Key SQL Function in DB2 9 for z/OS & Beyond

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August 2, 2010   4:30 pm – 5:30 pm
Session Number 7967

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Agenda

- SQL Enhancements in DB2 9 for z/OS
- Selected SQL Overview in DB2 10 for z/OS
  - Hash Access
  - Temporal Data
  - IBM ISAO

SQL Enhancements in DB2 9 for z/OS

Key SQL Functions in V9

- New data types: BIGINT, BINARY, VARBINARY, DECFLOAT
- Instead of Trigger
- Merge
- SELECT FROM MERGE/UPDATE/DELETE
- ORDER BY and FETCH FIRST in subselect
- TRUNCATE
- INTERSECT/EXCEPT
- Index on Expression

Key SQL Functions in V9 - cont'd

- Sparse Index and In Memory Data Caching
- Dynamic Index Anding and Star Schema
- OLAP specification -- RANK, DENSE_RANK, ROW_NUMBER
- RENAME INDEX/COLUMN
- REOPT (AUTO)

New data types: BIGINT, BINARY, VARBINARY, DECFLOAT

- **BIGINT** - big integer.
  - Big integer is a binary integer with a precision of 63 bits. The range of big integers is [-9223372036854775808, 9223372036854775807
- **BINARY** – fixed-length binary string.
  - Fixed-length binary string is in a range of [1,255]. The padding with hexadecimal zeros (X'00'). Not associated with any CCSID
- **VARBINARY** – varying-length binary string.
  - Varying-length binary string is in a range of [1,32704]. No padding is performed. Not associated with any CCSID
- **DECFLOAT** – Decimal float.
  - DECFLOAT(16) = decimal64 format (8 bytes)
  - DECFLOAT(34) = decimal128 format (16 bytes)

DECFLOAT

- Both IEEE and hexadecimal floating point numbers can only approximate common decimal numbers. But DFP can represent decimal number exactly.
- DFP can represent much bigger and smaller number than DECIMAL.

Description	Limit
Smallest DECFLOAT(16) Values	$-9.999999999999999 \times 10^{384}$
Largest DECFLOAT(16) Value	$9.999999999999999 \times 10^{384}$
Smallest positive DECFLOAT(16) Value	$1.000000000000000 \times 10^{-383}$
Largest negative DECFLOAT(16) value	$-1.000000000000000 \times 10^{-383}$
Smallest DECFLOAT(34) Value	$-9.999999999999999999999999999999999 \times 10^{6144}$
Largest DECFLOAT(34) Value	$9.999999999999999999999999999999999 \times 10^{6144}$
Smallest positive DECFLOAT(34) Value	$1.000000000000000000000000000000000 \times 10^{-6143}$
Largest negative DECFLOAT(34) Value	$-1.000000000000000000000000000000000 \times 10^{-6143}$

Instead of Trigger

- A new type of trigger (~ BEFORE, AFTER triggers)
- Defined on VIEWs
  - provides an extension to the updatability of views
  - requested update operation against the view gets replaced by the trigger logic
  - application still believes all operations are performed against the view
  - applicable even for updatable views

Instead of Trigger

```
CREATE TABLE WEATHER (CITY VARCHAR(25), TEMPF DECIMAL(5,2));
CREATE VIEW CELCIUS_WEATHER_V (CITY, TEMPC) AS
      SELECT CITY, (TEMPF-32)*5.00/9.00 FROM WEATHER

CREATE TRIGGER CW_INSERT INSTEAD OF INSERT ON
        CELCIUS_WEATHER_V
REFERENCING NEW AS NEWCW DEFAULTS NULL
FOR EACH ROW MODE DB2SQL
    INSERT INTO WEATHER VALUES (NEWCW.CITY,
                                          9.00/5.00*NEWCW.TEMPC+32)

CREATE TRIGGER CW_UPDATE INSTEAD OF UPDATE ON
         CELCIUS_WEATHER_V
REFERENCING NEW AS NEWCW OLD AS OLDCW DEFAULTS NULL
FOR EACH ROW MODE DB2SQL
    UPDATE WEATHER AS W
      SET W.CITY = NEWCW.CITY,
            W.TEMPF = 9.00/5.00*NEWCW.TEMPC+32
      WHERE W.CITY = OLDCW.CITY
```

Merge

- Combine **Update** and **Insert** operation to a target table or view, from a input source of a list of host-variable-arrays modeled as a source table
  - When source rows **match** to target, **Update** target rows from source
  - When source rows **do not match** to target, **Insert** source rows into target
  - Update/Insert triggers will be fired

```
MERGE INTO account AS T
  USING VALUES (:hv_id, :hv_amt) FOR 5 ROWS AS S(id,amt)
ON T.id = S.id
  WHEN MATCHED THEN
    UPDATE SET balance = T.balance + S.amt
  WHEN NOT MATCHED THEN
    INSERT (id, balance) VALUES (S.id, S.amt)
NOT ATOMIC CONTINUE ON SQLEXCEPTION
```

