Scaling To Infinity: Partitioning Data Warehouses on Oracle Database

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Thursday 15-November 2012

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Speaker Qualifications

- Co-author…
  1. "*Oracle8 Data Warehousing*", 1998 John Wiley & Sons
  2. "*Essential Oracle8i Data Warehousing*", 2000 John Wiley & Sons
  3. "*Oracle Insights: Tales of the Oak Table*", 2004 Apress
  4. *"Basic Oracle SQL"* 2009 Apress
  5. "*Expert Oracle Practices: Database Administration with the Oak Table*", 2010 Apress
- 28 years in IT…
  - "C" programmer, sys admin, network admin (1984-1990)
  - Consultant and technical consulting manager at Oracle (1990-1998)
  - Independent consultant (http://www.EvDBT.com) since 1998
  - B of D, Rocky Mountain Oracle Users Group (http://www.RMOUG.org) since 1995
  - B of D, Oracle Developer Tools Users Group (http://www.ODTUG.com) since 2012
  - Oak Table network (http://www.OakTable.net) since 2002
  - Oracle ACE since 2007, Oracle ACE Director since 2012

Agenda

- The virtuous cycle and the death spiral
- Basic 5-step EXCHANGE PARTITION load technique
- 7-step EXCHANGE PARTITION technique for “dribble effect”
- Performing MERGE/up-sert logic using EXCHANGE PARTITION

Data warehousing reality

- We have to recognize how features for large data volumes and optimal queries work together
  - Partitioning
  - Direct-path loading
  - Compression
  - Star transformation
  - Bitmap indexes
  - Bitmap-join indexes
  - READ ONLY tablespaces
  - Information lifecycle management
- Because it really *isn't* documented anywhere

The Virtuous Cycle

- Non-volatile time-variant data *implies*…
  - Data warehouses are INSERT only
- Insert-only data warehouses *implies*…
  - Tables and indexes range-partitioned by a DATE column
- Tables range-partitioned by DATE *enables*…
  - Data loading using EXCHANGE PARTITION load technique
  - Partitions organized into time-variant tablespaces
  - Incremental statistics gathering and summarization
- Data loading using EXCHANGE PARTITION *enables*…
  - Direct-path (a.k.a. append) inserts
  - Data purging using DROP/TRUNCATE PARTITION instead of DELETE
  - Bitmap indexes and bitmap-join indexes
  - Elimination of ETL "load window" and 24x7 availability for queries

The Virtuous Cycle

- Direct-path (a.k.a. *append*) inserts *enable*…
  - Load more data, faster, more efficiently
  - Optional NOLOGGING on inserts
  - Basic table compression (9*i*) or HCC (11gR2) for Oracle storage
  - Eliminates contention in Oracle Buffer Cache during data loading
- Optional NOLOGGING inserts *enable*…
  - Option to generate less redo during data loads
  - Optimization of backups
- Table compression enables…
  - Less space consumed for tables and indexes
  - Fewer I/O operations during queries
- Partitions organized into time-variant tablespaces *enable*…
  - READ ONLY tablespaces for older, less-volatile data

The Virtuous Cycle

- READ ONLY tablespaces for older less-volatile data *enables*…
  - Tiered storage
  - Backup efficiencies
- Data purging using DROP/TRUNCATE PARTITION *enables*…
  - Faster more efficient data purging than using DELETE statements
- Bitmap indexes *enable*…
  - Star transformations
- Star transformations *enable*…
  - **Optimal** query-execution plan for dimensional data models
  - Bitmap-join indexes
- Bitmap-join indexes *enable*…
  - **Further optimization** of star transformations

The Death Spiral

- ETL using “conventional-path” INSERT, UPDATE, and DELETE operations
- Conventional-path operations work well in transaction environments
  - High-volume data loads in bulk are problematic
  - High parallelism causes contention in Shared Pool, Buffer Cache
    - Mixing of queries and loads simultaneously on table and indexes
    - Periodic rebuilds/reorgs of tables if deletions occur
    - Full redo and undo generation for all inserts, updates, and deletes
  - Bitmap indexes and bitmap-join indexes
    - Modifying bitmap indexes is slow, SLOW, **SLOW**
    - Unavoidable locking issues in during parallel operations

