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# Oracle Database 11g SecureFiles and Database File System (DBFS)

Kevin Jernigan
Senior Director Product Management

Amit Ganesh
Vice President
Data and Systems Technology


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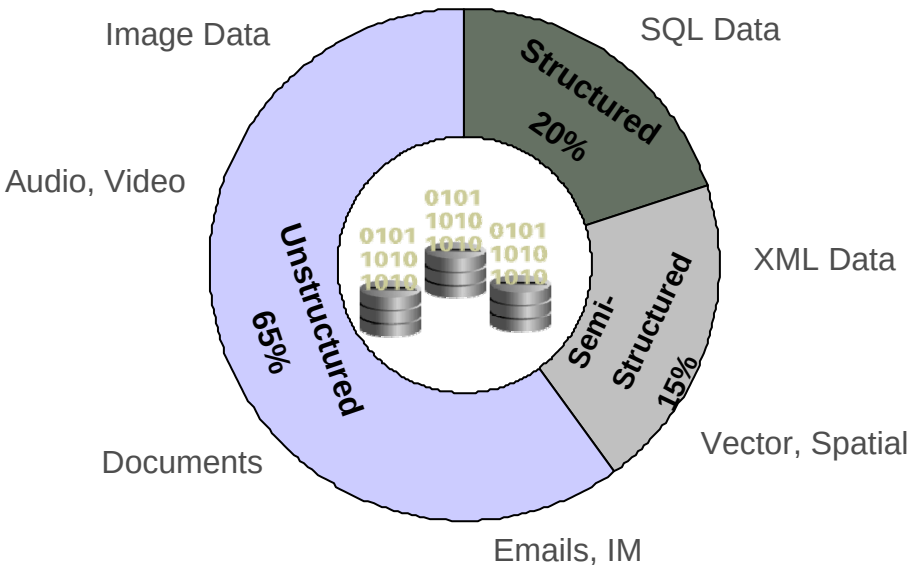
# Agenda

- Enterprise Data
- SecureFiles: Changing the paradigm
- SecureFiles: High Performance
- Database File System (DBFS)
- Summary

# Enterprise Data




Yearly Data Growth

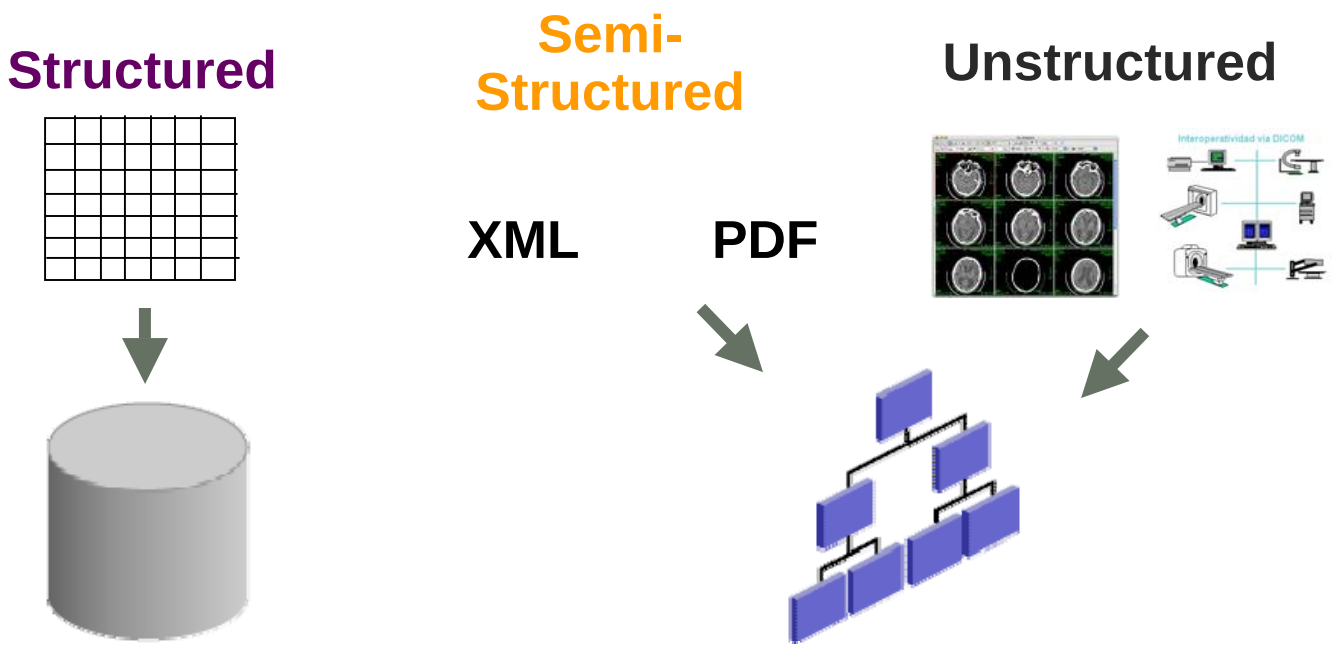
| Data | Growth |
|---|---|
| Structured | 15 - 20% |
| Semi & Unstructured | 50 - 100% |

*** Gartner & IDC Estimates**

- In a typical enterprise, Structured Data is ~20%
- Semi & Unstructured Data represents the other 80%
- Data growth is happening across the board!

# Managing Information

- Organizations need to efficiently and securely manage all data




- Simplicity and performance of file systems makes it attractive to store file data in file systems, while keeping relational data in DB
- Mainstream DBs support ANSI-standard LOBs for storing file data inside DB – performance is a concern for many users

# Files Belong with Relational Data

- Many Enterprise applications manipulate both files and relational data
  - Rich user experience, compliance, business integration
- This split compromises security, robustness, and management
  - Disjoint security and auditing models
  - Changes cannot be made atomically
  - Backup and recovery are fragmented
  - Search across relational data and files is difficult
  - Space management is complicated
  - Separate interfaces and protocols
  - Application architecture more complex