SELECT FROM MERGE/UPDATE/DELETE

- V8 - The INSERT statement was allowed in the FROM clause
- V9 - A searched UPDATE/DELETE is now allowed in the FROM clause

Delete employees at level 'Contractor' and return the total amount of salary:

```
SELECT SUM(Salary)
FROM OLD TABLE
(DELETE FROM Employee WHERE Level =
'Contractor');
```

SELECT FROM MERGE/UPDATE/DELETE

Update salaries of employees at level 'Associate' and return the new salary:

```
SELECT Name, Salary
FROM FINAL TABLE
(UPDATE Employee   SET Salary = Salary *1.1
  WHERE Level = 'Associate');
```

Update salaries of employees at level 'Associate' and return the old salary:

```
SELECT Name, Salary
FROM OLD TABLE
(UPDATE Employee   SET Salary = Salary *1.1
  WHERE Level = 'Associate');
```

ORDER BY and FETCH FIRST in subselect

- ORDER BY clause can be specified in subselect or fullselect
- FETCH FIRST n ROWS ONLY clause can be specified in subselect or fullselect
- ORDER OF table-designator extension to the ORDER BY clause

```
(SELECT * FROM T1
 ORDER BY C1)
UNION
(SELECT * FROM T2
 ORDER BY C2
 FETCH FIRST 2 ROWS)
```

```
(SELECT * FROM T1
 ORDER BY C1)
UNION
SELECT * FROM T2
ORDER BY C2
FETCH FIRST 2 ROWS
```

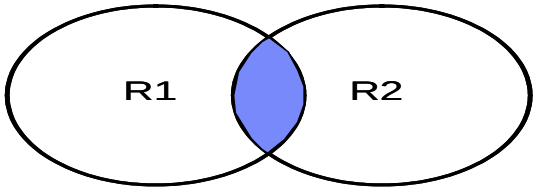
TRUNCATE Table

- A fast way to empty a table
- **DELETE Triggers are ignored**
- Indexes, LOB, XML Tablespaces are also deleted
- X lock on the target table, Mass-delete

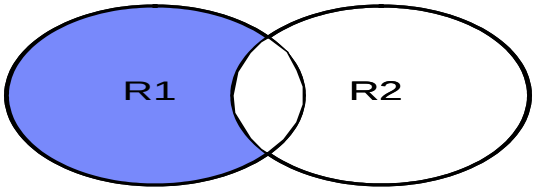
```
TRUNCATE <TABLE> TABLE-NAME

  < DROP STORAGE | REUSE STORAGE>

  < RESTRICT WHEN DELETE TRIGGERS | IGNORE DELETE TRIGGERS>

  < IMMEDIATE>
```

INTERSECT/EXCEPT

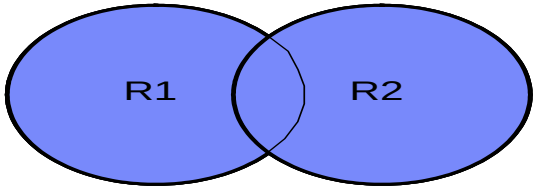
- SET operator: UNION, **INTERSECT, EXCEPT**



INTERSECT



EXCEPT
(Difference)



UNION

```
SELECT c11, c12, …, c1n FROM T1 <set-op>
SELECT c21, c22, …, c2m FROM T2
```

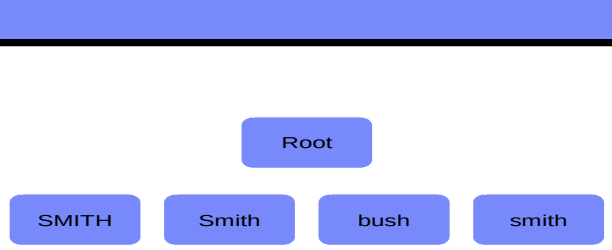
INTERSECT/EXCEPT

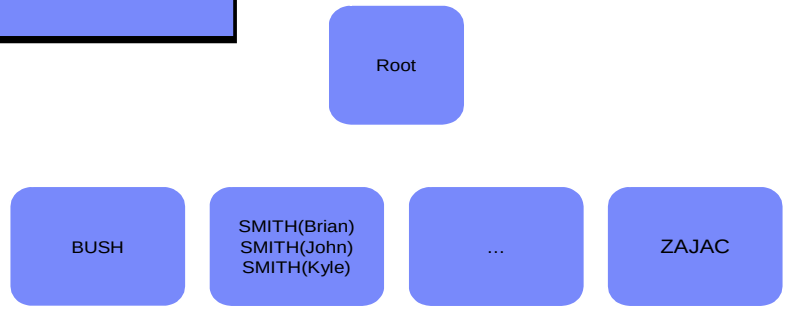
R1	R2	UNION ALL	UNION	EXCEPT ALL	EXCEPT	INTERSECT ALL	INTERSECT
1	1	1	1	1	2	1	1
1	1	1	2	2	5	1	3
1	3	1	3	2		3	4
2	3	1	4	2		4	
2	3	1	5	4			
2	3	2		5			
3	4	2					
4		2					
4		3					
5		3					
		3					
		3					
		3					
		4					
		4					
		4					
		5					