The Death Spiral

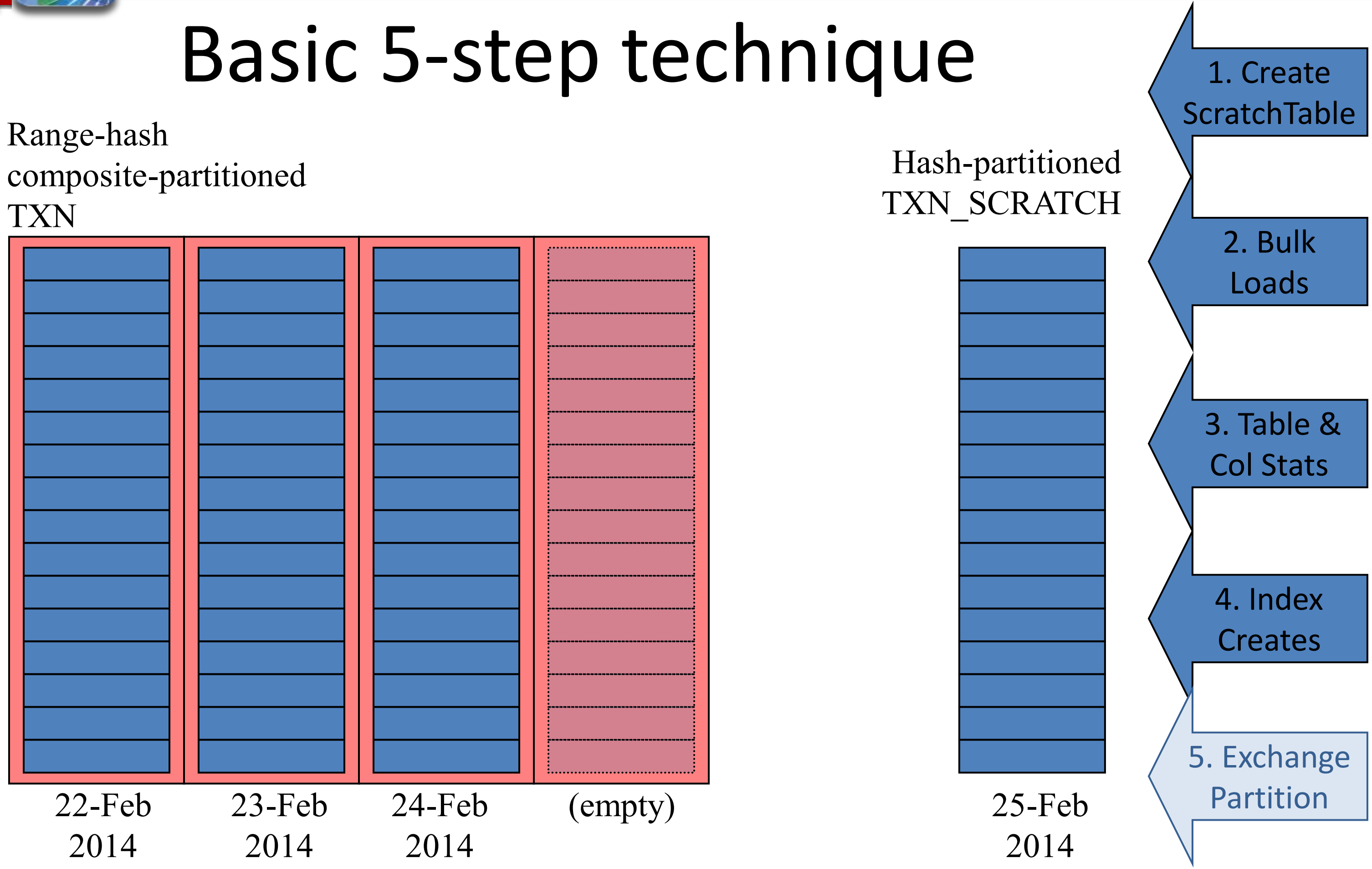
- ETL dominates the workload in the database
  - Queries will consist mainly of “dumps” or extracts to downstream systems
  - Query performance worsens as tables/indexes grow larger
  - Stats gathering takes longer, smaller samples worsen query performance
  - Contention between queries and ETL become evident
  - Uptime impacted as bitmap indexes must be dropped/rebuilt
- Backups consume more and more time and resources
  - Entire database must be backed up regularly
  - Data cannot be “right-sized” to storage options according to IOPS, so storage becomes non-uniform and patchwork, newer less-expensive storage is integrated amongst older high-quality storage, failure points proliferate