**Two data managers for one application is one too many!**

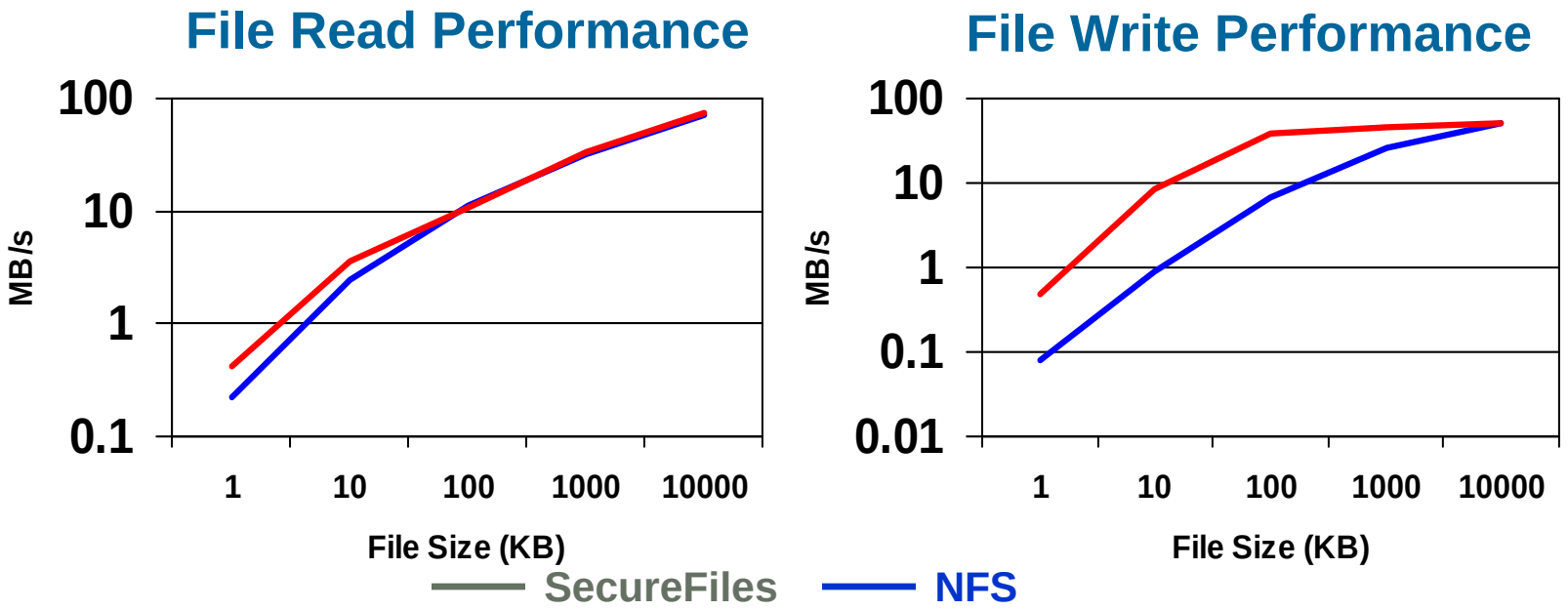
# Oracle SecureFiles

## Consolidated Secure Management of Data

- SecureFiles is designed to break the performance barrier keeping file data out of databases
- Introduced with Oracle Database 11g Release 1
- Similar to LOBs but much faster, and with more capabilities
  - Transparent encryption (with Advanced Security Option)
  - Compression, deduplication (with Advanced Compression Option)
  - Extends the security, reliability, and scalability of database to files
  - Superset of LOB interfaces allows easy migration from LOBs
- Enables consolidation of file data with associated relational data
  - Single security model
  - Single view of data
  - Single management of data

# High Performance

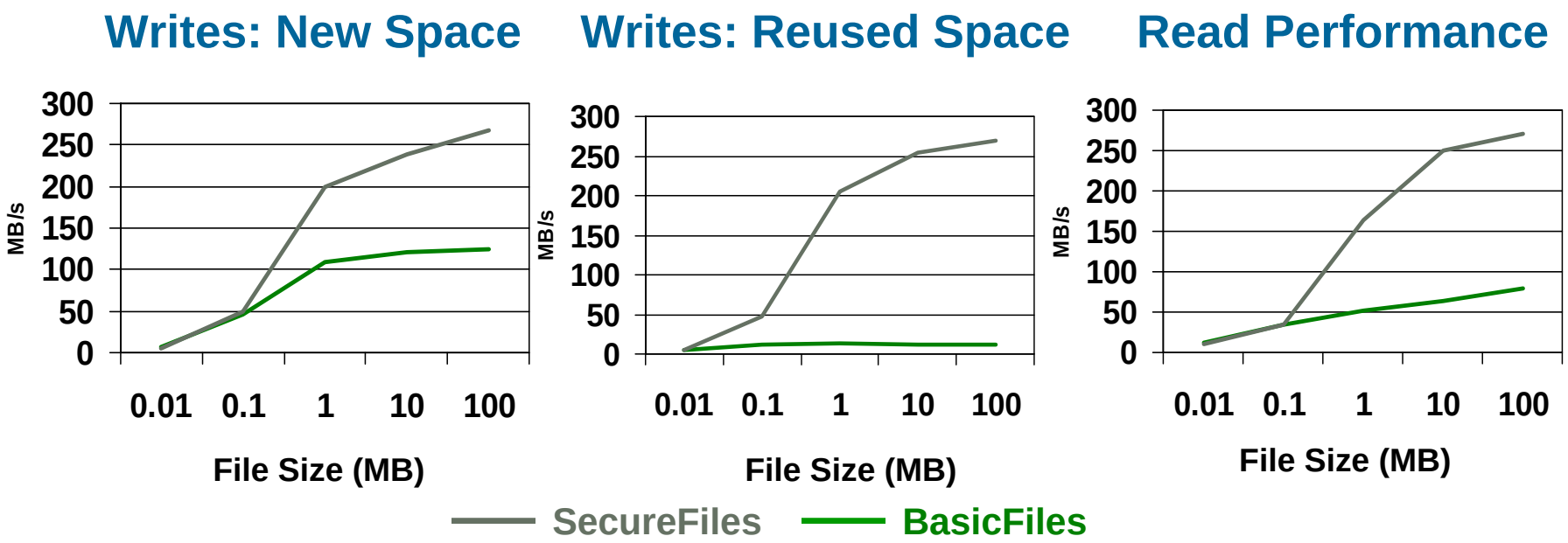
## SecureFiles Vs. NFS




- SQLPlus file test, single stream, single host
- Using SecureFiles is faster across the board
  - 2x-3x faster for Queries, 6x for Inserts
  - Tests run using both SecureFiles and NFS/ext3 in metadata journaling only (default for NFS)
- Filesystem-like performance

