Comparing Data Protection Solutions: Database-Integrated or Storage-Centric

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Database High Availability
Program

• Part I
  – Business Problem
  – Overview of 3rd party data protection solutions
  – Overview of Oracle-integrated data protection solutions

• Part II
  – Availability Comparison
  – Reducing Cost and Increasing Utilization
  – Summary of Benefits
Murphy’s Law?

From Oracle’s SR Database

- n node RAC … disks failed and no longer available … Backup was running when disks died.
- Database has only been backed up ONCE many years ago … Customer’s attempt at a backup strategy. Unfortunately disks and database died.

From a recent email

Subject: Data Guard ..
Date: Fri, 09 Oct 2009 17:42:44
To: Carpenter,Larry
XYZ is still trying to catch up after their data center got hit by lightning. [...]
**Business Problem**

**Reduce Run-time Costs**
- Utilize all systems resources – no idle components
- Keep it simple, automated, integrated

**Data Protection – RPO**
- Minimize data loss after disaster
- Isolate data faults so that valid data can still be accessed

**High Availability – RTO**
- Minimize unplanned & planned downtime
- Ensure full-stack application availability
What is a Disaster?

- Headline-grabbing disasters such as
  - Fire, earthquake, tsunami, flood, hurricane, …

- And . . . more mundane and frequent events such as
  - Faulty system components – server, network, storage, software, …
  - Data corruptions
  - Backup/recovery of bad data
  - Wrong batch job
  - Bad hardware & software installations / upgrades / patching
  - Operator errors
  - Power outages
  …
Real-life Disaster
Flood at Data Center Premises

Play Video
• Errors observed in the alert.log of the production database:

Errors in file /opt/app/oracle/admin/dg/bdump/dg1.trc:
ORA-01186 : file 93 failed verification tests
ORA-01122 : database file 93 failed verification check
ORA-01110 : data file 93: '/dbmnt/db01/oradata/dg/arch05.dg'
ORA-01251 : Unknown File Header Version read for file number 93

ORA-01251 - Corrupted file header. This could be caused due to missed read or write or hardware problem or process external to oracle overwriting the information in file header.

• Affected: primary customer facing applications for trade transaction confirmation, new accounts, and customer account information
Data Corruptions
Severe Impact on Data Availability

• Any component in the systems stack can fail and cause data corruptions*
  – Software – applications, middleware, database, …
  – Hardware – disk drives, disk controllers, HBAs, memory, …
  – Network – routers, switches, cables, …
  – Operational – human errors, bad installs & upgrades, …

• Data corruptions can be disastrous

• Very hard to debug and diagnose

Program

• Part I
  – Business Problem
  – *Overview of 3rd party data protection solutions*
  – Overview of Oracle-integrated data protection solutions

• Part II
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Storage-Centric Data Protection Solutions

**Criticality of Data**

- Storage Mirroring over WAN
- Continuous Data Protection (CDP)
- Snapshots
- Nearline Disk Backups
- Tape Backups

**Granularity of Data Protection**
Backup & Recovery

Data Protection 101

- A backup preserves full database state, enabling recovery from human errors, media failures, or site disasters
- Backup media: tape, disk, VTL, Cloud
- Coarse access granularity: datafiles, whole databases
- Backup products typically protect both database & non-database data
VTL & Deduplication
Optimize Backup & Recovery

- **VTL (Virtual Tape Library):**
  - Software or Appliance that makes a disk array emulate a tape library
  - Improves backup & recovery performance
  - Minimal disruption to existing tape backup infrastructure

- **Deduplication:**
  - Replace redundant data with pointers to shared copy
  - Lowers storage costs by reducing capacity requirements
  - Can be done inline or post-process

- **Note:** *RMAN block-level incremental backups inherently deduplicated*
Storage-level Snapshots
Application-agnostic Storage-state Undo

• Preserves disk state at specific time
  – Upon later error, system can be set back to that point