Basic 5-step technique

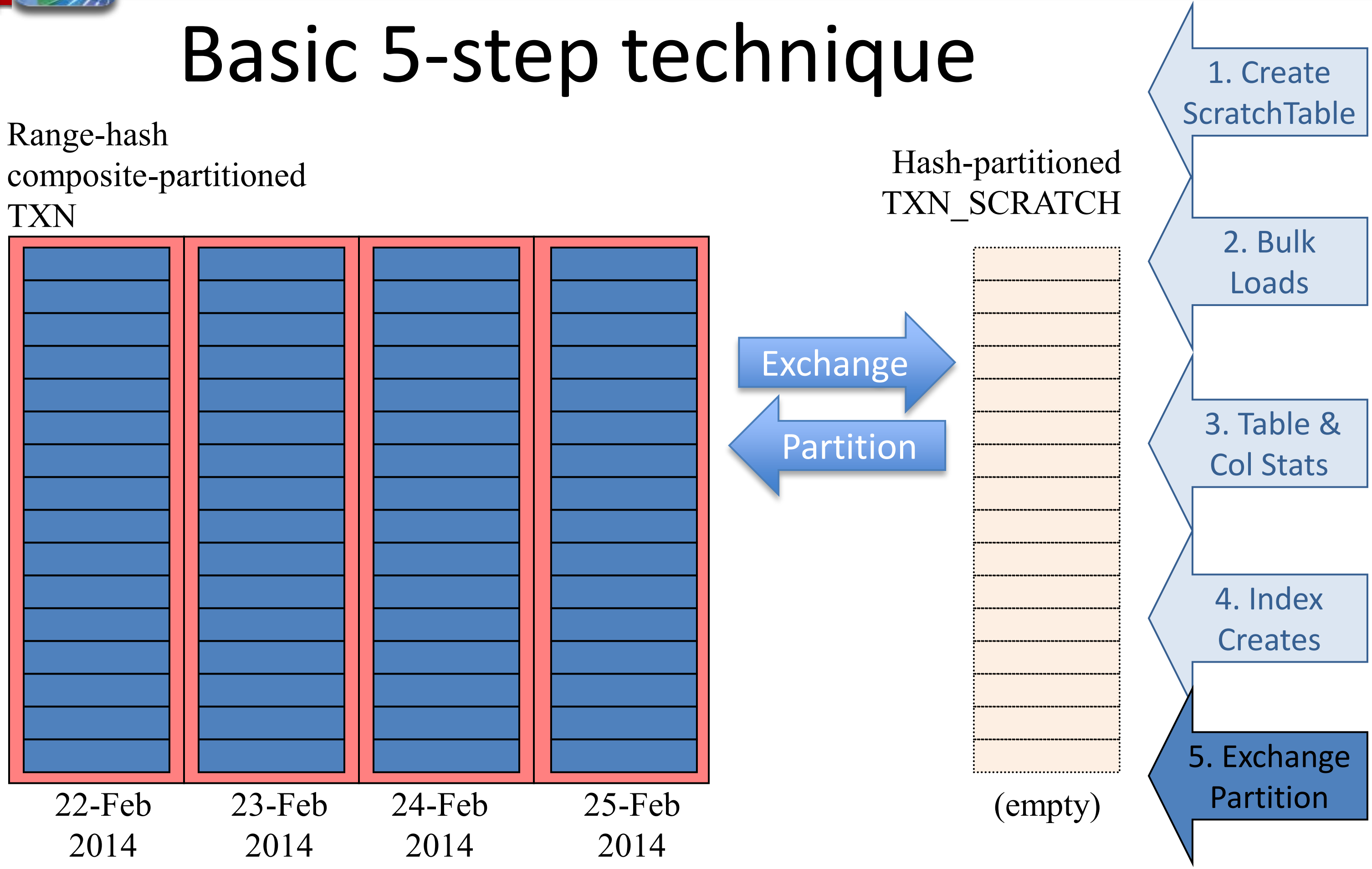
- The basic technique of bulk-loading new data into a temporary-user "scratch" table, which is then indexed, analyzed, and finally "published" using the EXCHANGE PARTITION operation
  - This should be the default load technique for all large tables in a data warehouse

- Assumptions for this example:
  - A "type 2" time-variant composite-partitioned fact table named TXN
    - Range partitioned on DATE column TXN_DATE
    - Hash sub-partitioned on NUMBER column ACCT_KEY
  - 25-Feb 2014 data to be loaded into "scratch" table named TXN_SCRATCH
  - Ultimately data to be published into partition P20140225 on TXN

Basic 5-step technique



Basic 5-step technique



Basic 5-step technique

1. Create “*scratch*” table TXN_SCRATCH as a hash-partitioned table
2. Perform parallel, append load of data into TXN_SCRATCH
3. Gather CBO statistics on table TXN_SCRATCH
   - Only table and columns stats
4. Create indexes on TXN_SCRATCH matching local indexes on TXN
5. alter table TXN

   exchange partition P20140225 with table TXN_SCRATCH

   including indexes without validation update global indexes;

Basic 5-step technique

- It is a good idea to encapsulate this logic inside PL/SQL packaged- or stored-procedures:

```
SQL> exec exchpart.prepare('TXN','TXN_SCRATCH','25-FEB-2014');
SQL> alter session enable parallel dml;
SQL> insert /*+ append parallel(n, 16) */ into txn_scratch n
  3  select /*+ full(x) parallel(x, 16) */ *
  4  from   ext_stage x
  5  where  x.load_date >= '25-FEB-2014'
  6  and    x.load_date < '26-FEB-2014';
SQL> commit;
SQL> exec exchpart.finish('TXN','TXN_SCRATCH');
```

- DDL for EXCHPART package posted at http://www.EvDBT.com/tools.htm#exchpart

The “dribble effect”