# High Performance

## SecureFiles Vs. BasicFiles



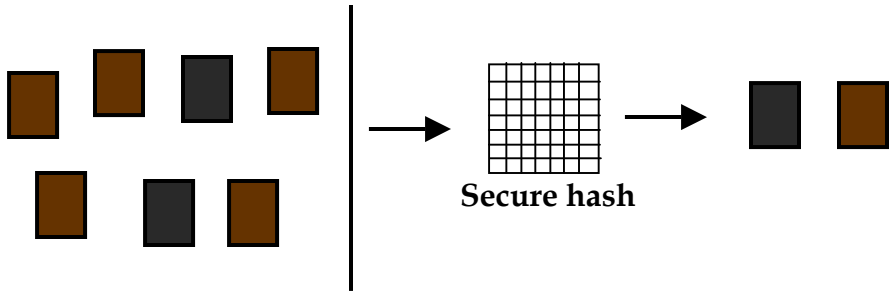

SQLPlus file test: Concurrent Reads/Writes, OCI, 4 streams

- Adding files using new disk space: ***Up to 2x faster***
- Adding files reusing space: ***Up to 22x faster***
- Reads up to ***3x faster***

# Advanced Features - Compression

- SecureFiles supports compression
- Huge storage savings
  - Industry standard compression algorithms
  - 2-3x compression for typical files (doc, pdf, xml)
- Auto-detects if SecureFiles data is compressible
  - Skips compression for already compressed data
  - Skips compression when space savings are minimal or zero
- Server-side compression
  - Allows for random reads and writes to SecureFiles data
- Three levels of compression
  - Compression Levels: LOW, MEDIUM (default), HIGH
  - More latency and CPU overhead for higher compression levels
- Part of the Advanced Compression Option

# Advanced Features - Deduplication




- Enables storage of a single physical image for duplicate data
- Significantly reduces space consumption
- Dramatically improves writes and copy operations
- No adverse impact on read operations
  - May actually improve read performance for cache data
- Especially useful for content management, email applications and data archival applications
- Part of the Advanced Compression Option

# Advanced Features - Encryption

- Extends Transparent Data Encryption (TDE) functionality to SecureFiles data
  - Data encrypted on disk
  - Key management completely transparent to applications
- Support for industry-standard encryption algorithms
  - 3DES168
  - AES192 (default)
  - AES256
- Unified security level for both file and relational data
- Part of the Advanced Security Option

# Out of the Box Benefits

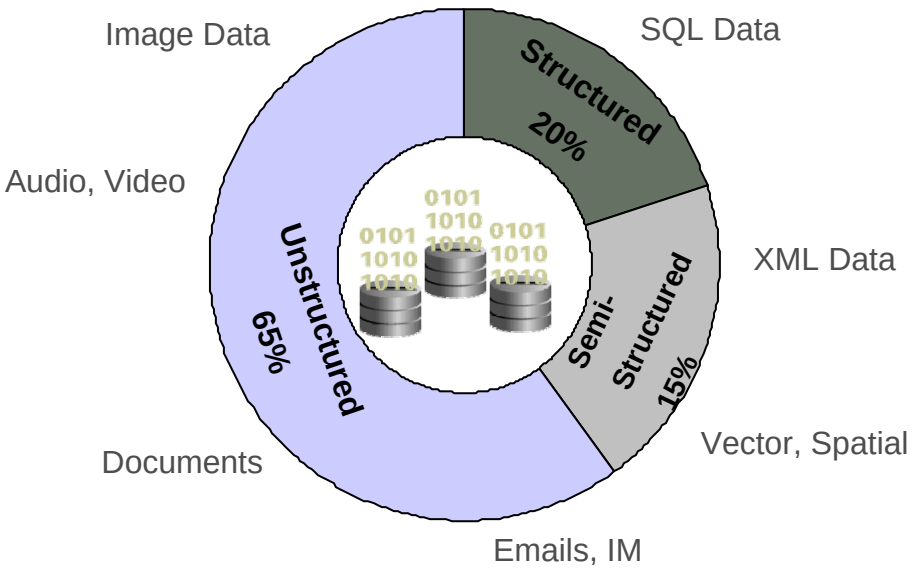
- Easy conversion from LOBs to SecureFiles using Online Redefinition
  - Existing LOB applications benefit with no changes
- SecureFiles can be enabled on new partitions
  - Requires no data migration
  - New data can benefit from high performance and other advanced features of SecureFiles
- New installations
  - By setting db_securefiles= ALWAYS
- SecureFiles is fully integrated with
  - XML DB, Oracle Multimedia, Oracle Spatial, Oracle UCM

# SecureFiles Interfaces

- SecureFiles is 100% backwards compatible with ANSI SQL 92 LOB interfaces
- Database clients use standard LOB interfaces
  - JDBC, ODBC, OCI, OCCI, .NET, PL/SQL

# Database File System - DBFS

# Enterprise Data

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# Kinds of Files

**Personal Files**

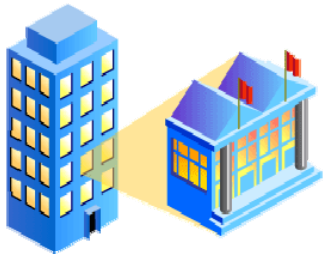
- Kept by users on their computers, usually on a local file system
  - e.g. draft documents, downloaded files, photos

**System Files**

- Files that make a system work
  - e.g. OS, application executables
- Often kept on filers, or cluster file systems. Owned by administrators

**Business Data Files**

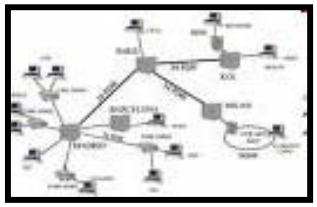
- Files managed by business applications
  - e.g. product images/manuals, reports, contracts
- Often kept in DB for consistency with DB data
- Business critical data

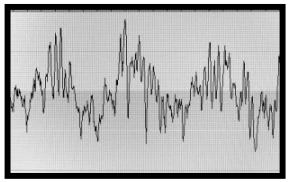


DBFS

# Business Data Files

- Files are an integral part of modern database applications
  - Documents – contract, manual, invoice, report, XML
  - Media Files – product image or video, configuration diagram, X-ray
  - Text Files - ETL file, Script, Application Log, User Comment

