DB2 UDB (NT, Unix, AS/400)
Data Links Technology & Solutions for the e-business World

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Topics

- e-business application characteristics
- Data Links technology
- Web Asset Integrity Solution demo -- LinkIntegrity+
- Conclusions
- Supporting foils

Please visit the Data Links website
http://www.almaden.ibm.com/cs/datalinks/
for all kinds of collateral including presentations, papers and brochures
e-business
Application Characteristics
An e-business organization connects critical business systems directly to employees, customers, suppliers and distributors, via the internet, intranets and extranets to gain a competitive advantage.
Business Critical Processes

- **e-commerce**
  - Customers search, browse, select, buy
    - expect quality personalized service
  - Vendors seek customer retention, growth and satisfaction
    - must satisfy, anticipate, create demand and provide a pleasant user experience
  - Information integrated from ERP (databases & files), data warehouses (databases), e-mail (files), voice mail (files), collaboration (files), web (files)

- **Customer Relationship Management (CRM)**
  - Deliver product/service to the right customer, through the right channel, at the right time and at the right cost
  - acquiring and retaining customers involves sales, service, support, customer care and marketing activities
  - Vendors collect history of customer interactions from all touchpoints, analyze, market, cross-sell, and support
  - Information integrated from ERP (databases & files), data warehouses (databases), e-mail (files), voice mail (files), collaboration (files), web (files)
e-business Challenges...

- Exacerbated infrastructure demands
  - 24x7x52 availability
  - Response time
  - Scalability
  - Security
  - Privacy
  - Heterogeneous client devices

- Technology demands
  - Complex architectures with eclectic mix of technologies & products
  - Less proven technologies
  - Flexible

- "Internet time"
  - Compressed development times
e-business Challenges

- Application demands
  - Global user community
    - national language support
    - cultural differences
    - laws of sovereign countries
  - Cope with savvy and demanding user community
    - satisfy
    - anticipate
    - create
  - Holistic view of information from multiple sources
    - databases, filesystems
    - ERP, data warehouses, workgroup, web, voicemail, fax, etc.
  - Data accessibility and integration from these sources

Content must be timely, accurate, consistent, and secure
e-business Demands on a Database

Why a DBMS

- Shared online access to information by hundreds and thousands of users
- Integrity
- Security
- Performance
- Optimal use of available resources

e-business

- (More) available
- (More) scaleable
- (More) secure
- NLS support
- (More) heterogeneity of client platforms
- (More) connectivity & integration with business critical systems

Unstructured Data

OLTP

Batch & Query Only

Decision Support

IBM's IMS is the first DBMS in mid 1960s
IBM invented the Relational Model in 1969
IBM DBMSs in 100% of Fortune 100 mission-critical applications
IBM leading visionary in final Gartner DBMS Magic Quadrant

Reduce

TCO

+ Multi-platform
Extensible to support emerging application requirements
Web technologies support

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Data Links Technology
Problem Domain Addressed...

- 70%-95% (or more) of data resides in file systems as compared to databases
  - Internet has exacerbated this divide

- Legacy applications using file systems abound, and new ones being developed involving unstructured data
  - Applications using file systems here to stay for a long time

- File system limitations
  - Search
  - Security
  - Integrity -- referential, domain, etc.
  - Transactional semantics
  - Administration
Problem Domain Addressed

- New e-business applications and certain existing and emerging applications need to integrate database systems with existing and new file systems
  - They all need database level integrity, security, backup and recovery, replication and transaction consistency

- Storing files in BLOBs gives it DBMS capabilities
  - Files must be copied/migrated to the BLOBs
    - Coexistence with existing and emerging applications using file system interfaces
  - Performance issues
    - Ability to deliver data isochronously
    - Scalability of a single database server
DB2 UDB Data Links

- Extends the following database management capabilities to file data in file systems
  - Referential Integrity
  - Value-based security
  - Coordinated backup & recovery
  All with transaction semantics

- Allows management of files AS IF it were stored in the database

- Retains file system performance, APIs and "look and feel"

- Leaves data where it is and manages it

Fusion of database and file system technologies

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**Data Links Programming Model**