- In real-life, data loading is often much *messier*…
  - Due to range partition key column not matching load cycles…

<u>Example</u>: data to be loaded on 25-Feb is ~1,000,000 rows:

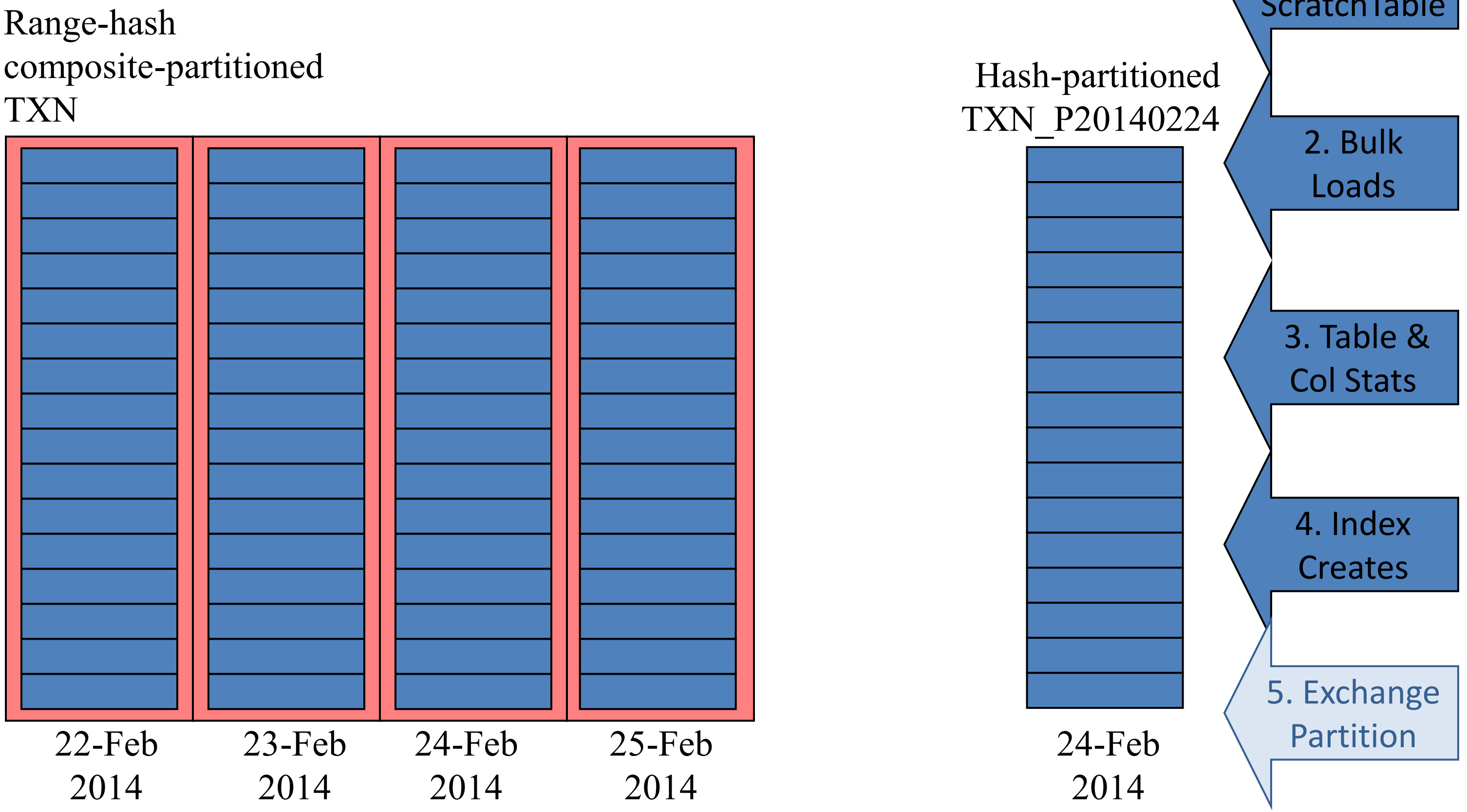
- 950,000 rows for 25-Feb
- 45,000 rows for 24-Feb
- 4,000 rows for 23-Feb
- 700 rows for 22-Feb
- 200 rows for 21-Feb
- 90 rows for 20-Feb
- …and a dozen rows left over from 07-Jan…

The “dribble effect”