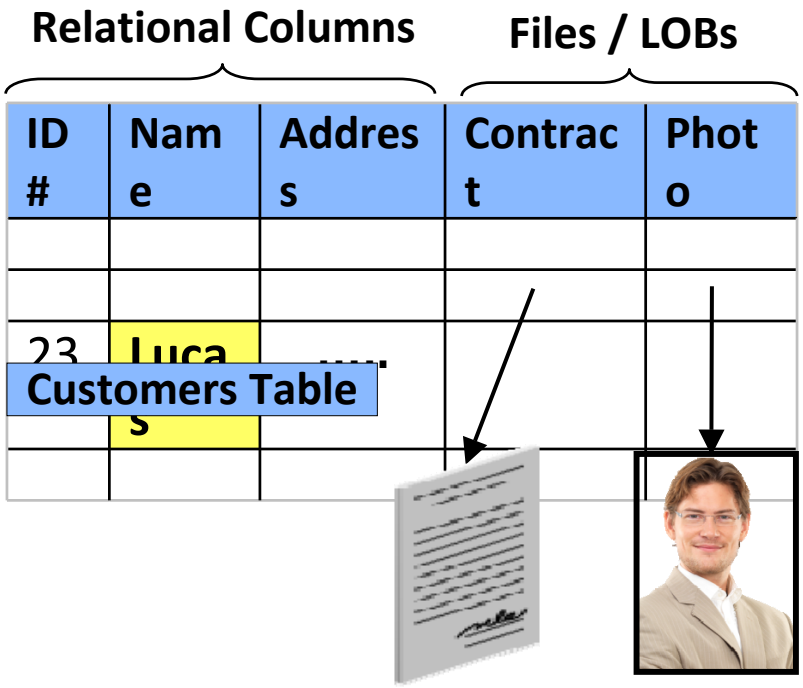






- It is much more robust to store business data files in the database
  - Transactional consistency and unified security, backup, search, etc.
  - Prevent application files from getting out of synch with data
- But files have been treated as second class types in the database
  - Poor performance, limited functionality, unreachable by file based tools

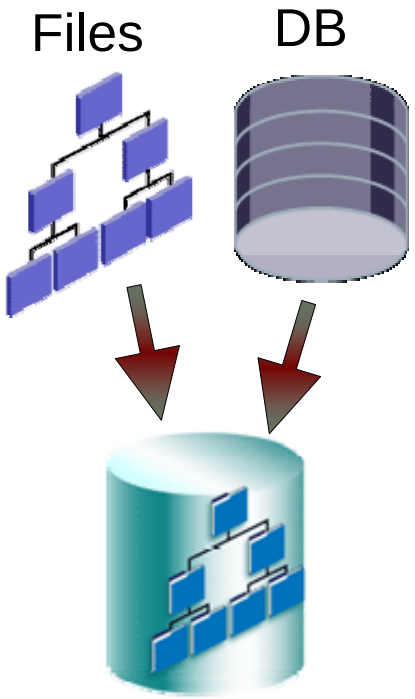
# Business Files in Database Applications

- Database applications store business data files as LOB columns
- 11g SecureFiles LOBs makes files in the database as fast as files in file systems
  - Also provides transactional consistency with database data
- Advanced file management capabilities
  - Compression, Encryption, Deduplication