• Quiesce application*, copy metadata state, then begin “branching” writes to snapshot storage
  – Branch via copy-on-write, redirect-on-write, or split-mirror
  – Extra write overhead often absorbed by storage hardware

• Low space and setup cost
  – Easy to take many snapshots
  – Easy to restore to point prior but near error
  – Split-mirrors protect from media failures, but increase space costs

* Note 604683.1 - Supported Backup, Restore & Recovery Operations using 3rd Party Snapshot Technologies
Storage-level Snapshots

Example

Data Blocks

Active Version

Snapshot 1
Continuous Data Protection (CDP)
Create a Separate Copy of Every Disk Write

- Split writes: each time data are written to disk, a copy is sent to a separate location (asynchronously)
  - Similar to snapshots, but every disk update is captured
  - Application agnostic, but at recovery time it is complicated to choose the consistent point to go back to
  - CDP may be space-efficient by saving byte- or block-level differences rather than entire write
  - High-frequency snapshots sometimes considered CDP

- Write may be split at host (driver) or at switch
  - Unsynchronized CDP of 2+ filesystems may cause corruption, so CDP infrastructure failures require careful management

- Works best for simple filesystems and manual recovery
Storage Mirroring

Block-level Disaster Recovery

- Storage array controllers at the primary site send changes to a similar storage array (mirror) at the secondary site
  - As I/Os occur at the primary server, data is written to the cache of the source array, and placed in a queue
  - The link adapter dequeues and moves data to the mirrored array
  - Supports synchronous/asynchronous writes
  - Protocols supported: ESCON, FICON, Fibre Channel, IP – controlled by specialized adapters loaded with appropriate microcode
- Target arrays unavailable for data access
Storage Mirroring Configuration

Primary Site

Application Access

Secondary Site

Database Server

SAN Switch

Storage Array

Storage Mirroring FC / IP
Program

• **Part I**
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  – Overview of 3\textsuperscript{rd} party data protection solutions
  – *Overview of Oracle-integrated data protection solutions*

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Oracle Backup & Recovery
Integrated Disk, Tape & Cloud Backup

- Recovery Manager (RMAN) underlies Oracle’s Integrated Backup & Recovery
  - Block validation
  - Online block-level recovery
  - Unused block compression
  - Online, multi-streamed backup
  - Native encryption

- Integrated backup technologies:
  - Fast Recovery Area: Disk backup
  - Oracle Secure Backup: Tape backup
  - Oracle Secure Backup Cloud Module: Cloud backup
Flashback Technologies
Error Detection & Correction

• Flashback revolutionizes error recovery
  – View ‘good’ data as of a past point-in-time
  – Simply rewind data changes
  – Time to correct error equals time to make error

\[ \text{Correction Time} = \text{Error Time} + f(\text{DB\_SIZE}) \]

• Low impact, easy – simple commands, no complex procedure
  • Flashback Query, Table, Transaction, Database, Drop
  • E.g.: SQL> flashback database to <timestamp>;

Traditional Recovery

Recovery Time (mins)

Flashback

80
60
40
20
0
ASM supports ALL data - database files, file systems, Clusterware files (OCR, Voting Disk)
Built-in mirroring protects from disk failures
Enables auto-repair from corrupt blocks using a valid mirror copy
Oracle Data Guard

Oracle Disaster Recovery

Production Database

Broker

Sync or Async Redo Shipping

Physical Standby

physical_data

Backup

Logically Standby

Logical Standby

Logical Standby

Open R/O with Active Data Guard

Open R/W for peripheral writes

Network

Chicago

Dallas

Boston

Transform Redo to SQL

SQL Apply

Redo Apply

Oracle Data Guard

Oracle Disaster Recovery
Data Recovery Advisor (DRA)

• Oracle Database tool that automatically diagnoses data failures, presents repair options, and executes repairs at the user's request

• Determines failures based on symptoms
  – E.g. an “open failed” because datafiles f045.dbf and f003.dbf are missing
  – Failure information recorded in Automatic Diagnostic Repository (ADR)
  – Flags problems before user discovers them, via automated health monitoring

• Intelligently determines recovery strategies
  – Aggregates failures for efficient recovery
  – Presents only feasible recovery options
  – Indicates any data loss for each option

• Automatically performs selected recovery steps

• Accessed via RMAN or EM
Remember Data Corruption Incident?