### SQL API vs. File System API (or http protocol)

#### Client application

1. **SQL SELECT**
   - SELECT DLURLPATH(PHOTO) FROM CUSTOMER WHERE SS# = '236911144'

2. **Return URL info**
   - (2) return URL info

3. **Open filename**
   - (3) Open filename

4. **Direct data delivery**
   - (4) direct data delivery

### Customer Table

- **SS#** (char)
- **Name** (varchar)
- **Photo** (DATALINK)

<table>
<thead>
<tr>
<th>SS#</th>
<th>Name</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>546952311</td>
<td>Blogs Joe</td>
<td>URL1</td>
</tr>
<tr>
<td>236911144</td>
<td>Jane Mary</td>
<td>URL2</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

### DDL Statement

```
CREATE TABLE CUSTOMER
(SS# CHAR(8),
 NAME VARCHAR (60),
 PHOTO DATALINK LINKTYPE URL FILE LINK CONTROL
 INTEGRITY ALL READ PERMISSION FS WRITE PERMISSION BLOCKED RECOVERY YES ON UNLINK RESTORE)
```

### Data Processing

- Leave the files as is
- Establish the metadata for a set of files and define it as columns in a DB2 UDB table
- Define a DATALINK (ISO/ANSI standard) column in the table that would contain the logical reference to the file in URL notation
- Populate the table
- Use SQL to search the metadata and find the files of interest -- get the URL of the file from the DATALINK column
- Access the file using the native file system APIs
Centralized Database with Multiple File servers in a network topology
Standard APIs for database access and File access
Archive Server (e.g., Tivoli Storage Manager) used for co-ordinated backup & recovery
NO modification of the Filesystem which stores files
Data Links Manager (DLM)

- DLM implements referential integrity, coordinated backup & recovery, and access security with transaction semantics via the DLFM and DLFF
- DLFM
  - DB2 UDB metadata repository that stores information about registered databases that can link files on this DLM, registered file systems that will be monitored by this DLM, file link/unlink history for recovery, persistent queue for file archive requests, etc.
    - Processes that copy & retrieve archive files, interact with the DB2 server and DLFF, garbage collect etc. -- more later
- DLFF
  - Is a control layer on top of a filesystem
  - Is stateless
    - Intercepts specific filesystem calls such as OPEN file, RENAME file and directory, and DELETE file
  - Performs token generation and validation -- more later
Data Links Process Model

DB2 Server

SQL & Utilities

Async Daemon

TCP/IP

db2agent

db2agent

DLFMD Daemon

Copy Daemon

Retrieve Daemon

Copy Daemon

ICP

Metadata in DB2 tables

LOCAL DISK/ TSM (ADSM)/ XBSA

DELETE-GROUP Daemon

Garbage Collection Daemon

Define-group

Streams driver (AIX), File System Driver (NT), DMAPP (DFS)

Native File System: JFS, Solaris, NTFS, DFS-DCE (AIX)

ARCHIVE SERVER
Referential Integrity...

- Comes into play when rows are INSERTed, UPDATEd and DELETEd

```sql
INSERT INTO CUSTOMER VALUES ('123456789', 'BLANKETYBLANK', DLVALUE('HTTP://WWW.ALMADEN.IBM.COM/CDRIVE/BBPIC.GIF'))

UPDATE CUSTOMER
SET PHOTO = DLVALUE('HTTP://WWW.ALMADEN.IBM.COM/CDRIVE/BB.GIF')
WHERE SS# = '123456789'

DELETE FROM CUSTOMER WHERE SS# = '123456789'
```

```
"file://server1/x/y/a.b"
"unc:\server2\gdrive\x\y\a.b"
"dfs://.../almaden.ibm.com/fs/x/y/a.b"
```

---

**Data Links Manager**

- (2) (a) Connect
- (2) (b) Get Prefixid
- (2) (c) Begin sub-transaction
- (2) (d) Link file

- (4) (a) Prepare
- (4) (b) Harden metadata
- (4) (c) Commit
- (4) (d) Takeover file

