and power from the hardware (especially Intel Architecture, on which it was originally developed) and provides better security than many commercial alternatives and is very reliable (fewer crashes).

The Linux Kernel

The Linux operating system, like UNIX, is split into a kernel and various system programs. The kernel is low-level software that is always present and handles the interface to peripheral hardware, schedules tasks, allocates storage and presents a default interface to the user when no application program is running. The various system programs use facilities provided by the kernel to perform higher-level housekeeping tasks, often acting as servers in a client-server relationship.

The currently released version of the kernel is 2.2, with 2.4 expected to be released soon. Kernel version numbers are significant: The odd-numbered series (e.g., 2.3.xx) are the development (or beta) kernels, which evolve very quickly. Stable (or release) kernels have even-numbered major version numbers (e.g., 2.2.xx).

Linux 2.2 was a major milestone in Linux’ evolution: It was the first kernel release that caught the eye of mainstream media. A great improvement over Linux 2.0, version 2.2 supported many new file systems and was much more scalable than Linux 2.0.

Linux 2.4 will build on the advancements provided with Linux 2.2 to become an even better platform for desktop, server and embedded tasks. Version 2.4 offers improved operation with multiple processors, support for larger file sizes, more robust memory management and more sophisticated asynchronous I/O handling.

See the white paper Linux Scalability: The Enterprise Question for a detailed discussion of scalability issues for database applications on Linux, especially Oracle.

Linux Operating System Features That Support Oracle8i

Here’s a brief list of the Linux kernel features that support high-availability operation of Oracle8i.

• Shared memory
• Symmetric multiprocessing (SMP) support
• Interprocess communication, signal handling and concurrency control
• Support for threads
• Extended memory support
• Large file size (> 2 GB) support

Optimized Linux/Oracle Solutions

One of Linux’ strengths is that it can be tailored to optimize its support for various applications, including Oracle8i. Red Hat, Inc. recently released Red Hat Linux Enterprise Edition Optimized for Oracle8i. Modifications to the kernel include a reduction in its overall size, the removal of unnecessary processes and streamlined operations to optimize database functionality. For example, input/output handling was improved to ramp up sustained data transfer rates, and memory-addressing improvements were made to better scale to accommodate large databases. For more information, see http://www.redhat.com/products/linux_oracle/.
Oracle8i Overview

Built on the object support of its predecessor Oracle8, Oracle8i is a relational database that delivers the ability to organize, access and manipulate a wide range of data in a wide range of formats, including conventional relational tables, legacy databases and ordinary user files. Web access through generated HTML pages, object connectivity through built-in ORB support and process support through a new Java* virtual machine in the DBMS server combine to make Oracle8i an enterprisewide, Internet-enabled information system platform. Businesses appreciate its full integration and management of current and legacy data, from IS databases to complex data and local files. It can deliver rich presentation of their content, with access available through commonly available facilities, including Web browsers, file systems, SQL, ODBC and analytical applications.

Oracle8i’s OLTP background provides a technology base that ensures reliability and availability, even during peak periods. In addition, Oracle8i offers a sophisticated, layered approach to workload management using queues and parallel processing. It involves providing consistent support for all kinds of requests with dynamic load-balancing capability. Oracle8i also provides a number of availability improvements, including a new fast-start fault recovery architecture that provides fast and predictable recovery from faults; online reorganization capability allowing users to reorganize tables, partitions, and indexes without taking down the database; and a significantly better standby database and catastrophic recovery capability. Together, these facilities support smooth operation, continuous availability and high performance as service demand fluctuates.