Index on Expression

- Create index on result of Expression
- Enhance Query Performance
- If we want to search for customers whose Upper(Lastname) = ‘SMITH’

```
CREATE INDEX IX_LastName ON CUSTOMER
 ( UPPER (Lastname), CUSTOMER_ID);

SELECT * FROM EMP
    WHERE UPPER (Lastname) = 'SMITH';
```





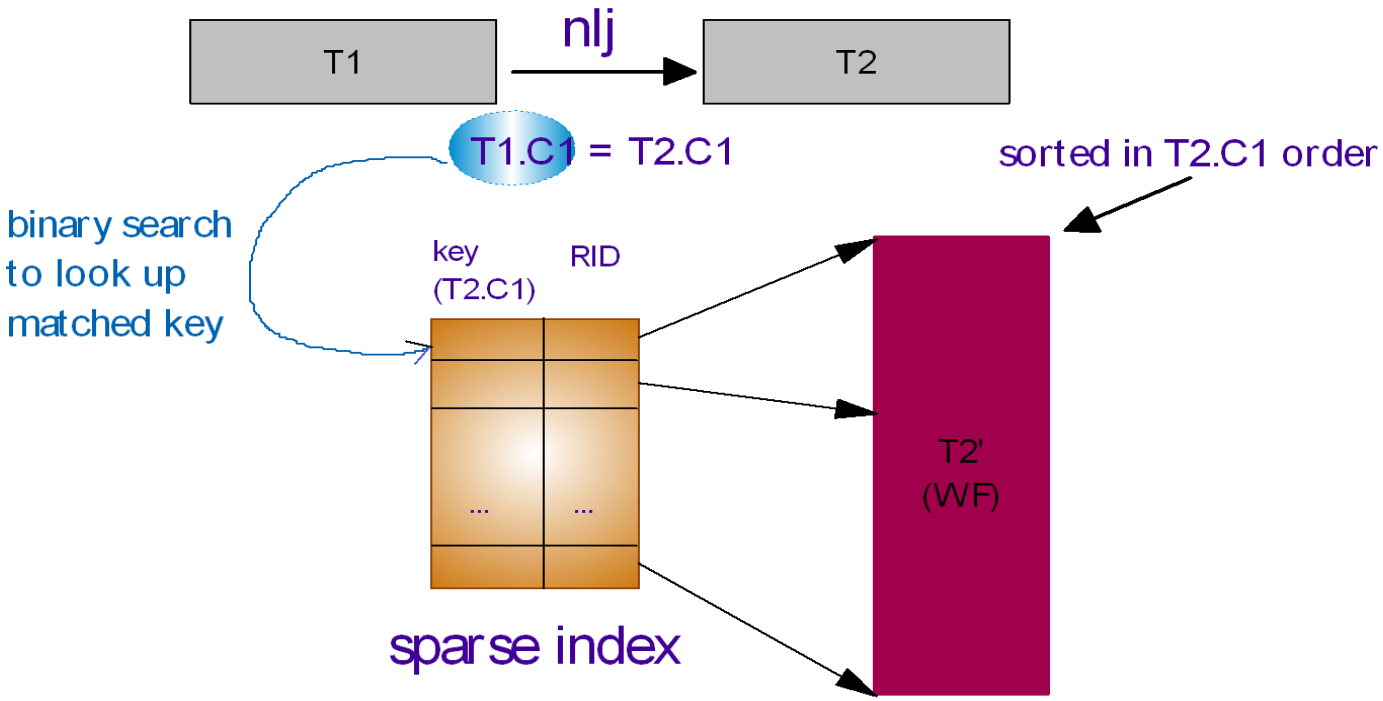
Index on Expression - 2

- CREATE INDEX IX1 ON T1 (HEX(c1), BINARY(LTRIM(c2)));
- CREATE INDEX IX2 ON T2 (SUBSTR(c2, 1, 23), CONCAT(c2, c3));
- CREATE INDEX IX3 ON T2 (salary, bonus/salary, bonus+salary);
- CREATE INDEX IX4 ON T1 (DAYOFYEAR(endship) - DAYOFYEAR(startship));
- CREATE INDEX IX5 ON T2 (GRAPHIC(c3));
- CREATE INDEX IX6 ON T1 (VARCHAR(INSERT(vchar30,1,0,''),20));
- CREATE INDEX IX7 ON T1 (posstr(lvcharx2, '7.2E+02')) ;
- CREATE INDEX IX8 ON T1 (MIDNIGHT_SECONDS(birthday));