---

**DLFM Daemons**

- (2) (d1) Check file
- (d2) Insert metadata

---

**DLFM_DB**

---

**DLFF**

---

**DB2 Client**

- (1) SQL INSERT

---

**DB2 UDB**

- (2) agents

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Referential Integrity

- Action on linked file when database row is DELETEd, or DATALINK column is set to NULL (or another DATALINK value) depends upon the "ON UNLINK" option in the DATALINK column attributes
  - "ON UNLINK RESTORE" causes the file permissions and ownership to be restored to what they were before they were first linked
  - "ON UNLINK DELETE" causes the linked file to be deleted

- Action when a user tries to use filesystem commands to DELETE or RENAME the file
  - DLFF intercepts these commands, and interacts with the UPCALL daemon to determine if the file is linked, in which case the DELETE or RENAME is prohibited
Coordinated Backup and Recovery

**INSERT**
- db2agent
- Insert
- dlfm_child
- Asynchronous Archive Request
- Copy Daemon
- dlfm_child
- ARCHIVE SERVER

**BACKUP**
- db2agent
- BackupVerify
- Ensure file backup complete
- dlfm_child

**RESTORE**
- db2agent
- Reconcile w.r.t. DB
- reconcile_child
- Retrieve Daemon
- File System
- Retrieve correct file version
- dlfm_child
- ARCHIVE SERVER

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Access Security

- Access security type depends upon the READ PERMISSION attribute chosen when the DATALINK column is defined
  - READ PERMISSION FS specifies that existing filesystem permissions are to be honored
  - READ PERMISSION DB specifies that a database generated access token must be presented to DLFF before file access can be granted to the user
    - File ownership changed to database
    - Access token (25 or 30 characters in length) generated on query & embedded in the filename
    - Token validated by DLFF during filesystem open()

- Token generation and validation
  - Example: /videos/french.mpg ==> /videos/04E2_CS7Fo___biV4fhZ_0UM;french.mpg
  - Shared secret between DB2 and DLM (algorithm and key)
  - Two levels of security
    - MAC0: encryption based on filename
    - MAC1: encryption based on full path name
Access Performance

- DLFF is NOT in the read/write path
  - File access performance is not impacted compared to the native file system
Utilities...

- All input formats to LOAD and IMPORT supported for tables containing DATALINK columns
  - DATALINK SPECIFICATION provides flexibility for transforming DATALINK values in data files
  - SAVECOUNT in LOAD causes consistency points for files linked in DLMs
  - Exceptions for DATALINK column(s) reported in exception table
  - ✓ LOAD COPY and LOAD REPLACE options not supported

- EXPORT
  - DB2 EXPORT command generates control file (TAR or ZIP) containing file references
  - dlfm_export generates a TAR (ZIP on NT) file based on control file

- IMPORT
  - dlfm-import uses the control file and TAR (ZIP on NT) file to materialize files prior to running IMPORT on DB2
  - See DB2 Data Movements Guide for details
Utilities

- **RECONCILE utility** keeps DB2 table & DLFM meta data in sync
  - Operates at the table level
  - Table is scanned and a list of files (+version identifier) sent to DLM
  - DLM verifies and if required retrieves file from archive server
  - Unresolved references are recorded in an exception table
- **db2_reconid_aid** provides ability to run RECONCILE on all tables with DATALINK column(s)
- **Fast RECONCILE** at database without restore rollforward (internal)
  - Sync is done based on LSN

**ULTIMATE SAFETY NET:**
Anytime when an out-of-sync condition suspected - Run Reconcile Utility on tables
Data Links Replication

- **Performance**
  - Reduce network traffic by moving data closer to the application
  - Load balancing by providing multiple copies of a system image

- **Availability**
  - Standby or Failover capability in case of system failure

- **Security**
  - Isolate sensitive data

Both database data and external referenced files will be replicated together in an automatic and consistent way.
Datalink changes are recorded in the database log.
Capture reads the database log and stores the changes to the CD table.
Apply copies the change data from the CD table to a spill file. At the same time, stores the Datalink file references in a separate file (input file).
User exit program maps the file references and copies them from the source file system to the target file system through FTP, and records file references in the "result" file.
Apply propagates the metadata and the new DATALINK file reference from the "result file" to the target table.
Data Links Applications...