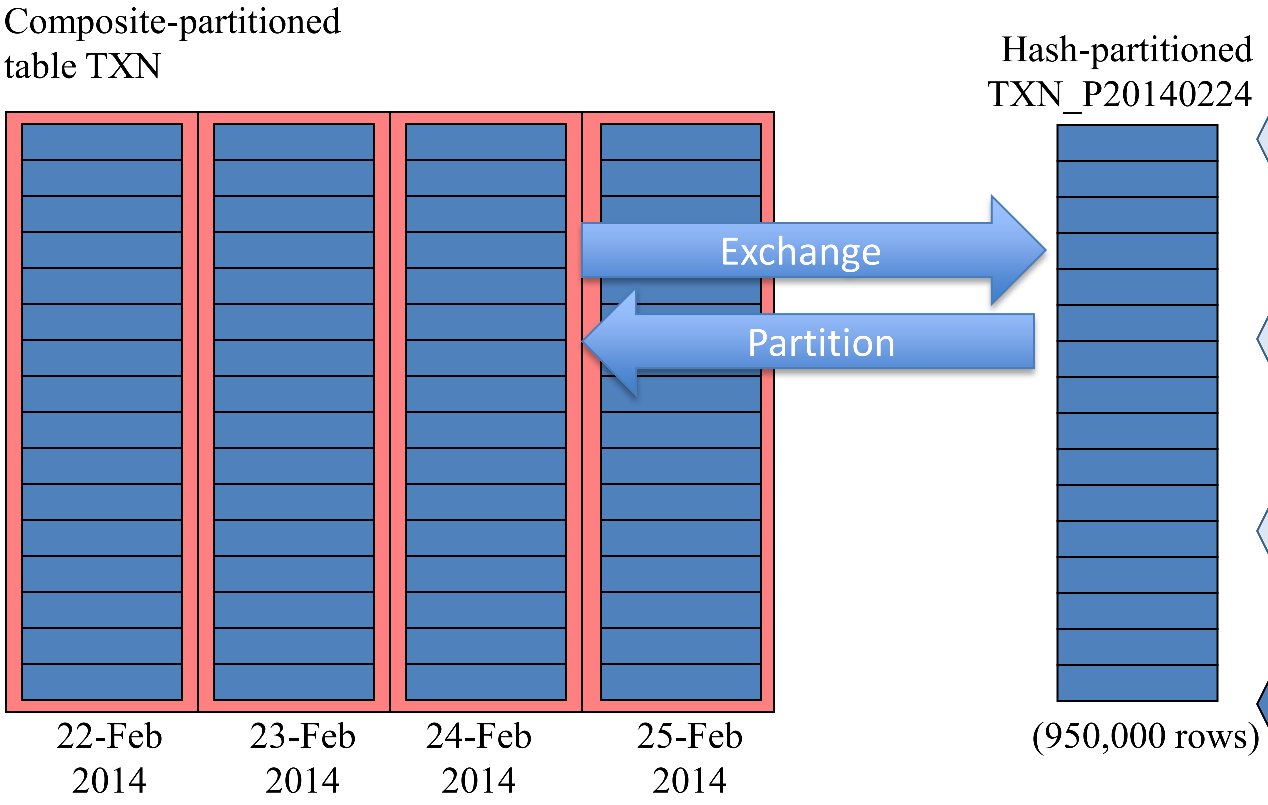
Use EXCHANGE PARTITION technique when >= N rows; otherwise, conventional INSERT

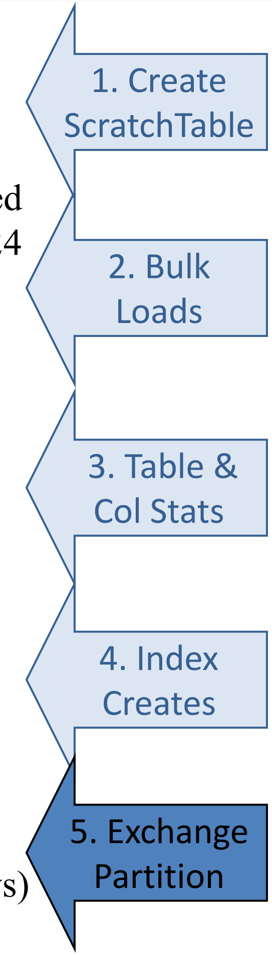
```
for d in (select trunc(txn_dt) dt, count(*) cnt from EXT_STAGE group by trunc(txn_dt)) loop
     --
     if d.cnt >= 100 then
          --
          exchpart.prepare(‘TXN’,’TXN_P’||to_char(d.dt,’YYYYMMDD’), d.dt);
          insert /*+ append parallel(n,16) */ into TXN_P20140224 n
          select /*+ parallel(x,16) */ * from EXT_STAGE x
          where  x.txn_dt >= d.dt and x.txn_dt < d.dt + 1;
          exchpart.finish(‘TXN’, ’TXN_P’||to_char(d.dt,’YYYYMMDD’));
          exchpart.drop_indexes(’TXN_P’||to_char(d.dt,’YYYYMMDD’));
          insert /*+ append parallel(n,16) */ into TXN_P20140224 n
          select /*+ parallel(x,16) */ * from EXT_STAGE x
          where  x.txn_dt >= d.dt and x.txn_dt < d.dt + 1;
          --
     else
          --
          insert into TXN
          select * from ext_stage
          where  txn_dt >= d.dt and txn_dt < d.dt + 1;
          --
     end if;
     --
end loop;
```