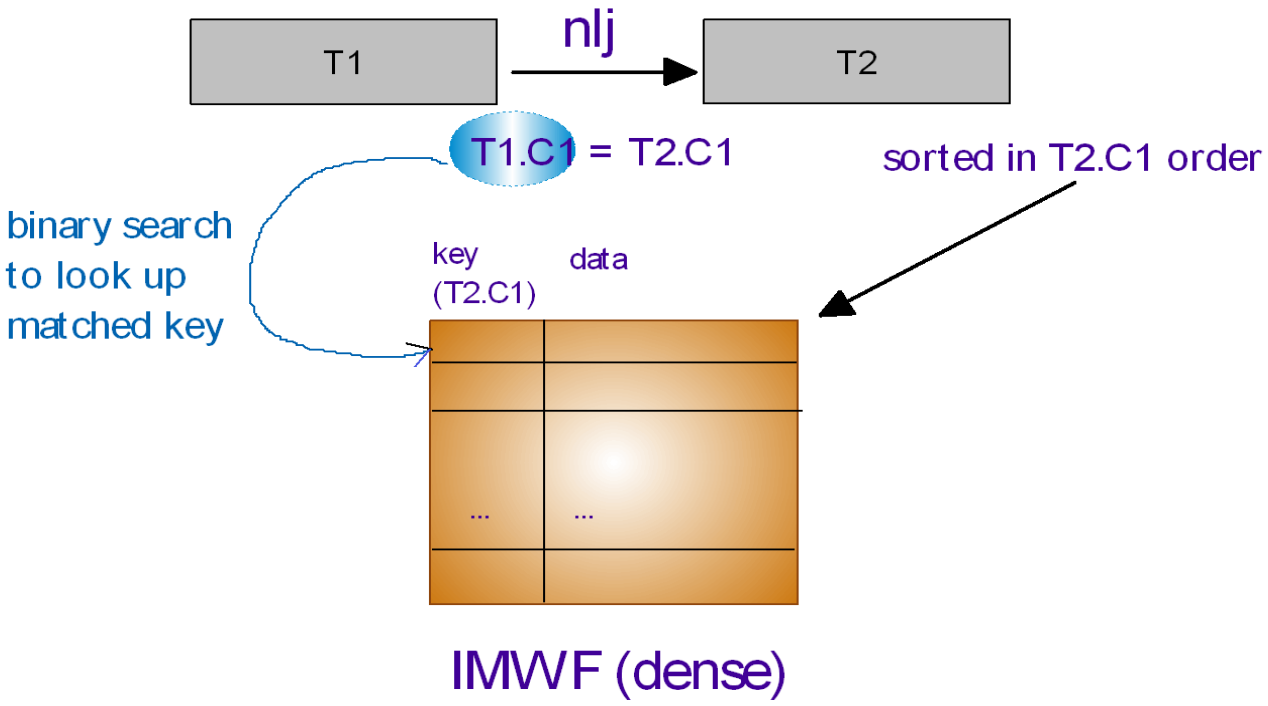
Sparse Index and In Memory Data Caching

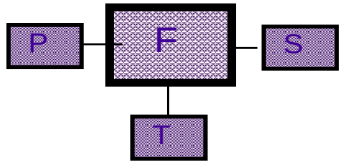
- Tables which are lack of appropriate index or enough statistics can benefit from sparse index / IMWF
- Sparse index / IMWF is used for **Nested Loop Join**
- Whether use sparse index or IMWF is a runtime decision according to storage availability

How does sparse index work?



How does IMWF work?