- **e.Commerce**
  - Product catalogs, price lists, brochures, thumbnail and full images, video, etc.
    - ✔ Integrity of file content
    - ✔ Integrity of file reference

- **Supply Chain Management (SCM)**
  - Common in automotive and aerospace industry for engineering designs
    - ✔ Large automotive manufacturer outsources 70% of a vehicle design
      - ✷ requires content sharing between different enterprises
      - ✷ needs replication of both the engineering drawings (files) and the metadata (database)
  - Customer support document system
    - ✔ Large airplane manufacturer needs to deliver maintenance documents in common format to relevant airlines
Data Links Applications

- **Customer Relationship Management (CRM)**
  - Holistic view of customer touchpoint interactions -- voice, e-mail, fax, web, database, etc.
    - ✔ Integrity of file content
  - ✔ Integrity of file reference

- **ERP**
  - Patient Information System where information is exchanged between hospitals and clinic -- Xrays, ECG charts, Doctor comments, medical history, etc.
  - Catalog distribution system -- catalogs include metadata & file data
  - Automotive insurance (vehicle damage pictures, claim forms, etc.)

- **CAD/CAM**
  - Engineering drawings

- **Asset & Configuration Management**
  - Content Management
    - ✔ Integrated Document Management
    - ✔ Media Access Management
    - ✔ Web Asset Management
BLOBs versus Data Links

Storing files in BLOBs gives it DBMS capabilities.
DataLinks allows files to remain as is, while extending DBMS capabilities to them.

- Use DataLinks when:
  - Performance & scalability are of concern.
  - Coexistence with existing and emerging applications that use the file system natively is required.

- BLOBs appropriate when above issues not a concern.

DB2 UDB is unique in the industry in offering the customer the choice to either implement BLOBs or Data Links.

Let the customer decide which option is most appropriate for their particular application requirement.

(Single application may adopt both technologies.)
Web Asset Integrity Solution Demo
Web Asset Integrity Solution

End Users
- No 404's -- improved user experience
  - Personalized categories
  - Subscriptions to content changes
  - ....

Webmaster(s)
- Multiple autonomous webmasterdomains in an intranet
- Notification of changes in the status of inter-domain links and internet links
- Enforcement of organization guidelines for web content
- Rollback "sets" of changes to a prior point-in-time
  - Guaranteed integrity of intra-domain & "virtual" links
  - Verification of the integrity of inter-domain links
  - Impact analysis of changes -- "what if"
  - Detection of "dead" and unused pages
  - ....

Web-Server Administrator(s)
- Higher availability through datalinks replication
  - Protection against web page corruption
  - Value add to data mining via personalized categories
  - ....

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Conclusions
Conclusions

Explosive growth in data stored in files critical to e-business applications

- Integrate structured and unstructured information from diverse sources
- Co-exist with existing and emerging file system based applications

Demand mission critical capabilities of scalability, availability, security and integrity

Data Links addresses e-business application demands by

- Extending to file systems, the umbrella of mission-critical RDBMS capabilities of referential integrity, value-based security, transaction consistency and co-ordinated backup and recovery
- Supporting coordinated database & file replication for load balancing, high availability and B2B requirements
- Providing a scaleable multi-platform solution
Supporting Foils
DataLinks Terminology...

- **Access Token**
  - Embedded token in the filename that can be used to open files that are owned by the DB

- **DATA LINK**
  - A base datatype whose value is a URL
  - Final Draft International Standard (FDIS) stage of ISO/ANSI standard (Database Language: SQL - Part 9: SQL/MED (Management of External Data) -- expected to be published as a standard in early 2001

- **DLFF**
  - DataLinks Filesystem Filter
  - Sub-component of DLM
  - Kernel/user level subsystem that sits atop the native filesystem to provide RI and access control
DataLinks Terminology

- **DLFM**
  - Data Links File Manager
  - Sub-component of DLM dealing with file metadata processing, user-process level daemons
  - Interacts with DLFF and DB2

- **DLM**
  - Data Link Manager
  - DataLinks application that is installed on the file server

- **DPropR**
  - IBM's replication technology

- **Prefix**
  - The mount point of the DLFF monitored filesystem
DATATYPE GRAMMAR

```
DATALINK

(link integer)

LINKTYPE

URL

NO LINK CONTROL

FILE LINK CONTROL

MODE DB2OPTIONS

INTEGRITY ALL

READ PERMISSION

DB

RECOVERY

NO

YES

WRITE PERMISSION

FS

ON UNLINK

RESTORE

DELETE

BLOCKED

FS

RESTORE

DELETE
```