7-step technique

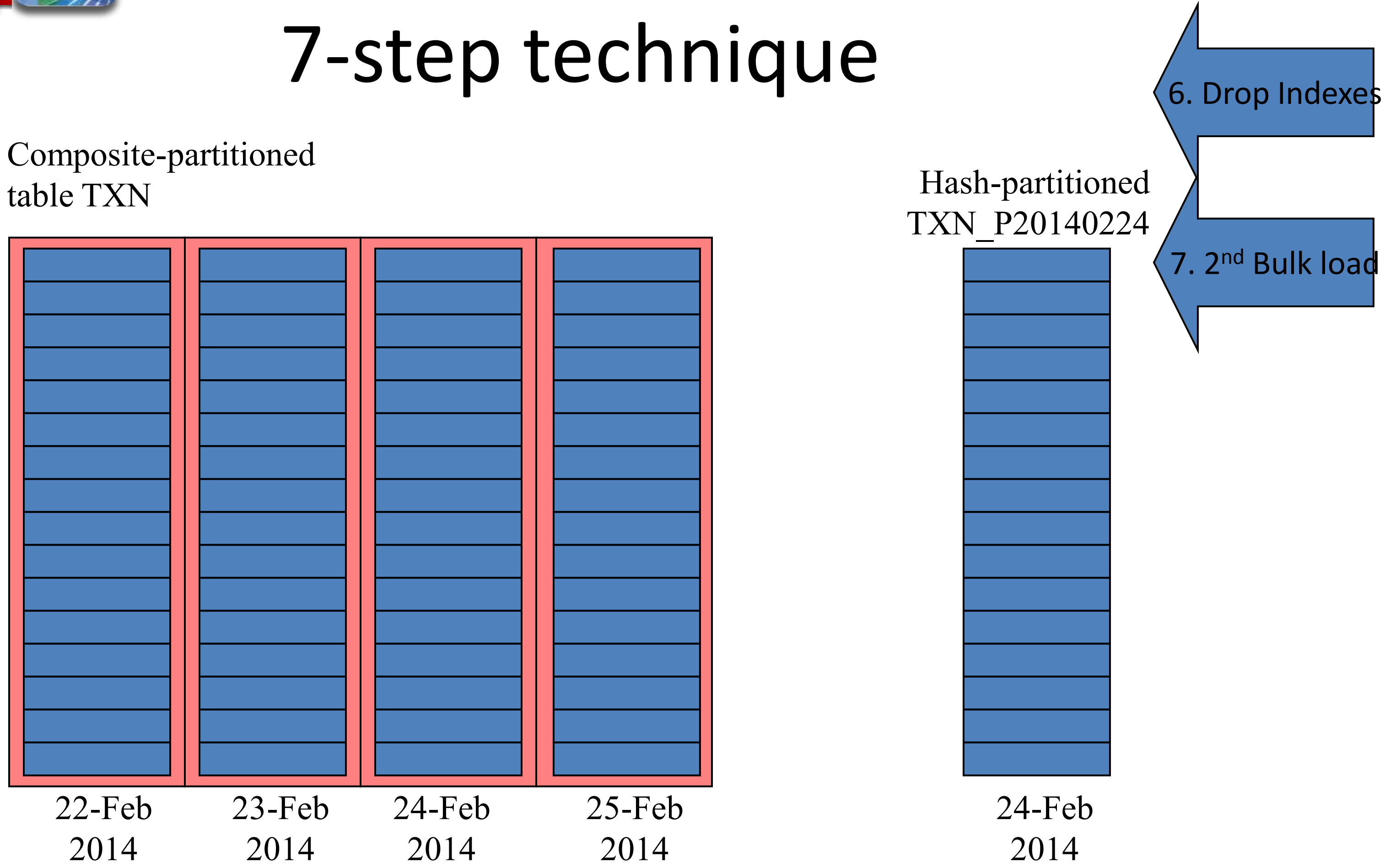


7-step technique





7-step technique



7 step technique

1. Use existing hash-partitioned "*scratch*" table TXN_P20140224
   - From previous load cycle
2. Perform parallel, append load of data into TXN_P20140224
3. Gather CBO statistics on table TXN_P20140224
   - Only table and columns stats
4. Create indexes on TXN_P20140224 matching local indexes on TXN
5.
```
alter table TXN
    exchange partition P20140224 with table TXN_P20140224
    including indexes without validation update global indexes;
```
6. Drop indexes on TXN_P20140224
7. Perform parallel, append load of data into TXN_P20140224

…and…

…OK, more than 7 steps…

8. Need to determine how long to retain time-stamped "scratch" tables
   - EXCHPART.PREPARE procedure can first check if the specified "scratch" table already exists
     - If not, then creates it from base partition
     - If so, just use what exists
   - Need logic to drop "scratch" tables after N load cycles