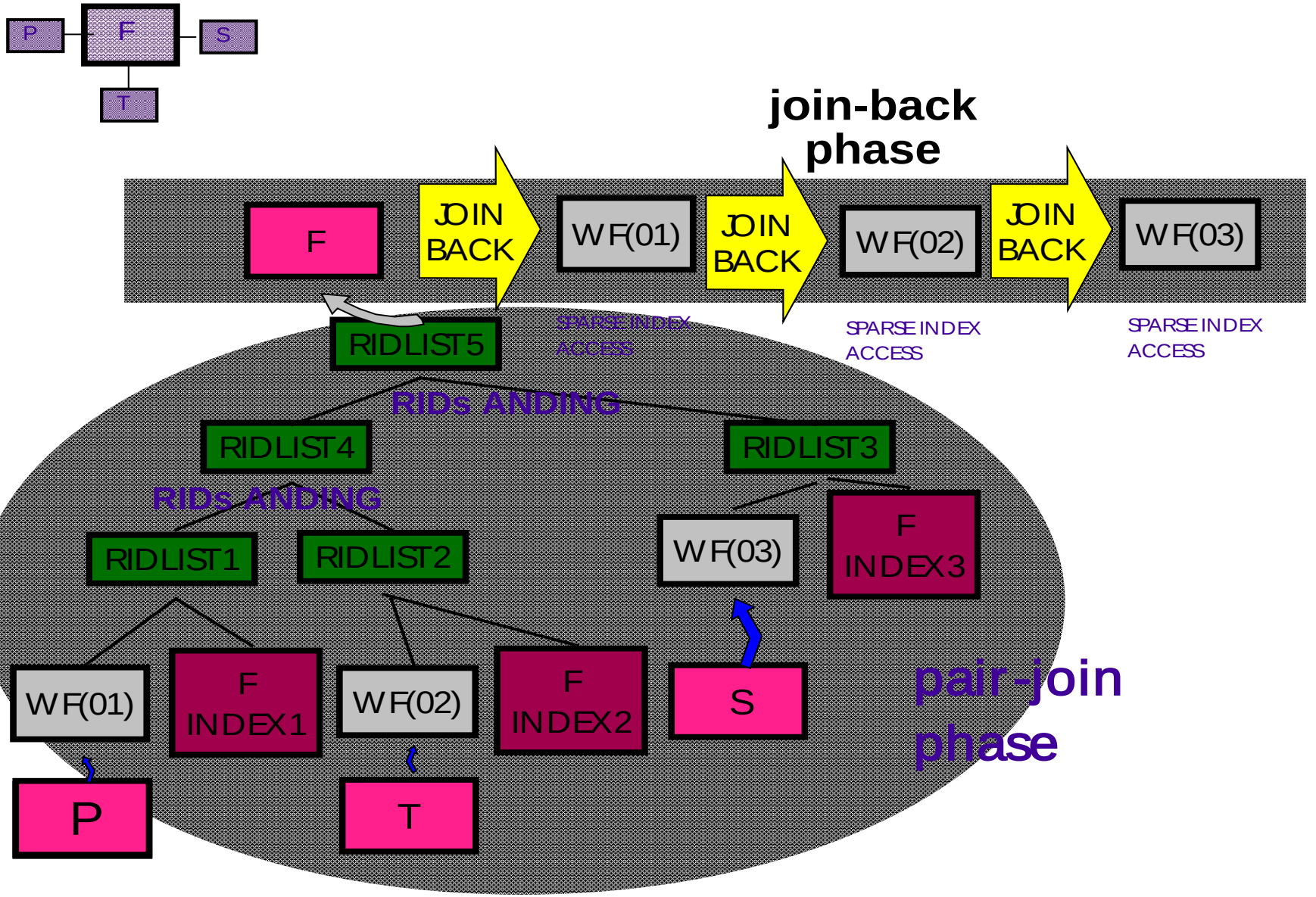




Dynamic Index Anding and Star Schema

- Each dimension table joins with Fact table separately
- The join result is Rid lists of Fact table
- Using Rids Merge (ANDing) to generate final set of Fact table Rid lists

```
SELECT PRODNAME, SUM(SALES), ...
 FROM F, PROD P, CUST C, TIME T, STORES S
WHERE F.PID = P.ID
     AND F.TID = T.ID
     AND F.SID = S.ID
 AND T.MONTH IN ('JAN', 'FEB')
 AND S.LOCATION IN ('SAN JOSE', 'DALLAS')
 AND P.TYPE IN ('FOOD', 'SODA')
GROUP BY ...
```


P
F
S
T
join-back phase
F
JOIN BACK
WF(01)
JOIN BACK
WF(02)
JOIN BACK
WF(03)
RIDLIST5
SPARSE INDEX ACCESS
SPARSE INDEX ACCESS
SPARSE INDEX ACCESS
RIDs ANDING
RIDLIST4
RIDLIST3
RIDs ANDING
RIDLIST1
RIDLIST2
WF(03)
F INDEX3
WF(01)
F INDEX1
WF(02)
F INDEX2
S
P
T
pair-join phase

OLAP specification -- RANK, DENSE_RANK, ROW_NUMBER

- RANK() OVER Window ----> OLAP Function
  - PARTITION BY sh.territory --- row should be assigned to partition according to territory
  - ORDER BY sh.sales --- row sorted in the order of sales amount within each partition
- Apply after Join, Predicates, Group By, Having
- A new class of aggregate functions
  - Rank
  - DENSERANK
  - ROWNUMBER

```
SELECT  sh.territory, sh.sales,
        Rank() over (PARTITION BY sh.territory
                     ORDER BY sh.sales desc) as rank
    FROM sales_history;
```

OLAP specification -- RANK, DENSE_RANK, ROW_NUMBER

```
SELECT EMPNUM, DEPT, SALARY,
    RANK()      OVER (ORDER BY SALARY DESC) as RANK,
    DENSERANK() OVER (ORDER BY SALARY DESC)as DENSERANK,
    ROWNUMBER() OVER (ORDER BY SALARY DESC) as ROWNUM
FROM EMPLOYEE;
```

EMPNUM	DEPT	SALARY	RANK	DENSERANK	ROWNUM
3	-	84000	1	1	1
8	3	79000	2	2	2
6	1	78000	3	3	3
2	1	75000	4	4	4
7	1	75000	4	4	5
12	3	75000	4	4	6
10	3	55000	7	5	7
11	1	53000	8	6	8