Key Oracle8i Features

Following is a brief summary of features within Oracle that support high-availability operation:

- 100 percent ANSI/ISO SQL 92 Entry Level compliant: NIST tested
- Transactional processing
- Large database support
- High-availability features
- Online backup by file, tablespace or database
- Online recovery
- Mirrored, multisegment log files
- National language support
- Systems management and ease of administration
- Concurrency control and declarative integrity constraints
- Programming interfaces including JDBC and SQLJ for Java* applications

System Downtime Equals Lost Business

Reliability standards have increased awareness of the need to provide 24 X 7 operations to:

- Meet customer expectations
- Avoid quantifiable losses, such as lost revenue and productivity
- Avoid losses that are more difficult to quantify, but are just as damaging (e.g., loss of opportunity, damaged reputation and compromised competitive position).

In the fast-paced, highly competitive world of Web-based business, for example, one hour of downtime can cost a firm thousands, or even millions, of dollars an hour (see Table 1). Home shopping channels can incur a loss of nearly $113,000 an hour. Gartner Group and Dataquest studies project that in 1999 alone, downtime cost U.S. firms in excess of $4.6 billion.

High availability is a widely used term applied to a broad spectrum of technologies and techniques that are used to create and maintain computer systems that function continuously, with acceptable and predictable performance. There are different levels of availability, but little standardization in

<table>
<thead>
<tr>
<th>Business</th>
<th>Cost per hour of downtime*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brokerage</td>
<td>$6.45 million</td>
</tr>
<tr>
<td>Credit card/sales authorization</td>
<td>$2.6 million</td>
</tr>
<tr>
<td>Home catalog sales</td>
<td>$90,000</td>
</tr>
<tr>
<td>Airline ticketing</td>
<td>$89,500</td>
</tr>
<tr>
<td>Tele-ticket sales</td>
<td>$69,000</td>
</tr>
<tr>
<td>Package shipping</td>
<td>$28,000</td>
</tr>
<tr>
<td>ATM fees</td>
<td>$14,500</td>
</tr>
</tbody>
</table>

Table 1. Cost of downtime in dollars per hour. Source: Strategic Research Division of Find/SVP (http://www.steel-eye.com/support/whitepaper1.html, 7 Sep 2000).
the terms people and vendors use in describing and differentiating various levels. Price is also a differentiator, with systems that ensure the highest level of availability protection (with practically no downtime) being magnitudes more expensive than those that provide very little if any downtime.

According to IDC (High Availability: The Key to the Impact of the Internet on the Server Market by Graham Penn, Nov 1999), the overall growth rate of high-availability servers is almost twice that of the overall server market (14.8 percent versus 8.3 percent).

Levels of High-Availability Protection

The most basic level of availability protection is provided by systems with features (generally hardware related) that help make the server stay in operation longer, such as an uninterruptible power supply (UPS) or mirrored disk (RAID). While these systems protect from hardware failures, they offer little or no protection for the applications or networked environment running on the system. This is the lowest-cost form of high-availability protection.

Fault resilience is the next level of protection. In this scheme, software, in addition to hardware solutions, is added that prompts other servers to take over for failed servers or failed applications. When a system fails or is brought offline for maintenance, other systems can immediately take over so that the switch is completely transparent to clients. This kind of switching is called failover protection. There are various ways to implement failover, but in general fault resilience provides adequate high-availability protection at manageable cost.

The highest level of protection, and the most expensive, is fault tolerant. Far from being tolerant of faults, in these systems, hardware is redundant to the point that no single element exists that can cause system failure. They provide for an average of five minutes or less of downtime per year, but are not affordable for most companies.

Fault Resilience Basics

Clustering, pioneered by Digital Equipment in the 1980s, ties several servers together so that they work as one, adding both redundancy and failover capabilities to a system. It increases the horsepower of the server and provides reliability benefits — that is, if one server fails, the application can disperse its processes across the remaining servers instead of crashing the entire system. Clusters are free or cheap and can be very large and highly available. There is a wide variation between clustering capabilities between different vendors and operating systems; Oracle operates well in all leading clustered environments, including Linux.