Oracle HA in Action

ORA-01251 - Corrupted file header. This could be caused due to missed read or write or hardware problem or process external to oracle overwriting the information in file header.

They had already implemented Data Guard
- Corruptions isolated to the primary database
- Failed over to standby database
- Resumed operation in minutes
- Investigated & resolved hardware problems with no impact
Comprehensive Oracle Data Validation

• Oracle Database has checks to detect and repair corruptions
  – Detects corruptions in data and redo blocks using checksum validation
  – Detects data block corruptions using semantic checks
  – Detects writes acknowledged, but actually lost by the I/O subsystem

• Various levels of checks can be configured by the administrator
  – Choose the desired protection level
  – Can be configured for data blocks / data + index blocks

• Specific technologies provide additional validation
  – RMAN – validating while doing backup & recovery
  – ASM – validating using mirrored copies
  – Data Guard – validating while synchronizing standby database
Oracle Maximum Availability Architecture
Robust & Integrated Data Protection

Production Site

Database

Storage

Data Recovery Advisor
Intelligent, Guided Recovery Analysis

Flashback Technologies
Correct Errors by Moving Back in Time

Active Data Guard
Fully Active Failover Replica

Standby Site

Database

Storage

Recovery Manager (RMAN) & Oracle Secure Backup (OSB)
Low Cost, High Performance Backup & Recovery
Program

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Oracle’s HA Design Principles

1. Scale-out model
   - Based on low-cost commodity hardware
   - Ensure all components active in a grid infrastructure

2. Application oriented
   - Protect and recover application objects
   - Enable online application changes

3. Integrated and simple
   - Provide built-in high availability with pluggable components
   - Automate to eliminate manual touch points

4. Complete
   - Minimize all planned and unplanned downtime
   - Offer a standard validated platform for maximum availability
Oracle IT – Supporting 90,000 Users

Beehive Office Applications

• Beehive – Oracle’s unified collaboration solution
  – Email, instant messaging, conferencing, collaboration, calendar …
  – Oracle Database 11.1.0.7
MorphoTrak

Printrak Biometrics Identification Solution

• Chosen by FBI as Biometric Provider for Next Generation Identification Program *
• Goal – high availability and disaster recovery at minimal cost

Read-write transactions

Data Guard Maximum Availability - SYNC
continuous redo shipping, validation and apply
(up to 10ms network latency - approx 60 miles)

Read-only transactions

Active Data Guard

• Oracle 11.1.0.7
• Oracle RAC, XML DB, SecureFiles, ASM
• 15TB, 2MB/sec redo rate
• Mixed OLTP – read intensive
• At 10ms network latency, SYNC has 5% - 10% impact on primary throughput

• Automatic database failover (Fast-Start Failover)
• Complements RAC HA
• Remote location provides DR
• Off-load read-only transactions to active standby
• Full utilization reduces acquisition cost
• Simpler deployment reduces admin cost

* http://www.sagem-securite.com/eng/site.php?spage=04010847
Availability and Data Protection
High Availability Criteria

• Handle top failures
  – Component failures (network, host, controller, disk, site)
  – Data failures (physical or logical data corruptions)
  – Transaction centric failures (malicious DDL and DML)
  – Human errors

• Enable fast application availability
  – Automatic failover
  – Application stack integration
  – Consistency between database and non-database and multiple databases

• Reduce downtime for planned maintenance activities
  – System changes (hardware, storage)
  – Software changes (volume manager, OS, database, application)
### Handling Failures