RENAME INDEX/COLUMN

- Without having to drop and recreate the object
- Rename Column

```
ALTER TABLE tb1
   RENAME COLUMN   old_columnname
     TO    new_columnname
```

- Rename Index

```
RENAME  INDEX/TABLE
      old_name  TO  new_name
```

REOPT(AUTO)

- We currently have REOPT(NONE), REOPT(ONCE) and REOPT(ALWAYS) for a dynamic query (with parameter marker).
  - **REOPT(NONE)**
    - Generate access path based on default filter factor at BIND time
    - Cache the access path
  - **REOPT(ALWAYS)**
    - Generate access path based on real parameter marker value at each execution
    - No statement cache
  - **REOPT(ONCE)**
    - Generate access path based on real parameter marker value at the first excution
    - Cache the access path

REOPT(AUTO)

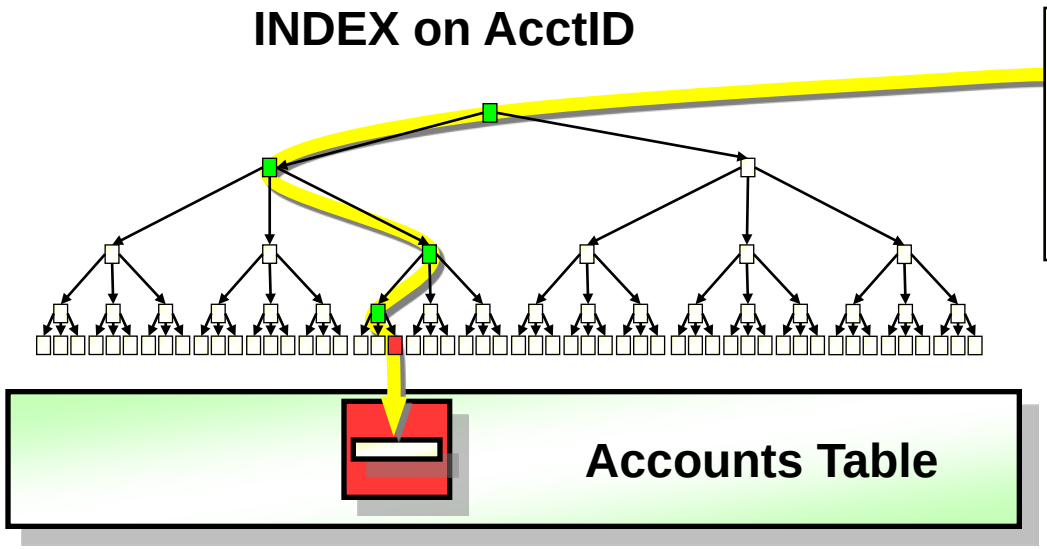
- **REOPT(AUTO)**
  - Generate access path based on real parameter marker value at the first execution.
  - Cache the access path
  - At each execution, DB2 will check if the cache plan is still a good one based on the real value.
  - A new prepare might be automatically invoked
  - Cache the newly generated access path
  - If statement cache is turned off, no reopt occurs

DB2 10 Query Enhancements

- CPU time reductions for queries, batch, & transactions
- SQL enhancements: Moving Sum, Moving Average, temporal, timestamp, implicit cast, SQL PL, …
- pureXML improvements
- Access improvements: Index include columns, hash, index list prefetch, workfile spanned records, …
- Optimization techniques
  - Remove parallelism restrictions and more even parallel distribution. Increased zIIP usage.
  - In-memory techniques for faster query performance
  - Access path stability and control
- Analysis: instrumentation, Data Studio & Optim Query Tuner
- Advanced query acceleration techniques
  - IBM Smart Analytics Optimizer