- But Database LOBs are difficult to access from file-based tools

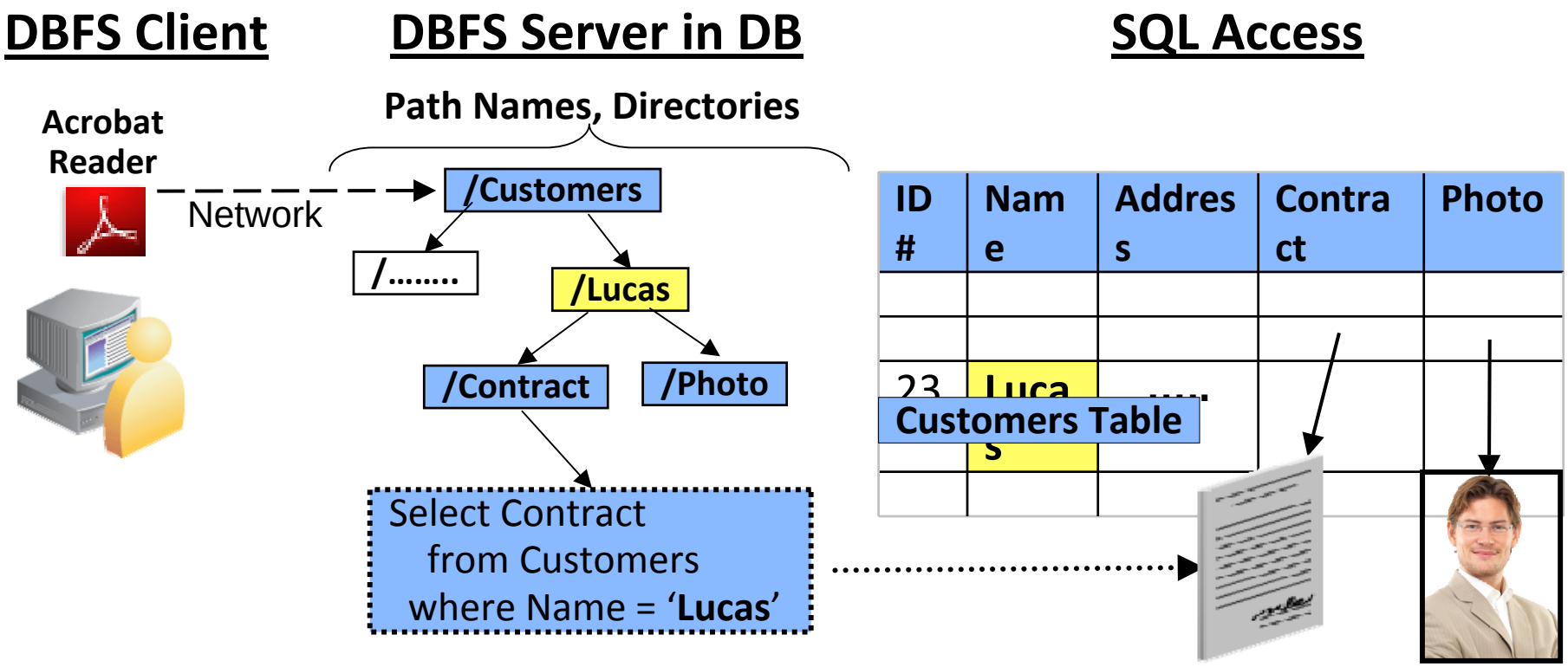
# Files in the Database Reinvented




- 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

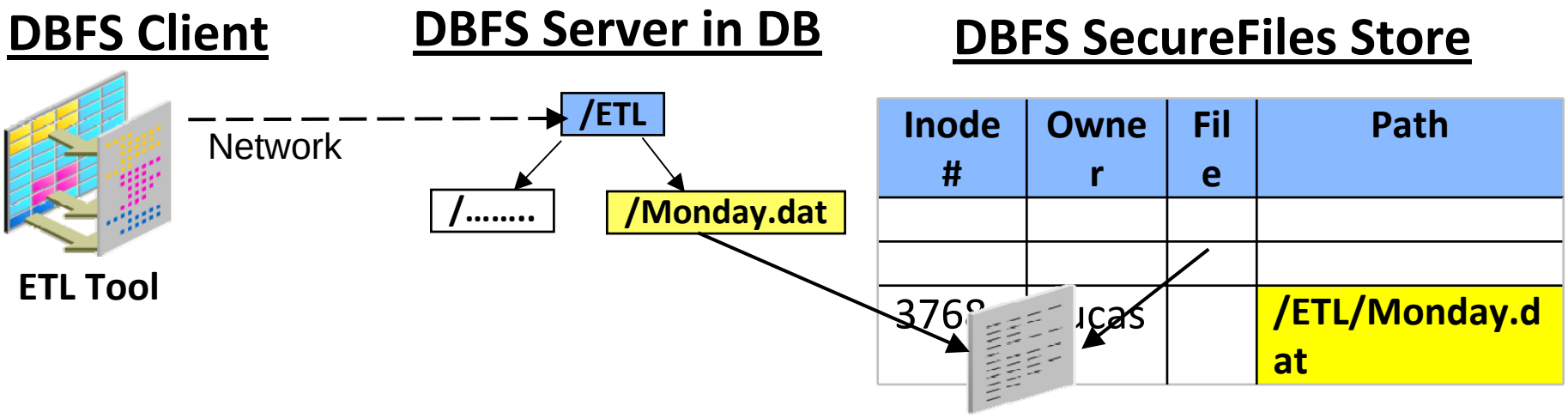
# Database-Enabling File-Based Tools

- DBFS allows access to files in the db using file system interfaces
  - File operations translated into SQL operations
  - Directories and path names are derived from key columns in tables
  - Enables access by existing file-based tools



# DBFS SecureFiles Store

- DBFS also implements stand alone file systems in the database
  - Directory information stored in tables
  - Files stored in SecureFiles LOBs
- Used for operational application files such as ETL files, reports, etc. that are not in application tables
  - Provides unified data and file backup, DR, management

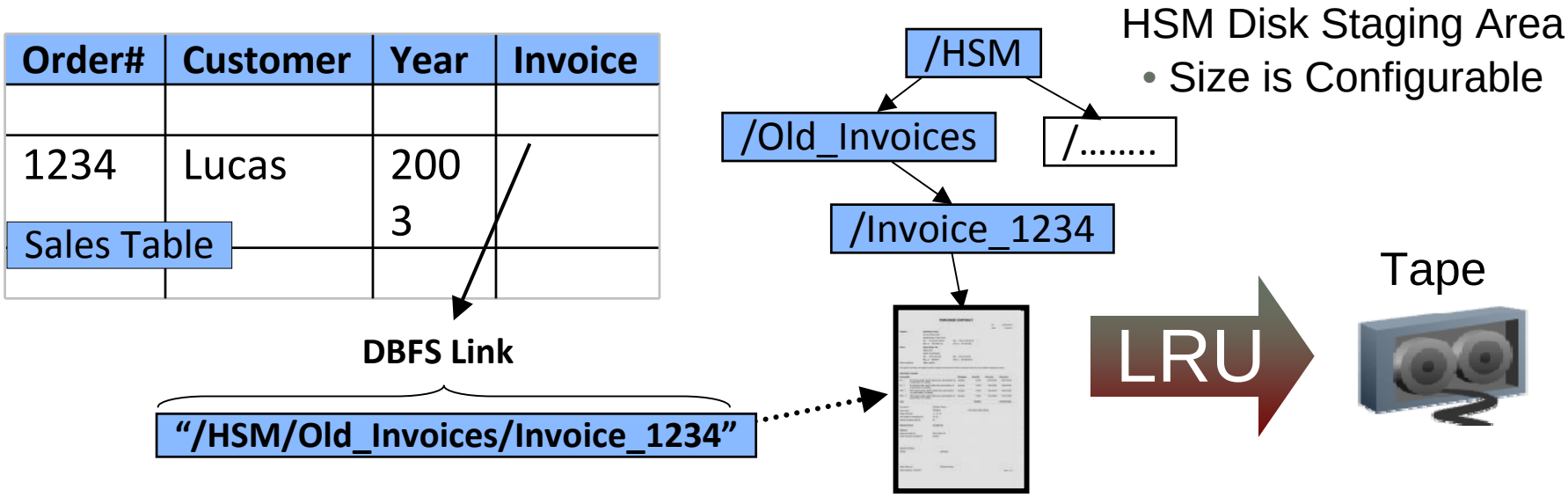


# DBFS SecureFiles Store Capabilities

- Powerful Configuration Options
  - Full data logging, or meta-data only logging
  - Cache, or direct read from disk
  - Partitioning
  - Compression
  - File level de-duplication
  - Encryption
  - Total Recall
    - Retain all file versions – historical query, or regulatory compliance
- Snapshots
  - Can create file system snapshots at user-selected past point in time
  - Uses Flashback Query to create snapshots
  - Can be used to recover deleted files or old file versions

# DBFS HSM Store

- A DBFS HSM store allows archiving files to tape
- Application migrates older files to HSM store (e.g. old invoices)
  - A DBFS Link replaces the LOB, LOB reads on links are transparent
  - A LOB can be easily migrated back to the table for updates
- HSM store has disk staging area for storing recently accessed files
  - Seldom accessed files are migrated to tape, brought back on reference