<table>
<thead>
<tr>
<th>Top Failures</th>
<th>Storage Centric Solutions</th>
<th>Oracle Integrated Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component Failures</td>
<td>Excellent HW Redundancy, Storage Mirroring, Clustering, Remote Mirroring</td>
<td>Excellent HW Redundancy, ASM, RAC, Data Guard, DBM</td>
</tr>
<tr>
<td>Data Failures</td>
<td>Insufficient Storage checksums, Stray write detection. Corruptions are propagated. Snapshots and Remote Mirroring do not help.</td>
<td>Comprehensive Oracle Parameters, ASM, Exadata, Data Guard, Auto Block Media Recovery and Lost Writes protection</td>
</tr>
<tr>
<td>Transaction centric Failures and Human errors</td>
<td>Excellent Snapshots, Fast Restore</td>
<td>Excellent ASMFS Snapshots, Restore Points, Flashback technologies</td>
</tr>
</tbody>
</table>

Peter Kelemen, CERN,

“Silent corruptions are a fact of life… Correction will cost time AND money.”

Oracle Active Data Guard

Auto Block Protection

- Automatically repair block corruptions online
  - Application transparent

New in 11.2

Oracle Active Data Guard

Auto Block Protection

- Automatically repair block corruptions online
  - Application transparent

Primary Database

Continuous redo shipping validation & apply

Active Standby Database

Read/Write Workload

Real-time Reporting

Fast Backups
# Reducing Application Downtime

<table>
<thead>
<tr>
<th>Attributes of Fast Application Failover</th>
<th>Storage Centric Solutions</th>
<th>Oracle Integrated Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Failover</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Detection/Trigger Scripts, Cold Clusters, Remote Mirroring Failover</td>
<td>HW Redundancy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASM, RAC, Data Guard, DBM</td>
</tr>
<tr>
<td>Application stack integration</td>
<td>Insufficient</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>VIPs for cluster failover</td>
<td>Timeouts, FAN notification,</td>
</tr>
<tr>
<td></td>
<td>Scripts to restart</td>
<td>Automatic Reconnect,</td>
</tr>
<tr>
<td></td>
<td>application after failover</td>
<td>Integration with RAC and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data Guard</td>
</tr>
<tr>
<td>Data consistency (non-DB files &amp; DB and multiple DBs)</td>
<td>Very Good</td>
<td>Good for 11gR2</td>
</tr>
<tr>
<td></td>
<td>Replication set can include logical set of databases and file system</td>
<td>DBFS, Data Guard, Flashback</td>
</tr>
<tr>
<td></td>
<td>Not always realistic to include everything in one set.</td>
<td>For multiple databases,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>require manual point-in-time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>recovery</td>
</tr>
</tbody>
</table>

“Fast Database Failover does not help when my application takes 3-4 hours to restart.”
Automatic Client Failover

1. Data Guard Automatic Failover
2. Role specific database services start automatically
3. FAN breaks clients out of TCP timeout. TAF automatically reconnects applications to new primary

Primary Database
- Database Services
- Primary Database
- Database Tier - Oracle Real Application Clusters
- Application Tier - Oracle Application Server Clusters

Standby Database
- Standby becomes primary database
- Standby Database
- Standby Database
- Data Guard
- Automatic Failover

ORACLE
Files in the Database Reinvented

- Oracle Database 11g reinvents files in the database
- SecureFiles provides super fast and powerful file storage
  - Removes performance barrier to storing files in the database
- DBFS provides simple file system interface to files stored in the database
  - Enables existing file based tools to access database files
  - Familiar access through pathnames, directories, links
  - Files kept in a dedicated file store, or existing application tables
- Storing business data files inside the database is now simpler, faster, and more robust than storing them outside
Full Stack High Availability

- Application Tier Files stored in DBFS are kept in Sync with DB
  - Full Stack backup and DR
  - The database and the application fail over together
  - Remote site can read files using Active Data Guard
Reducing Downtime for Planned Maintenance