Cluster parallel processing offers several important advantages:

- Every machine in a cluster can be a complete system, usable for a wide range of other computing applications.
- Most of the hardware needed to build a cluster sells in high volume, with low “commodity” prices as the result. Further savings come from the fact that only one video card, monitor and keyboard are needed for each cluster (although you will have to swap these to each machine to perform the initial installation of Linux; once running, a typical Linux-based PC does not need a console).
- Cluster computing can scale to very large systems. While it is currently hard to find a Linux-compatible SMP with much more than four processors, most commonly available network hardware easily builds a cluster with up to 16 machines. With a little work, hundreds or even thousands of machines can be networked. Replacing a failed machine within a cluster is trivial compared to fixing a partly faulty SMP and yields much higher availability for well-designed cluster configurations. This becomes important not only for particular applications that cannot tolerate significant service interruptions, but also for general use of systems containing enough processors so that single-machine failures are fairly common. (For example, even though the average time to failure of a PC might be two years, in a cluster with 32 machines, the probability that at least one will fail within six months is quite high.)

<table>
<thead>
<tr>
<th>Availability Protection</th>
<th>Percent of uptime</th>
<th>Average downtime per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Availability</td>
<td>99 percent</td>
<td>8.5 hours</td>
</tr>
<tr>
<td>Fault Resilience</td>
<td>99.99 percent</td>
<td>53 minutes</td>
</tr>
<tr>
<td>Fault Tolerant</td>
<td>100 percent</td>
<td>5 minutes or less</td>
</tr>
</tbody>
</table>

Table 2: Average downtime per year based on the level of high availability protection employed. Source: SteelEye, Inc. (http://www.steeleye.com/support/whitepaper2.html, 15 Sep 2000).
Failover Basics

In the simplest failover situation, two systems are participating: the primary, or active, server and the secondary server that will take over when the primary fails. If the secondary server is sitting idle while waiting to take over, it is considered passive. If the secondary server is occupied with server tasks of its own while also waiting to take over, it is considered to be active as well (and its own active processes must be safeguarded when a failover occurs). In the section Setting Up an Automated Standby Database in this paper, the procedure for setting up an active-passive Oracle database server failover is described.

Other common failover schemes are differentiated by the readiness of the standby system to take over in case the primary system fails.

Cold failover: Failover begins when a node fails and notifies a second node; the database is started and the recovery process begins. This is the slowest failover approach.

Warm failover: When failover begins, the second node is already operational, but some overhead is involved to synchronize the new node with the operations and state of the failed node.

Hot failover: For all intents and purposes, the secondary node is immediately ready to act as the production node if there is a failure.

Oracle Parallel Server (OPS) is a clustered database with failover built in, but it is not yet available for release on Linux. Therefore, to set up automatic failover for Oracle8i on Linux, you need to apply one of the solutions described in this white paper.

Introducing Automated Standby Databases

An automated standby database is a means to create and maintain a remote copy of a production database, so that critical data is protected from loss in case some harm befalls the production server or it requires planned maintenance that takes it offline. In that event, the standby database can take over processing from the primary production database, providing near continuous database availability.

For customers needing high-availability failover capabilities (and for whom OPS is not a solution), Oracle recommends using standby (failover) databases. This architecture uses Database Replication via snapshots and/or triggers and automated operating system file copying (for the database's archived redo logs) to duplicate the primary database to remote nodes with warm standby databases. Standby databases are the simplest-to-setup, lowest-cost option for full high-availability database failover.

Supporting the Oracle standby database architecture are Linux' underlying failover mechanisms. After a service failure is noted, the primary database server is shutdown, the predefined standby database servers are switched into hot mode and incoming requests are seamlessly redirected.

Database replication is the process of running and maintaining multiple databases that make a single distributed database system. The process keeps the databases synchronized so that when a failure happens on the active server, failover to the secondary server can take place with minimum data loss.

![Figure 1: The standby database takes over data processing and serving after a disaster befalls the production server.](image-url)
Products such as SteelEye LifeKeeper* for Linux and Legato* Cluster* on Linux handle the process of setting up an automated standby database with replication, making these products particularly attractive.