# Rich Capabilities Inherited from DB

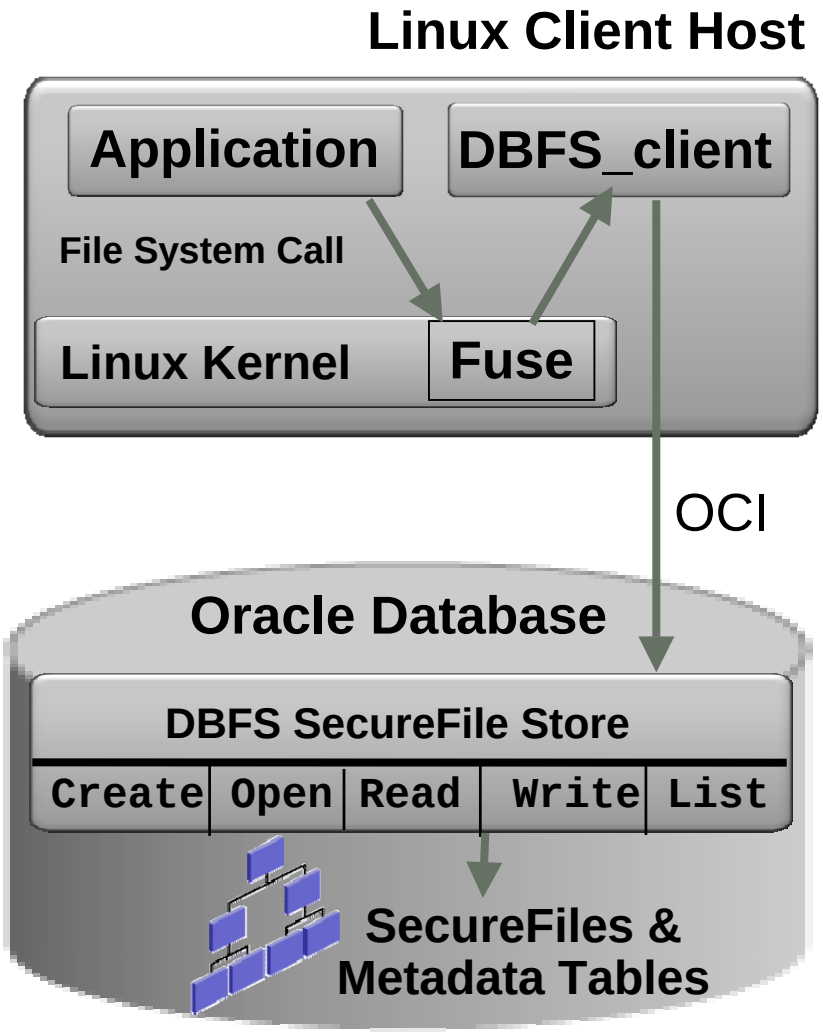
| DBFS Capability | Provided By |
|---|---|
| Compression, Deduplication, Encryption | SecureFiles |
| Crash Tolerance | Atomic transactions, Logging |
| Mirroring, Striping, Online Add Storage | ASM |
| Disaster Recovery, Readable Remote Mirror | Data Guard |
| Consistent Backup | RMAN, Hot backup |
| Multi-Node Scalability, Transparent Failover | RAC |
| Impromptu Snapshots | Consistent Read |
| Restore to Point in Time | Flashback, Media Recovery |
| Retention / Compliance | Total Recall |
| Network Security | SSL |

# DBFS Client Interfaces

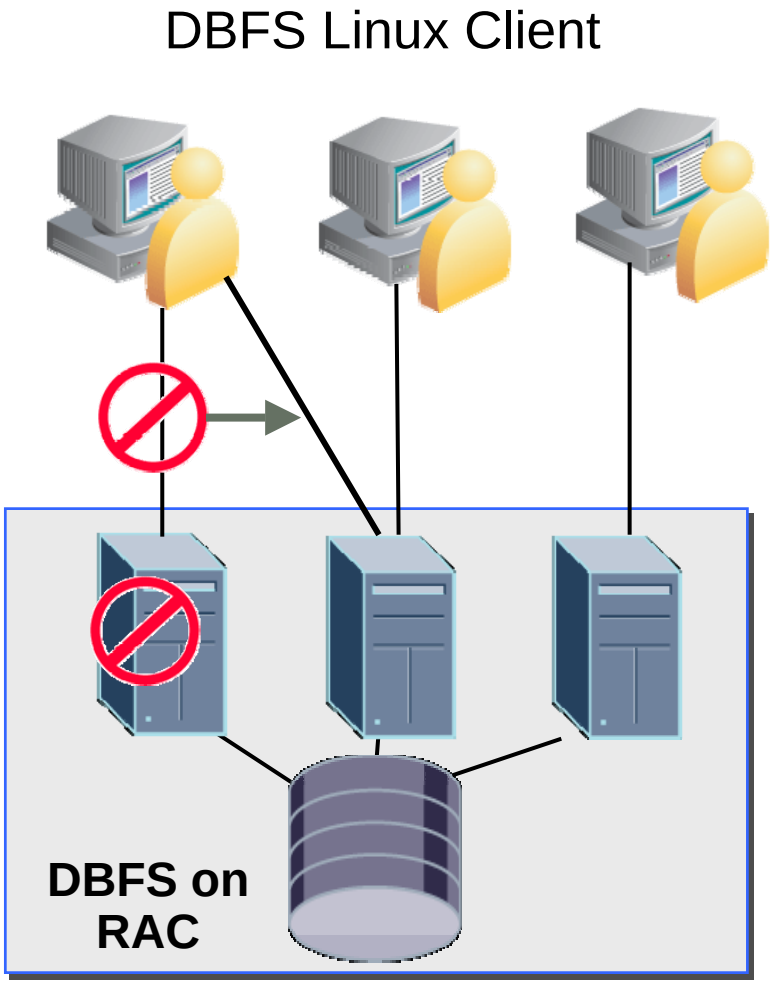
- Linux File System Client
- Command Line Client

# DBFS Linux File System Client

- DBFS Client for Linux allows mounting DBFS file systems on Linux hosts
  - Similar to NFS mount
- Application makes normal file calls
- Linux FUSE module forwards file calls to DBFS_client executable
- DBFS_client makes remote calls to DBFS Stores in the database
- DBFS Stores in Database implement a File Server
  - PL/SQL package implements file calls
    - File create, open, read, list, etc.
  - Directories and files stored in application tables or dedicated tables
- DBFS supported on all major platforms
  - Mounting DBFS file systems supported only on Linux



# DBFS Linux Client and RAC




- DBFS Linux File System client provides scaling and HA by leveraging RAC databases
- Transparently redirects file access to surviving RAC instances on node failures
  - Failures detected based on FAN notification
  - Replays outstanding transactions to surviving RAC instance