<table>
<thead>
<tr>
<th>Planned Maintenance Activities</th>
<th>Storage Centric Solutions</th>
<th>Oracle Integrated Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>System changes (Hardware, Storage)</td>
<td>Good Clusters allow planned maintenance on idle nodes Rolling upgrade</td>
<td>Excellent Scaling and growing with RAC and Storage GRID ASM rolling upgrade CRS rolling upgrade RAC rolling upgrade</td>
</tr>
<tr>
<td>Software changes Volume Manager, clusterware, OS, database, application</td>
<td>Insufficient No database or application upgrade capabilities</td>
<td>Excellent ASM rolling upgrade CRS rolling upgrade Online Patching RAC rolling upgrade Database rolling upgrade Application rolling upgrade</td>
</tr>
</tbody>
</table>

*Planned downtime typically accounts for over 80% of datacenter downtime.*

*From http://www.regantech.com/*
Zero Downtime
Siebel Demo
## Availability and Data Protection

### Report Card

<table>
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<tr>
<th></th>
<th>Storage Centric Solutions</th>
<th>Oracle Integrated Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure Resolution</td>
<td>Insufficient corruption protection</td>
<td>Excellent</td>
</tr>
<tr>
<td>Application Consistency and Fast Failover</td>
<td>Lack of integrated application failover</td>
<td>DBFS is only in 11gR2</td>
</tr>
<tr>
<td>Reducing downtime for planned maintenance</td>
<td>No support for database or application upgrades</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Oracle’s comprehensive and data centric protection is unrivaled by third party solutions.
Program

- **Part I**
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Reducing Run Time Costs
## Utilizing Available Resources

<table>
<thead>
<tr>
<th>Utilization</th>
<th>Storage Centric Solutions</th>
<th>Oracle Integrated Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Storage</td>
<td>Excellent</td>
<td>Excellent ASM is flexible, Oracle compression, Exadata Hybrid Columnar Compression (10+X)</td>
</tr>
<tr>
<td></td>
<td>Different RAID levels, compression, deduplication</td>
<td></td>
</tr>
<tr>
<td>Snapshots and Clones</td>
<td>Excellent Read only snapshots are fast and easy</td>
<td>Good More Storage Requirements</td>
</tr>
<tr>
<td></td>
<td>Writable snapshots</td>
<td>ASMFS read only snapshots in 11gR2, Restore Points, Incremental backups, Snapshot Standby</td>
</tr>
<tr>
<td></td>
<td>Minimal storage requirements</td>
<td></td>
</tr>
<tr>
<td>Disaster site utilization</td>
<td>Insufficient Backups, Read only and writeable snapshots off the replica but no application scalability using this database resource</td>
<td>Excellent Backups, Snapshot Standby</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Active Data Guard provides read only access with zero sacrifice. GoldenGate, Streams and Logical Standby</td>
</tr>
</tbody>
</table>
Peoplesoft Active Data Guard Demo
### Keeping it Simple … the KISS Principle

<table>
<thead>
<tr>
<th></th>
<th>Storage Centric Solutions</th>
<th>Oracle Integrated Solutions</th>
</tr>
</thead>
</table>
| **Managing Backups, Restores & Recovery** | Excellent  
Taking snapshots and restoring snapshots are quick and easy.  
Backups can be done off the snapshots.  
Can create mirror backups.  
**Snapshots alone do not address corruptions.** | Good  
RMAN incremental backups and backup strategy.  
Integration with OSB  
ASMFS snapshots |
| **Managing Read only or writeable clones** | Excellent  
Read only snapshots are fast and easy  
Writable snapshots  
Minimal storage requirements | Good  
ASMFS read only snapshots in 11gR2,  
Restore Points,  
Incremental backups,  
Snapshot Standby |
| **Managing HA and DR solution** | Good  
Deploying and executing a failover  
**Insufficient** because of lack the application integration | Good  
A lot improvement in simplifying management for RAC and Data Guard.  
Continue to evolve. |
## Reducing Run Time Costs