Setting Up an Automated Standby Database

The following instructions describe the process for setting up an active-passive failover solution for Oracle on Linux.

Step 1: Install Linux

Install Oracle8i on Linux Red Hat 6.1 on both the primary and secondary servers following the instructions found at http://technet.oracle.com/tech/linux/htdocs/install.pdf.

[NOTE: You need a password to access these instructions.]

1) Oracle8i requires the following software and versions. If you do not have these programs and versions, download them from the locations shown below.
   Java Runtime Environment (JRE) 1.1.6v5: http://www.blackdown.org/
   TCL 7.5: http://www.ajubasolutions.com/
   Oracle8i for Linux patch set 8.1.5.0.2: http://technet.oracle.com/support/tech/linux/support_index.htm
   [NOTE: You need a password to access this information.]

2) As the root user, perform the following tasks.
   a. Set up JRE if necessary.
   b. Make gmake available as a command.
   c. Make sure there is enough disk space (800 MB) and memory (256 MB).
   d. If necessary, clean up after any previous attempts to install Oracle by removing files that may otherwise interfere with installation.
   e. Set up a directory, group owner and account for Oracle.
   f. Change the ownership of the database mount points to the Oracle account.
   g. Set the password for the Oracle account.
   h. Mount the Oracle8i CD.

3) Set up the Oracle8i account.
   a. Log onto the Oracle account.
   b. Set up the protection mask for installing the software.
   c. Edit the profile or login script for the shell you are using to contain all the following environment variables.

   #
   # Oracle Stuff Goes Here
   #
   ORACLE_HOME=/usr/local/oracle/8i/u01/app/oracle/product/8.1.5
   ORACLE_BASE=/usr/local/oracle/8i/u01/app/oracle
   export ORACLE_HOME ORACLE_BASE
   NLS_LANG='english_united kingdom.w8iso8859p1'
   ORA_NLS33=$ORACLE_HOME/ocommon/nls/admin/data
   ORACLE_TERM=vt100
   LD_LIBRARY_PATH=$ORACLE_HOME/lib
   PATH=$PATH:$ORACLE_HOME/bin
   export NLS_LANG ORA_NLS33 PATH LD_LIBRARY_PATH
   #
   # Java Stuff Goes Here
   #
   export JAVA_HOME=/usr/local/jre
   export PATH=$JAVA_HOME/bin:$PATH

   d. Execute the profile or login script you just edited to set up the environment for the installer.
   e. Verify that the environment variables have been set and are valid.

4) Install the Oracle8i software.
   a. Start the Oracle Universal Installer, and respond to the prompts and instructions it presents.
   b. Install the Oracle8i for Linux patch set.

5) Create a database for Oracle8i.
Step 2: Set Up the Standby Database

1) Copy, or clone, the production database on the primary server to the secondary server.
2) The production server normally creates log files, so maintaining a standby database does not impose additional logging requirements on the production server.


Step 3: Set Up Synchronization

The standby database must be resynchronized with the production database on a regular basis to support failover with minimum lost data and lost time.

Automatic Synchronization

Automatic resynchronization provides additional insurance and reduces the possibility of human error. Follow these steps to set up an automatic resynchronization process.
1) Place standby database in sustained recovery mode.
2) As archived redo logs are generated by the primary (production) system, they are transferred to the secondary (standby) system.
3) After logs are received by the secondary system, they are automatically applied to the standby database.

Enhanced Synchronization

To transfer the log files more efficiently and prevent bottlenecks if the volume of database change is high, you can set up one or more ARCHiver processes.

Manual Synchronization

Resynchronize the standby database using the log files from the production database.

Figure 2: Manual synchronization of the production and standby databases.

Figure 3: Automatic synchronization of the production and standby databases eliminates a potential source of human error and increases database and application availability.