MERGE / Up-sert logic

- Slowly-changing dimension tables
  - Change often enough to require time-variant image of data
    - Should be loaded similar to fact tables using basic 5-step or advanced 7-step EXCHANGE PARTITION loads
  - Also require current point-in-time image of data
    - MERGE or update-else-insert (a.k.a. up-sert) logic
      - If row exists, then update, else insert

MERGE / Up-sert or…

- So we could either do it this way…

```
merge into curr_acct_dim
using (select * from acct_dim
       where eff_dt >= '25-FEB-2014'
       and   eff_dt <  '26-FEB-2014')
when matched then update set ...
when not matched then insert ...;
```

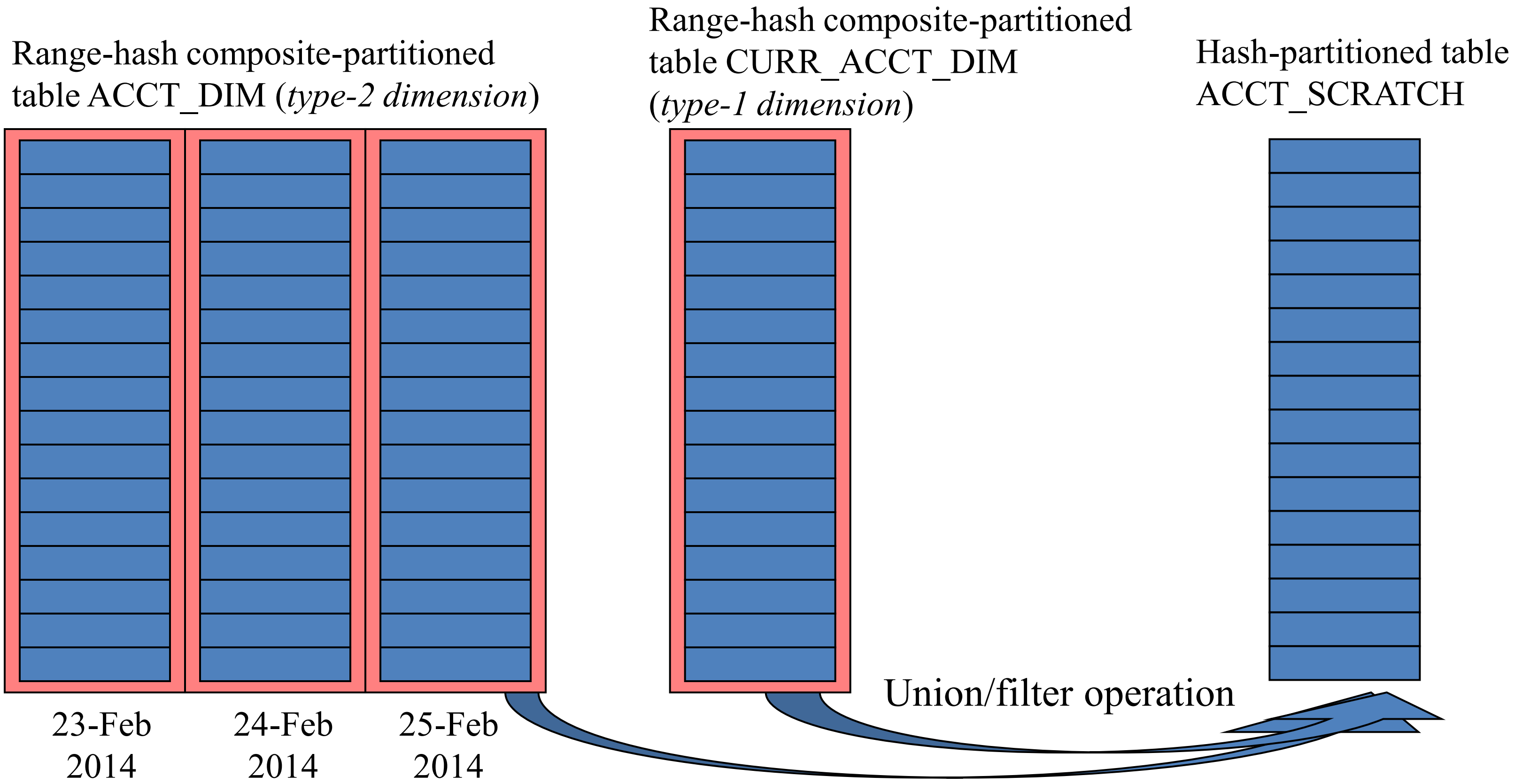
...or EXCHANGE PARTITION

1. Create/reuse hash-partitioned "*scratch*" table ACCT_SCRATCH
2. Perform parallel, append load of data into ACCT_SCRATCH
   - Nested in-line SELECT statements doing UNION, ranking, and filtering
3. Gather CBO statistics on table ACCT_SCRATCH
4. Create indexes on ACCT_SCRATCH matching local indexes on CURR_ACCT_DIM
5. alter table CURR_ACCT_DIM