DB2 10 Hash Access Overview

Index to Data Access Path



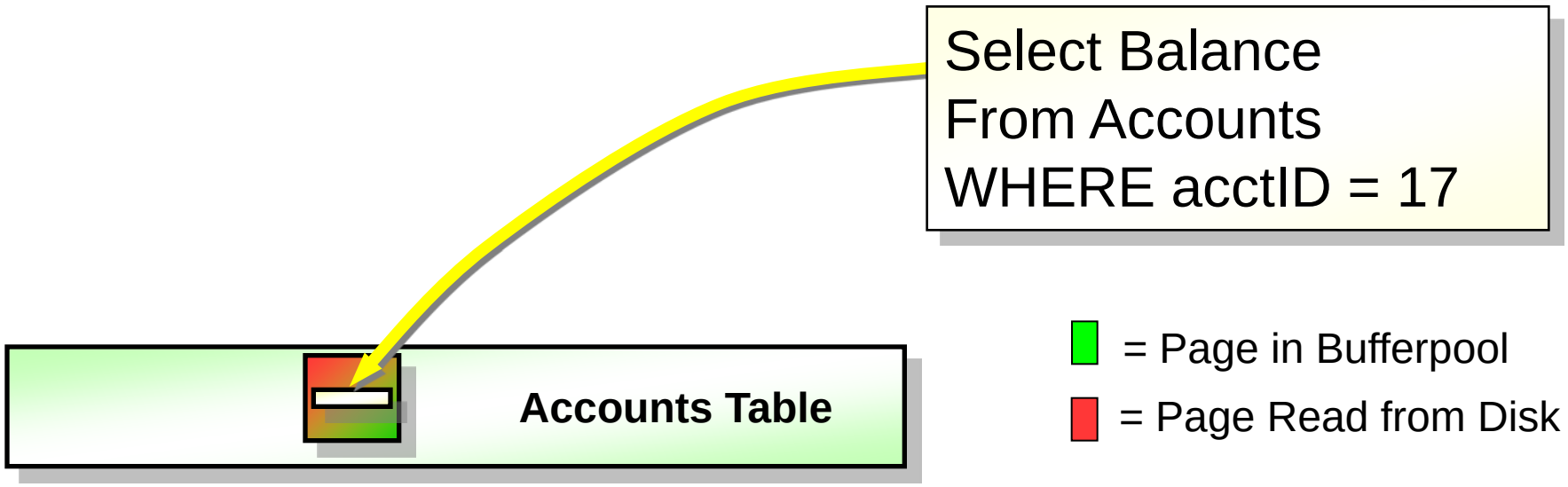
Select Balance
From Accounts
WHERE acctID = 17

= Page in Bufferpool

= Page Read from Disk

- Traverse down Index Tree
  - Typically non-leaf portion of tree in the bufferpool
  - Leaf Portion of the tree requires I/O
  - Requires searching pages at each level of the index
- Access the Data Page
  - Typically requires another I/O
- For a 5 Level Index (6 GETP/RELPs, 2 I/O's, and 5 index page searches)

Hash Access



- Hash Access provides the ability to directly locate a row in a table without having to use an index
- Single GETP/RELP in most cases
- 1 Synch I/Os in common case
  - 0 If In Memory Table
- Greatly reduced Search CPU expense

Using Hash Access

- **Hash Access is good for tables:**
  - With **a unique key**
  - Queried by applications (such as OLTP) needing **single row access via the unique key**
  - With **known approximate size**
  - Tables where **clustering order of data** is not important
    - *Applies to any kind of range processing*
  - When 20%-50% extra space is not an issue
- **Hash Access Path will be chosen when:**
  - The SELECT statement includes an **equal predicate on all hash key columns (or IN-List)**
  - DB2 APS determines via hash availability and the specific query **if hash access is suitable**

- **Follow-up**
  - Run BIND with EXPLAIN option and query the PLAN_TABLE to **check access path**

Examples of Select Statements Using Hash Access

- Simple hash access
  - SELECT * FROM T1 WHERE HASHCOL = :HV
- List prefetch/multi-index access with hash access
  - SELECT * FROM T1 WHERE (HASHCOL = :HV1 OR INDEXCOL = :HV2)
- No query parallelism with hash access
- No hash access with star join or hybrid join

Example of Application for Hash Access

- Typical Online Banking Application
  - SELECT the Account details using account number (Unique Key)
    - *Retrieving account details and maybe account balance*
    - *So far this would be suitable for Hash access*
  - SELECT all transactions for a certain period
    - *Used to show money into and out of the account each day*
    - *This period would probably invoke Sequential processing*
    - *Either using BETWEEN or > and <*
    - *Neither of these are allowed for Hash access*

Example of a Suitable Application For Hash Access

- Car Insurance Application
  - Typical Car Insurance application where customer details are only ever accessed by Policy Number (Unique key)
    - When policy is set up a unique policy number is created
    - Policy number is used if Customer wants details of policy
    - Policy number is used if customer updates policy
    - Policy number is used when customer makes a claim
    - Policy number is used when claim is processed
  - All accesses will use = predicate in t[illegible] SQ[illegible]

Hashing Summary

- Provides fast, direct location of most rows
  - Reduces I/O and CPU in some cases
  - Can replace an existing Primary or Unique Key Index
    - Faster Insertion/Deletion
- Size of Fixed Size Hash Area is important
  - Too small and performance degrades
  - Too large and space is wasted
- DB2 helps you manage the size
  - REORG AUTOESTSPACE YES
  - RTS tracks the number of overflowed entries