# DBFS Linux Client Restrictions

- DBFS supports most file system operations except
  - IOCTL, locking, memory mapped files, async IOs, O_DIRECT file opens, hard links
- DBFS cannot be used when the database is not running
  - Cannot use DBFS for Linux root file system or database home
- DBFS does not support exporting NFS or SAMBA exports

# Command Line Interface

- DBFS can also be accessed from client hosts using a command interface
  - Only requires OCI connection, no file system mount
  - Shell-like interface
    - Remote Copy, Create, Delete, List files
  - Direct connection to database provides high performance
- Command interface available on Oracle Database 11g Release 2 on:
  - Linux x64, Linux x32, Solaris x64, Solaris Sparc, HP-UX PA-RISC64, HP-UX IA64, AIX PPC64, Windows
- DBFS supported on all major platforms

```
$dbfs_client scott@dbhost:1521 --command
             cp /tmp/csv-files/* dbfs:/staging_area
```

# DBFS Server Interface

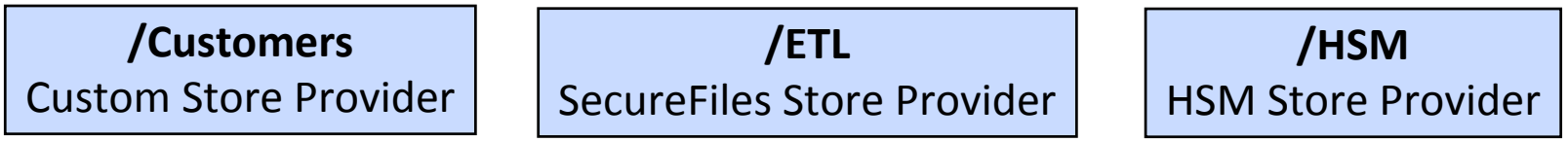
# DBFS Store API

- DBFS interface is DBFS Store API
- PL/SQL & SQL interface called directly by applications inside the database
  - PL/SQL interface has all operations
  - SQL view for read only access
- Same interface called remotely by clients on other hosts
- Strong support for storage of metadata associated with files
- Transactional file system operations
  - E.g. Multiple files can be created atomically in a DB transaction

**DBFS Store API**

- Create Operations
  - Create files, directories, links
- Delete Operations
  - Delete files, directories, links
- Get/Put Operations
  - Read and write LOB and attributes of existing file paths
- Rename Operation
- Directory Operations
  - List, Search
- Locking Operations
- Create Snapshot at point in time using consistent read

# Creating a User Defined DBFS Store




- Developers build file system implementations in the database by writing a PL/SQL package according to the DBFS Store API
  - Conceptually similar to Linux FUSE user mode file system interface
- Many kinds of DBFS Store Providers are possible
  - A provider to allow file system access to LOBs in an application table
  - A filter file system provider that passes operations to an underlying file system, but adds additional logic
    - E.g. A virus check filter, or filter that enforces application rules on access
  - A provider that translates relational data into file data, or vice-versa
- File systems are created by choosing a provider and mount point
- Two built-in Store Providers
  - DBFS SecureFiles Store, DBFS HSM Store

# Building your own “file system” integrated with your application

- Similar to how databases allow you to create a data model & an application, you can now build your own file system
  - Innovate and create new value by creating a file system interface
- Database developers can now write a robust file system: No need to be a OS kernel developer or debug kernel crashes
- Create a file system interface to data stored in relational tables: Like a “file system view” for an existing database application
- Write a file system in Java, SQL/PL/SQL
  - Or any other language using callouts
- Build your application-integrated file system in less than a day
  - Writing a basic read only file system view on the LOBs that are currently in your database application in 60 seconds!

# A file system: 100 lines of PL/SQL

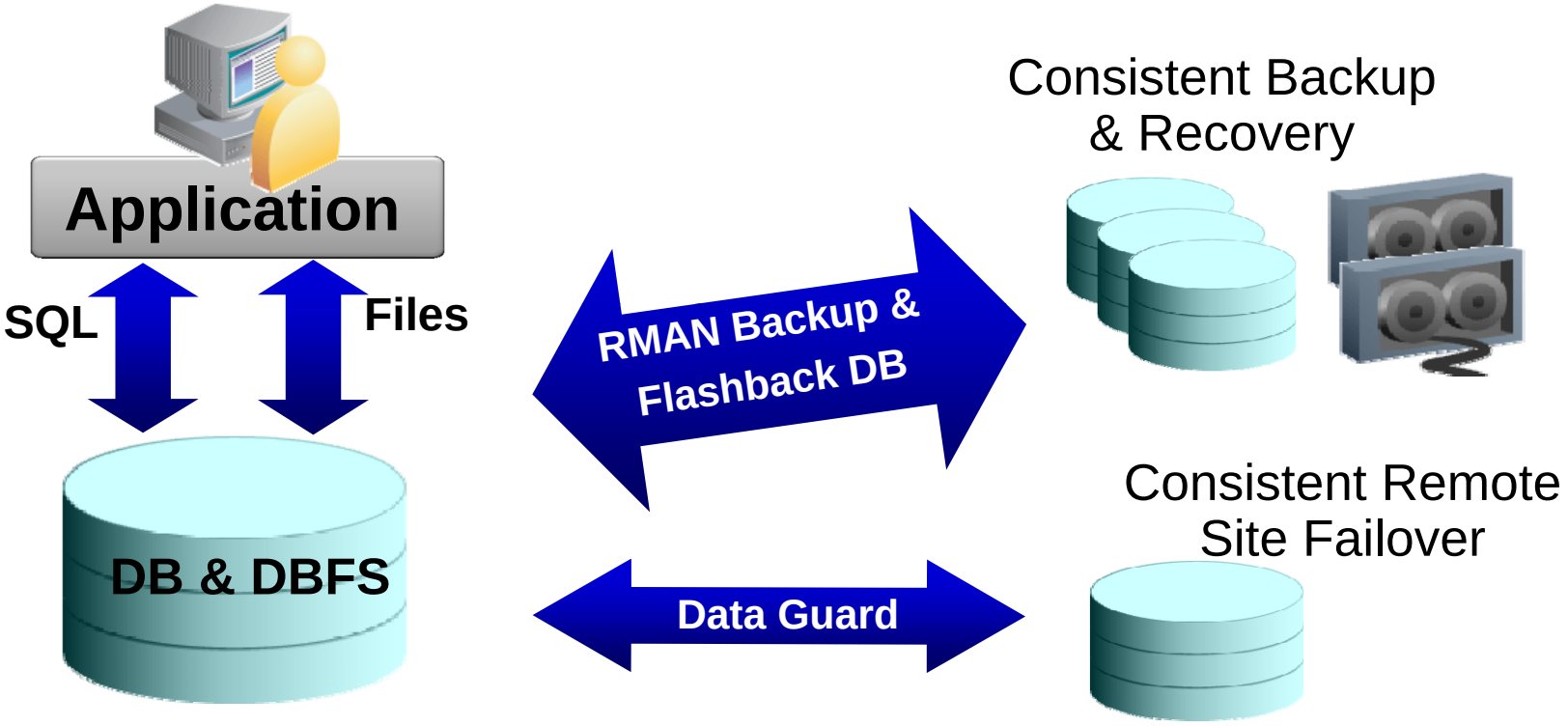
```
create table tbfst(
 key     varchar2(256)
         primary key check (instr(key, '/') = 0),
 data    blob)
    tablespace users
lob(data)
    store as securefile
        (tablespace users);

grant select on tbfst to dbfs_role;
grant insert on tbfst to dbfs_role;
grant delete on tbfst to dbfs_role;
grant update on tbfst to dbfs_role;

function    list(
    store_name  in              varchar2,
    path        in              varchar2,
    filter      in              varchar2,
    recurse     in              integer,
    ctx         in              dbms_dbfs_content_context_t)
        return  dbms_dbfs_content_list_items_t
            pipelined
is
begin
    for rws in (select * from sys.tbfst)
    loop
        pipe row(dbms_dbfs_content_list_item_t(
          '/' || rws.key, rws.key, dbms_dbfs_content.type_file));
    end loop;
end;
```

```
procedure   getPath(
      store_name  in              varchar2,
      path        in              varchar2,
      properties  in out nocopy
  dbms_dbfs_content_properties_t,
      amount      in out          number,
      offset      in              number,
      buffer      out    nocopy   raw,
      prop_flags  in              integer,
      ctx         in              dbms_dbfs_content_context_t)
  is
      content     blob;
      guid        number;
begin
      if (path = '/') then
          raise dbms_dbfs_content.unsupported_operation;
      end if;

      select t.data into content from sys.tbfst t
            where ('/' || t.key) = path;
      select ora_hash(path) into guid from dual;
      dbms_lob.read(content, amount, offset, buffer);

      properties := dbms_dbfs_content_properties_t(
          dbms_dbfs_content_property_t(
              'std:length',
              to_char(dbms_lob.getlength(content)),
              dbms_types.TYPECODE_NUMBER),
          dbms_dbfs_content_property_t(
              'std:guid',
              to_char(guid),
              dbms_types.TYPECODE_NUMBER));
 end;
```

