Using a Data Warehouse to Audit a Transactional System

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Agenda

- Introduction
- Why Audit
- How to Audit
  - The Setup
  - The Audit
- Audit Results
- Questions

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UMBC

University of Maryland - Baltimore County

- Located in suburban Baltimore County, between Baltimore, MD and Washington, DC
- One of the three public research campuses in the University of Maryland System
- 10K undergraduate and 2K graduate students
- 2,200 Employees; 715 full-time faculty
- 8 Pan-Am chess championships

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UMBC RETRIEVERS™

UMBC Data Warehouse

- Custom HR and Student tables for IR
  - 5 years
  - Oracle
  - Relational tables

- Purchased iStrategy DW for Campus
  - Legacy student > 1 year
  - PS Student Admin live for 1 month
  - SQL Server 2005
  - 15 fact tables
  - 100 custom reporting tables for IR
  - 75 GB in size
  - 3 IR staff + 1.5 IT staff

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What is an “Audit”?

Need to identify and reconcile the data that was changed yesterday

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Why Audit in the DW?

- Audit HR data entry
  - Piecing together 4 pages every day
- Learn about changes to codes

- Why in the Data Warehouse?
  - Take pressure off OLTP
  - No custom tables
  - No changes to transactional tables
  - No need to turn on audit

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Auditing at UMBC

- 10 tables
  - PS_Job, PS_Citizenship, Tax_Data
  - PS_Acad_Plan_Tbl (majors)
  - Translation table
  - Error Messages

- Average 825,000 records audited per night
- Average 1,000+ changes per night
- Average about 45 seconds for complete audit
- Max < 4 minutes with 825,000 changes

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How to Audit

- Make a copy of “yesterday”
- Refresh the table with “today”
- Compare “yesterday” with “today”
- Report the differences

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How We Audit

- Nightly_YDAY_Tables
  - Copy Source tables to _YDAY
- Refresh Source tables
- Nightly_Audit
  - Load_Data_Changes for each table
    - Data_Changes_Staging
    - Parse updates by field
  - Email_Audit_Summary

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Setup

- Create YDAY table
- Create “Current” view (optional)
- Index YDAY table
- Add to Nightly YDAY procedure
- Add to Nightly Audit procedure

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YDAY table

- Make a copy of “yesterday”
- Setup is one time copy of the table to be audited
  - Tablename with suffix _YDAY
  - Index on primary key
- YDAY table populated every night
  - Copy of yesterday’s source table
  - Before nightly refresh of source tables
  - Truncated to preserve indexes

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Setup

- Create YDAY table
- Create “Current” view (optional)
- Index YDAY table
- Add to Nightly YDAY procedure
- Add to Nightly Audit procedure

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Special Case

Effective Dating

- Transaction tables keep a history
- Current data is based on effective date
- New effective dated record inserted when something is updated
- Want to treat new record as UPDATE

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“Current” View

- Create view (virtual table) of rows currently in effect
- Populate YDAY table from view
- Primary key does not include Effdt
- Compare YDAY to view of rows currently in effect
- Skip Effdt column during comparison

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Effective Dating

Yesterday

Emplid (PK)	Effdt (PK)	Major
1000	2/3/2008	Mathematics

Today

Emplid (PK)	Effdt (PK)	Major
1000	2/3/2008	Mathematics
1000	4/1/2009	English

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Effective Dating

Yesterday

Emplid (PK)	Effdt	Major
1000	2/3/2008	Mathematics

Today View

Emplid (PK)	Effdt	Major
1000	4/1/2009	English

Emplid 1000 updated major from Math to English

The changed EFFDT is ignored during comparison

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Setup

- Create YDAY table
- Create “Current” view (optional)
- Index YDAY table
  - Create primary key
- Add to Nightly YDAY procedure
- Add to Nightly Audit procedure

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Nightly YDAY Procedure

```
BEGIN TRANSACTION

  TRUNCATE TABLE   Stage.PS_Citizenship_YDAY

  INSERT INTO Stage.PS_Citizenship_YDAY
    SELECT * FROM Source.PS_Citizenship

COMMIT TRANSACTION
```