### Report Card

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<th>Storage Centric Solutions</th>
<th>Oracle Integrated Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>RO and RW snapshots and clones</td>
<td>Great snapshot and cloning technologies</td>
<td>Capabilities exist but not as storage efficient</td>
</tr>
<tr>
<td>Cluster and Disaster Site Utilization</td>
<td>No application scalability with cold clusters or DR resources</td>
<td>RAC scales the app. Active Data Guard scales reads. GoldenGate/Streams</td>
</tr>
<tr>
<td>Manageability</td>
<td>Simple to leverage. Lack application integration for fast failover</td>
<td>Creating and managing clones require more work</td>
</tr>
</tbody>
</table>

Oracle’s *evolutionary* enhancements are reducing overall cost of ownership and removing most advantages of third party solutions.
Program

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Summary

Oracle Integrated Solutions
✓ Clear winner in delivering comprehensive HA and data protection

Storage centric solutions
✓ Provide easy to manage, feature rich capabilities around read only snapshots, writeable snapshots, backups and clone
✗ Lack application integration for failover, limited solutions for planned maintenance activities, insufficient protection from corruptions

Takeaway
✓ When balancing availability, data protection and reducing runtime costs, Oracle integrated solution is your best choice
Maximum Availability Architecture
Complete, Open, Integrated Availability

- Protection from
  - Server Failures
  - Storage Failures
  - Network Failures
  - Site Failures

- Real-time remote standby open for queries
- Human error correction
  - Database, table, row, transaction level
- Online indexing and table redefinition
- Online patching and upgrades
## HA Sessions, Labs, & Demos by Oracle Development

### Sunday, 11 October – Hilton Hotel Imperial Ballroom B
- **3:45p** Online Application Upgrade

### Monday, 12 October – Marriott Hotel Golden Gate B1
- **11:30a** Introducing Oracle GoldenGate Products

### Monday, 12 October – Moscone South
- **1:00p** Oracle’s HA Vision: What’s New in 11.2, Room 103
- **2:30p** Oracle Streams: What’s New in 11.2, Room 301
- **4:00p** Database 11g: Performance Innovations, Room 103
- **5:30p** Comparing Data Protection Solutions, Room 102

### Tuesday, 13 October – Moscone South
- **11:30a** Oracle Streams: Replication Made Easy, Room 308
- **11:30a** Backup & Recovery on the Database Machine, Room 307
- **11:30a** Next-Generation Database Grid Overview, Room 103
- **1:00p** Oracle Data Guard: What’s New in 11.2, Room 104
- **2:30p** GoldenGate and Streams - The Future, Room 270
- **2:30p** Backup & Recovery Best Practices, Room 104
- **2:30p** Single-Instance RAC, Room 300
- **4:00p** Enterprise Manager HA Best Practices, Room 303

### Hands-on Labs Marriott Hotel Golden Gate B2
- **Monday 11:30a-2:00p** Oracle Active Data Guard, Parts I & II
- **Thursday 9:00a-11:30a** Oracle Active Data Guard, Parts I & II

### Tuesday, 13 October – Marriott Hotel Golden Gate B1
- **11:30a** GoldenGate Zero-Downtime Application Upgrades
- **1:00p** GoldenGate Deep Dive: Architecture for Real-Time

### Wednesday, 14 October – Moscone South
- **10:15a** Announcing OSB 10.3, Room 300
- **11:45a** Active Data Guard, Room 103
- **5:00p** Exadata Storage & Database Machine, Room 104

### Thursday, 15 October – Moscone South
- **9:00a** Empowering Availability for Apps, Room 300
- **12:00p** Exadata Technical Deep Dive, Room 307
- **1:30p** Zero-Downtime DB Maintenance, Room 103

### Demos Moscone West DEMOGrounds
- **Mon & Tue 10:30a - 6:30p; Wed 9:15a - 5:15p**
  - Maximum Availability Architecture (MAA), W-045
  - Oracle Streams: Replication & Advanced Queuing, W-043
  - Oracle Active Data Guard, W-048
  - Oracle Secure Backup, W-044
  - Oracle Recovery Manager & Flashback, W-046
  - Oracle GoldenGate, 3709
ORACLE IS THE INFORMATION COMPANY