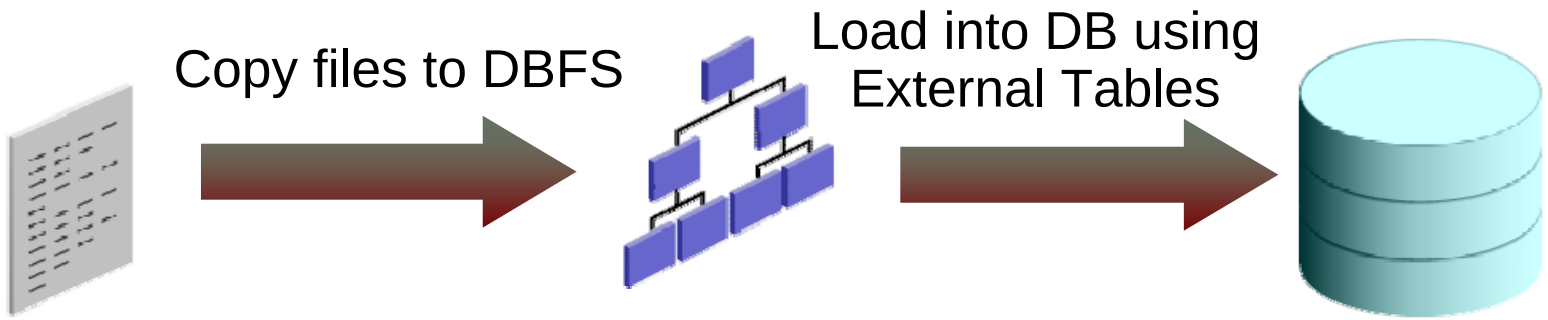
# DBFS Examples

# Full Stack HA

- 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



# Database Machine Shared File System

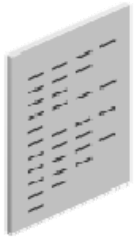



- DBFS client for Linux is used in the Oracle Database Machine to implement a shared file system
  - Shared storage for scripts, reports and other application files
- Great for ETL Staging area
  - User or Application copies files to mounted DBFS Staging Area
    - Any OS copy utility - FTP, SCP, RCP
    - Or use dbfs_client command interface for high performance copy from any 11gR2 platform without having to mount a file system
  - ETL tool loads file data from DBFS into database
    - Using database external tables interface
  - 5 to 7 GB/sec file system I/O throughput

# DBFS - Scalable Shared File System

New

- Database Machine comes with DBFS shared Linux file system
  - Shared storage for ETL staging, scripts, reports and other application files
- Files stored as SecureFile LOBs in database tables stored in Exadata
  - Protected like any DB data – mirroring, DataGuard, Flashback, etc.
- 5 to 7 GB/sec file system I/O throughput



Load into database
using External Tables

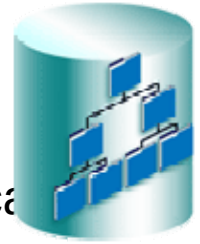

**ETL Files in DBFS**

**ETL**

**More File Throughput than High-End NAS Filer**

# Conclusion

# Files in the Database Reinvented



- Best of Both Worlds
- File Capabilities
  - File System Interface
  - High Performance
  - Compression
  - Encryption
  - Deduplication
  - HSM
- Database Capabilities
  - Transactions
  - Query Consistency
  - Advanced Backup and Recovery
  - Powerful Security
  - Flashback
  - Scale up SMPs
  - Scale out Clusters

- Files are an integral part of modern database applica
  - Product images, contracts, XML, ETL files, manuals, etc.
- Applications developers want to store business data files in the database to benefit from transactional consistency, and unify HA and Security
  - Poor performance, limited functionality, and lack of access by existing file based tools have held them back
- 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 a file system interface to files in the DB
  - Enables existing file based tools to easily access DB files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