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Nightly Audit Procedure

```
SELECT @table = 'PS_CITIZENSHIP'

EXECUTE Admin.Load_Data_Changes

    @p_base_table = 'Stage.PS_Citizenship_YDAY',
    @p_comp_table = 'Source.PS_Citizenship',
    @p_details = 'YES',
    @p_changes_tablename = @table
```

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Setup

- Created YDAY table
- Created “Current” view (maybe)
- Created Primary Key
- Added to Nightly YDAY procedure
- Added to Nightly Audit procedure

- PS_Citizenship table is now going to be audited every night

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The Audit

How do we know what changed?

```
SELECT @table = 'PS_CITIZENSHIP'

EXECUTE Admin.Load_Data_Changes

    @p_base_table = 'Stage.PS_Citizenship_YDAY',
    @p_comp_table = 'Source.PS_Citizenship',
    @p_details = 'YES',
    @p_changes_tablename = @table
```

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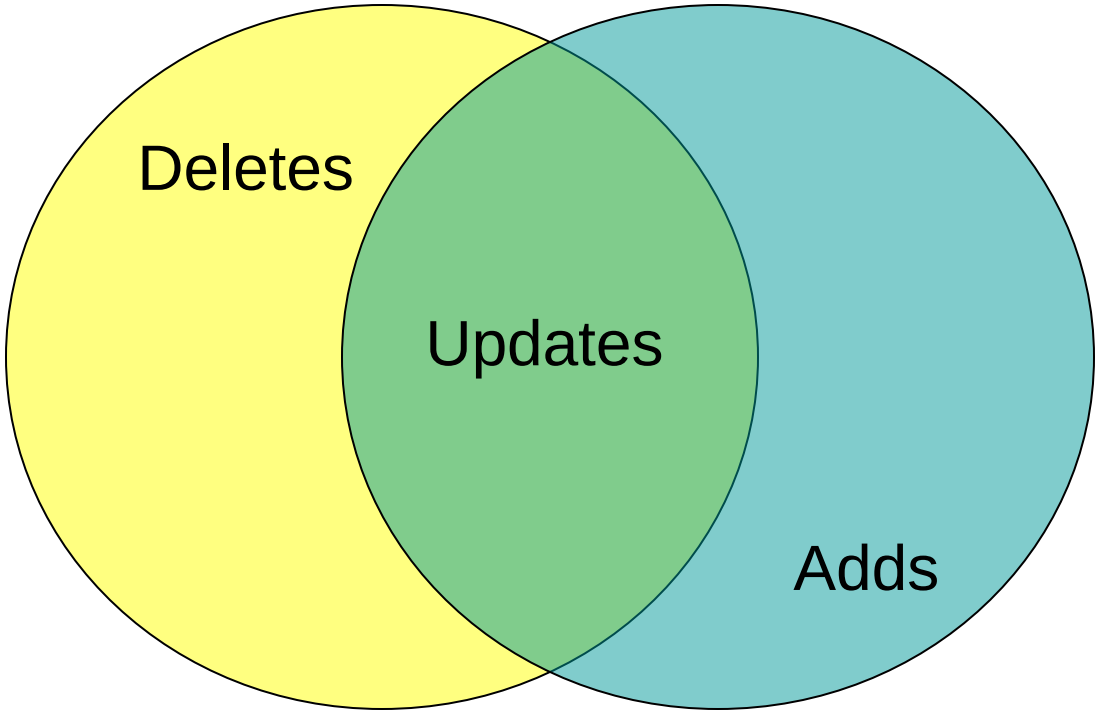
Delete, Add, Update?

Compare Primary Keys



Compare Yesterday to Today

- Read database metadata to determine primary key
- Read metadata to build dynamic SQL
- Dynamic SQL is built for ADDs and DELETEs
- Dynamic SQL is built for UPDATEs
- The dynamic SQL inserts records into staging table
- Final step parses staging table

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Sample Table

Sample

Column Name	Type
Key1	Varchar(4)
Key2	Integer
Field1	Varchar(10)
Field2	Datetime

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Sample Data

Yesterday

Key1	Key2	Field1	Field2
UMBC	1	Update Me	7/8/2009 12:00 AM
UMBC	2	Delete Me	6/7/2009 12:00 AM