   exchange partition PDUMMY with table ACCT_SCRATCH

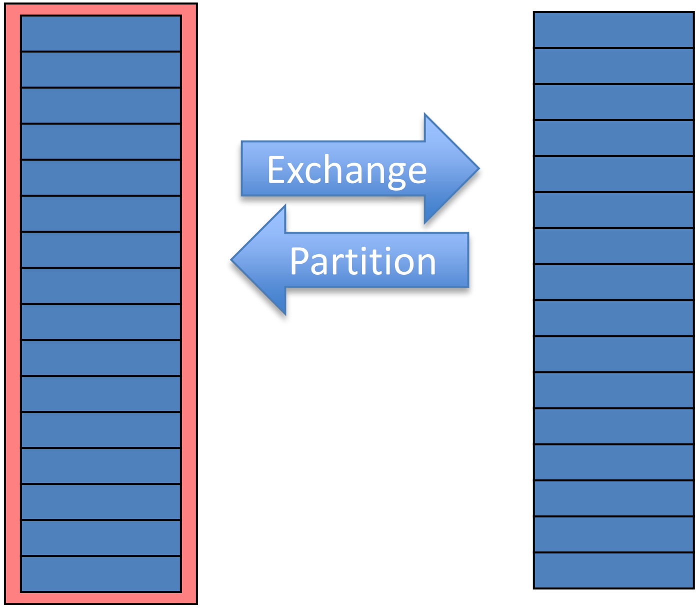
   including indexes without validation;

Merge / Up-sert



Merge / Up-sert

CURR_ACCT_DIM
- Range-hash composite-partitioned
- Range partition key column = PK column
- Single range partition named PDUMMY
- B*Tree index on PK (local)
- Bitmap indexes (local) on attributes



ACCT_SCRATCH
- Hash partitioned
- Hash partition key column same as CURR_ACCT_DIM
- Indexes created to match local indexes on CURR_ACCT_DIM

Merge / Up-sert

```
INSERT /*+ append parallel(t,8) */ INTO ACCT_SCRATCH t
SELECT ...(list of columns)...
FROM    (SELECT ...(list of columns)...,
                ROW_NUMBER() over (PARTITION BY acct_key
                                   ORDER BY eff_dt desc) rn
         FROM  (SELECT   ...(list of columns)...
                FROM     CURR_ACCT_DIM
                UNION ALL
                SELECT   ...(list of columns)...
                FROM      ACCT_DIM partition(P20140225)))
WHERE  RN = 1;
```

1. Inner-most query pulls newly-loaded data from ACCT_DIM, unioned with existing data from type-1 CURR_ACCT_DIM
2. Middle query ranks rows within each ACCT_KEY value, sorted by EFF_DT in descending order
3. Outer-most query selects only the latest row for each ACCT_KEY and passes to INSERT
4. INSERT APPEND (direct-path) and parallel, can compress rows, if desired

Merge / Up-sert

- Assume that…
  - CURR_ACCT_DIM has 15m rows total
  - 1m new rows just loaded into 25-Feb partition of ACCT_DIM
    - 100k (0.1m) rows are new accounts, 900k (0.9m) rows changes to existing accounts
- Then, what will happen is…
  - Inner-most query in SELECT fetches 15m rows from CURR_ACCT_DIM unioned with 1m rows from 25-Feb partition of ACCT_DIM, returning **16m rows** in total
  - Middle query in SELECT ranks rows within each ACCT_KEY by EFF_DT in descending order, returning **16m rows**
  - Outer-most query in SELECT filters to most-recent row for each ACCT_KEY, returning **15.1m** rows
  - Inserts **15.1m** rows into ACCT_SCRATCH

Summary

1. During load cycles, load time-variant type-2 tables…
   – Either using basic 5-step EXCHANGE PARTITION load technique when load cycles match granularity of range partitions…
   – Or using 7-step EXCHANGE PARTITION load technique for “dribble effect” when load cycles do not match granularity of range partitions
2. …**then**, merge newly-loaded data from time-variant tables into point-in-time type-1 tables
   – Using EXCHANGE PARTITION load technique to accomplish merge / up-sert logic

Things To Remember (1)

- If…
  - …you are loading large volumes of data…
  - …the data is to be compressed…
  - …there are bitmap or bitmap-join indexes…
- Then…
  - …use EXCHANGE PARTITION load technique

Things To Remember (2)

- If you are performing a large MERGE/Up-sert or UPDATE (or DELETE!) operation…
  - The fastest MERGE or UPDATE is an INSERT
    - Followed by EXCHANGE PARTITION

Thank You!

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