Setting Up Replication

Replication is the process of copying and maintaining database objects in multiple databases that make up a distributed database system. Internet systems use distributed databases and replication to improve performance for different geographic areas, ensure high availability and increase scalability. To set up replication, follow the guidelines in http://www.oracle.com/database/documents/o8i_adv_replication_fo.pdf.
SteelEye LifeKeeper for Linux

SteelEye Technology, Inc., a privately held, Mountain View, Calif., company, created a product called LifeKeeper for Linux that enables the automatic system and application recovery from a system failure. LifeKeeper’s application awareness is a key feature. The product is descended from a UNIX-based equivalent from NCR and has already established a favorable performance track record in the commercial community. The company was funded in December, 1999 and is an active member of the Linux community, committed to working with organizations and other vendors to help make Linux a key part of enterprise computing.

Based on a flexible cluster framework, LifeKeeper ensures continuous computer operations even in the event of multiple system failures. It provides for communication between servers in a cluster via a digital “heartbeat.” The heartbeat is a signal between server nodes to determine system and application health. When LifeKeeper detects an event that can create an interruption in a server’s availability, or the availability of the application, it automatically moves the protected resources and applications to another server in the cluster. This switchover is transparent to users, so a system failure does not impact users’ productivity.

What LifeKeeper does:
- Detects application and system failures
- Restarts application(s) on alternate servers
- Transfers network addresses
- Returns the recovered system back into the cluster

For more information, see http://www.steeleye.com/.

Legato Cluster Enterprise on Linux

Legato Systems, Inc. produces products to help companies leverage their business-critical, corporate data assets. Founded in 1988, the company makes its products available through a network of Legato-licensed resellers, integrators and OEM partners. It has approximately 60,000 customers.

Legato Cluster Enterprise on Linux is a heterogeneous, high-availability software solution that supports the Linux operating system (specifically, Caldera OpenLinux eServer 2.3 and Red Hat Linux 6.2).

What Legato Cluster Enterprise does:
- Detects system failures and restarts Oracle on another server
- Detects Oracle application failures and restarts Oracle, either on the same Linux-based server or on another server (configurable by the system administrator)
- Transfers network addresses
- Switches to a standby database
- Provides availability tracking

For more information, see http://www.legato.com/.
Summary

High availability an important part of an e-Business solution. In an increasingly interconnected world, customer expectations of reliability are high and globalization and 24 X 7 availability are assumed. As more and more people use the Internet to stay in touch, do business and play, the need for high-availability strategies will grow.

A few different approaches can be taken to achieve high reliability, from beefing up servers using redundant hardware (such as RAID) to creating clusters so that each node (or server) in the cluster is able to take over from any failures of partner nodes. The Linux operating system, which is known to be very stable, is an ideal candidate regardless of the specific approach selected. Oracle8i provides a number of availability features, including standby database capability that supports continuous operation, with acceptable and predictable performance.

As the need for a flexible, yet powerful architectural environment emerges from the Internet model, the need for a building block computing framework becomes increasingly important. Building blocks will allow businesses to deploy not only the right sizing according to their needs, and also for affordable redundancy, cost-effective serviceability and the overall lowering of cost.

Intel Solution Services are a critical part of the effort to deliver optimal e-Business solutions utilizing Intel Architecture based building blocks. Through a suite of cutting edge-services and state of the art centers, they offer services to test, tune and optimize companies’ computing infrastructure. These services provide customers with the technical expertise to deploy leading edge solutions effectively and efficiently.

For more information on Intel Solution Services, please visit: http://developer.intel.com/software/idap/services.

Additional Resources

- http://www.steeleye.com/support/whitepaper2.html
  [NOTE: You need a password to access this information]
- http://www.legato.com
  [NOTE: You need a password to access this information]
- http://yara.ecn.purdue.edu/~pplinux/ppcluster.html

References


4 These numbers represent losses in sales revenue and productivity only. They don’t include intangible losses, such as losing customers who migrate to competitors.