Today

Key1	Key2	Field1	Field2
UMBC	1	Updated	5/1/2009 12:00 AM
UMBC	3	Add Me	3/4/2009 12:00 AM

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Staging Audit Data

Table Name	Action	Key Fields	Key Values	Changes
Sample	Delete	Key1~Key2	UMBC~2	
Sample	Add	Key1~Key2	UMBC~3	
Sample	Update	Key1~Key2	UMBC~1	~~Field1…

~~Field1=[Update Me^^Updated]

~Field2=[Jul 8 2009 12:00AM^^May 1 2009 12:00AM]~

~	field delimiter
^^	old/new value delimiter

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Audit SQL for Add

```
INSERT INTO Stage.DATA_CHANGES
     (Tablename, Action, Key_Fields, Key_Values, Changes)

SELECT 'Sample' tname, 'ADD' action, 'Key1~Key2' kfields,
          convert(varchar,A.Key1) + '~' +
          convert(varchar,A.Key2) kvalues, null

FROM mglasser.Sample A
LEFT OUTER JOIN mglasser.Sample_YDAY B
  ON  A.Key1 = B.Key1 and A.Key2 = B.Key2
WHERE B.Key1 is null
```

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Create Dynamic SQL for Add

```
SET @SQL =

  'INSERT INTO Stage.DATA_CHANGES
  (Tablename,Action,Key_Fields,Key_Values,Changes) SELECT '" +
  @p_changes_tablename + '" tname, ''ADD" action, '" +
  @Key_Fields + '" kfields, ' + @Key_Values + ' kvalues, null ' +
  @Outer_Join + ' ON ' + @Join_Keys + ' WHERE B.' +
  substring( @Key_Fields,1,charindex('~',@Key_Fields+'~')-1) +
  ' is null'

EXECUTE (@SQL)
```

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Primary Key Fields

- Derived from Primary Key metadata
  - SQL Server
    - Table_Constraints
    - Key_Column_Usage
  - Oracle
    - All_Indexes
    - All_Ind_Columns
- Tells us the name of the primary key
- Tells us the fields in the primary key

Primary Key SQL

```
SELECT
  stuff(( select '~' + k1.column_name
          from information_schema.key_column_usage k1
          where k1.constraint_name = c.constraint_name
          order by ordinal_position
          for xml path('')
        ), 1,1,'')
FROM INFORMATION_SCHEMA.Table_Constraints c
WHERE c.table_schema = @Schema1
  AND c.table_name = @Table1
  AND c.constraint_type = 'PRIMARY KEY'
GROUP BY constraint_name
```

Result for @Key_Fields: **Key1~Key2**

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Audit SQL for Add

```
INSERT INTO Stage.DATA_CHANGES
     (Tablename, Action, Key_Fields, Key_Values, Changes)

SELECT 'Sample' tname, 'ADD' action, 'Key1~Key2' kfields,
          convert(varchar,A.Key1) + '~' +
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FROM mglasser.Sample A
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  ON  A.Key1 = B.Key1 and A.Key2 = B.Key2
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Staging Audit Data

Table Name	Action	Key Fields	Key Values	Changes
Sample	Delete	Key1~Key2	UMBC~2	
Sample	Add	Key1~Key2	UMBC~3	
Sample	Update	Key1~Key2	UMBC~1	~~Field1…

~~Field1=[Update Me^^Updated]

~Field2=[Jul 8 2009 12:00AM^^May 1 2009 12:00AM]~

~	field delimiter
^^	old/new value delimiter

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Audit for Update

- Join tables by primary key
- Compare each field in YDAY with same field in today's table
- String together results of comparison
  - Delimited by ~
- If fields are equal, results are empty
- If not equal, then put fieldname and both values
- In one SQL insert statement
  - Created dynamically from metadata

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Comparison Results

- No updates in Sample data

  ~~~~

- Updates from Sample data

  ~~Field1~Field2~

- Insert into staging table only those records where result has something other than ~

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  ~~~~

SQL for Comparison

SQL Server

```
CASE
  WHEN YDAY.Field1 = TODAY.Field1 THEN '~'

  ELSE
    'Field1=['+ YDAY.Field1 + '^^' + TODAY.Field1 + ']~'
END
```