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## DATALINK Datatype Features

### Valid Combinations for FILE LINK CONTROL Options

<table>
<thead>
<tr>
<th>Opt #</th>
<th>Read</th>
<th>Write</th>
<th>Recovery</th>
<th>Unlink</th>
<th>Referential Integrity</th>
<th>DB Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FS</td>
<td>FS</td>
<td>No</td>
<td>N/A</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>2</td>
<td>FS</td>
<td>Blocked</td>
<td>No</td>
<td>N/A</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>3</td>
<td>FS</td>
<td>Blocked</td>
<td>Yes</td>
<td>N/A</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>DB</td>
<td>Blocked</td>
<td>No</td>
<td>Delete</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>5</td>
<td>DB</td>
<td>Blocked</td>
<td>Yes</td>
<td>Delete</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>6</td>
<td>DB</td>
<td>Blocked</td>
<td>No</td>
<td>Restore</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>7</td>
<td>DB</td>
<td>Blocked</td>
<td>Yes</td>
<td>Restore</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

**Scalar functions**
- `→ DLVALUE`
- `→ DLINKTYPE`
- `→ DLURLSCHEME`
- `→ DLURLSERVER`
- `→ DLURLPATH`
- `→ DLURLPATHONLY`
- `→ DLURLCOMPLETE`
- `→ DLURLCOMMENT`

**CLI**
- `→ SQLBuildDataLink`
- `→ SQLGetDataLinkAttr`

**SQL Restrictions for DATALINK columns**
- Cannot be part of an index
- Cannot be part of a constraint
- Cannot be compared
Table States

- **DRP (DataLink Reconcile Pending)**
  - Data Links Manager metadata is out-of-sync with table data

- **DRNP (DataLink Reconcile Not Possible)**
  - Data Links Manager metadata is missing for the table

- **RESTORE** and **ROLLFORWARD** utilities may set these states

- Table access is restricted in these states
  - **SELECT** is permitted
  - **INSERT/DELETE** is not permitted
  - **UPDATE** is permitted selectively in DRNP state
  - User may set state to DRNP if (s)he suspects integrity has been compromised
  - **SELECT** access may also be prohibited by setting the **CHECK PENDING** state in addition to the **DRNP** state

- **RECONCILE** utility should be run to bring the table out of **DRP** state
  - See the SQL & DB2 Administration Guides for details
Some Configuration Parameters

- **DL_EXPINT**
  - Expiry time of the token generated by DB2

- **DL_TOKEN**
  - Algorithm choice for generating the token

- **DL_UPPER**
  - Whether the token generated can have only upper case or both upper and lower case characters in it

- **DL_TIME_DROP**
  - Number of days after a DROP for which the archive of unlinked files should be retained

- **REC_HIS_RETENTN**
  - Number of days entries are retained in the history file

- **NUM_DB_BACKUP**
  - Number of backups after which archive of unlinked files can be deleted
Architecture on DCE-DFS for AIX

- DB2 Client
- DCE-DFS Client (with DCE-DFS CE)
- DFLM Daemons
- DCE-DFS (AIX)
- DLFF (DMAPP)
- Storage
- DFLM_DB (metadata repository)
- DFLM daemons (remote clients)
- DLFF (DMAPP)
- DCE-DFS (AIX)
- Storage
- Data Links Manager Server
- Data Links Manager Client

Control Path for DataLinks Integrity
Control Path for DML & Utilities
Control Path for DataLinks Integrity
Control Path for DML & Utilities

SQL Access Path

DB2 UDB
DB2 agents

ARCHIVE SERVER

DFS Server 1
DFS Server 'n'

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File Archive Optimization in DCE-DFS

*/.../almaden.ibm.com/fs/dl*

Copy daemon

Retrieve daemon

Backup Dir

Prefix

Regular Data Access Path in DFS

Disk/Memory based DFS Cache Manager

Optimized Data Access Path

DFS Mount

Native FS Mount

*/.../almaden.ibm.com/fs/dl/kiran.pic* <=> */localmount/dl/kiran.pic*