Oracle

```
DECODE( YDAY.Field1, TODAY.Field1, null,
      'Field1=[' || YDAY.Field1 || '^^' || TODAY.Field1 || ']~')
```

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Create Dynamic SQL for Update

```
SELECT @Changes =
      stuff( (
        select '+ case when isnull(convert(varchar,A.' + c1.column_name +
             '),"") = isnull(convert(varchar,B.' + c1.column_name +
             '),"") then "~" else "' + c1.column_name +
             '=["+isnull(convert(varchar,A.' + c1.column_name +
             '),"") + "^^" +isnull(convert(varchar,B.' + c1.column_name +
             '),"") + "]~" end '
          from information_schema.columns c1
          where c1.column_name not in
               ('LOAD_DTTM','LASTUPDDTTM','DW_LOAD_DTTM',
               'UW_LOAD_DTTM','AGE','EFFDT','EFFSEQ')
            and c1.table_schema = c2.table_schema
            and c1.table_name = c2.table_name for xml path('') )
            , 1,1,'')
  FROM Information_Schema.Columns c2
  WHERE table_schema = @Schema1 and table_name = @Table1
  GROUP BY c2.table_schema, table_name
```

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Staging Audit Data

Table Name	Action	Key Fields	Key Values	Changes
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~	field delimiter
^^	old/new value delimiter

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Final Audit Data

Table Name	Action	Key Fields	Key Values
Sample	Delete	Key1~Key2	UMBC~2
Sample	Update	Key1~Key2	UMBC~1
Sample	Update	Key1~Key2	UMBC~1

Fieldname	Old Value	New Value	DW Load Dttm
			4/15/2009 14:30
Field1	Update Me	Updated	4/15/2009 14:30
Field2	Jul 8 2009 12:00AM	May 1 2009 12:00AM	4/15/2009 14:30

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Report the Differences

- The audit is complete
  - The keys for deleted or new records
  - The old and new values for updated fields
- Notify users of summary results
- Allow reporting of details

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Email Outputs

Email sent to HR data manager and OIR nightly

Records	Add	Delete	Update	Table Name
45	1	0	338	Employees_Cur
52	8	0	602	Jobs_Cur
23	19	1	3	PS_CITIZENSHIP
5	1	0	20	PS_FED_TAX_DATA
53	8	0	461	PS_JOB
19	15	0	8	PS_PERS_DATA_EFFDT
5	1	0	7	PS_STATE_TAX_DATA
12	8	0	6	PS_UM_JOB_INFO

Fields

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Crystal Report

Audit Updates

Comparing 04/21/2009
to changes made 04/22/2009

Table: **PS_JOB**

Key:	Emplid~Empl_Rcd 1000000808~1		
HR_Status		Old:	A
		New:	I
Empl_Status		Old:	A
		New:	T
Action		Old:	PAY
		New:	TER
Action_Dt		Old:	Jun 27 2008 12:00AM
		New:	Apr 22 2009 12:00AM
Action_Reason		Old:	NLY
		New:	TMP
Ben_Status		Old:	A
		New:	T
Termination_Dt		Old:	
		New:	Apr 12 2009 12:00AM
Asgn_End_Dt		Old:	
		New:	Apr 12 2009 12:00AM
Last_Date_Worked		Old:	
		New:	Apr 12 2009 12:00AM
Lastupdoprid		Old:	
		New:	DENISE

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Potential Alternatives

- Database logs
  - Utility program from vendors that read the logs the database keeps
  - Not available choice for us
  - Costs money (free ones?)
  - Output may not be flexible?
- Smaller views
  - Only audits the fields in the view
  - Can control for specific records
  - Smaller YDAY tables
  - Faster performance

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Poor Alternatives

- Separate program for each table
  - Longer development
  - Potentially huge SQL
  - Maintenance for table changes
- Separate dynamic SQL for each field
  - Horrible performance
  - Reads the tables once for each field

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Alternative Uses

- Debugging & development
- Table structure changes
  - ALL_TAB_COLS
  - Information_Schema.Columns
- Deltas for data warehouse loads
- Monitor or analyze database actions over time
- ???

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Wrap Up

Any Questions?

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Source code is available upon request

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