DB2 10 Temporal Data Overview

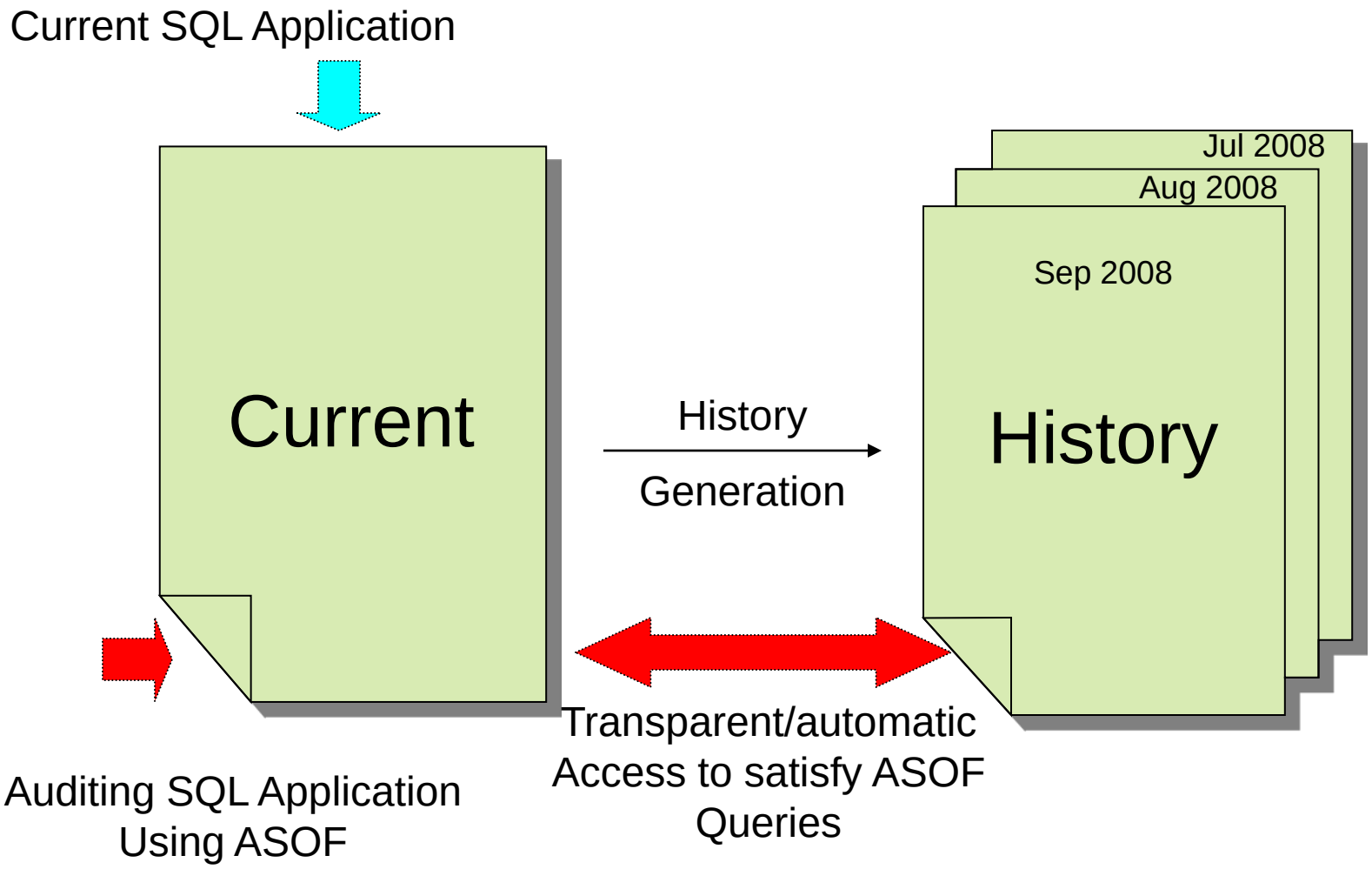
Motivation for Temporal Data

- Dramatic cost savings via Application Simplification
- Dramatic Reduction in Time to Deployment
- Auditing compliance advantages by moving logic from application to database layer
- Provides an easy way for applications to manage time sensitive data
  - Powerful, novel, yet intuitive SQL
  - End users deploy without IT Staff intervention
  - Query past/future data with current queries
  - Same schema name, simply add novel temporal clause
  - Response time for current DML/queries preserved
  - Response time for past/future queries comparable

Versioned data or Temporal Data

- Table-level specification to control data management based upon time
- Two notions of time:
  - System time: notes the occurrence of a data base change
    - “row xyz was deleted at 10:05 pm”
    - Query at current or any prior period of time
    - Useful for auditing, compliance
  - Business time: notes the occurrence of a business event
    - “customer xyz’s service contract was modified on March 23”
    - Query at current or any prior/future period of time
    - Useful for tracking of business events over time, application logic greatly simplified
- New syntax in FROM clause to specify a time criteria for selecting historical data

Current and History



Temporal UPDATE example (business time)

Simple table definition (Policy#, start, end, coverage)

Table has 1 row of (123,'01/01/2001', '12/31/2001', 1000)

```
UPDATE policy p
   FOR BUSINESS_TIME FROM DATE('03/01/2001') TO DATE('03/31/2001')
   SET coverage = 2000;
```

Result of the update statement is 3 rows:

(123,'01/01/2001','03/01/2001',1000)
(123,'03/01/2001','03/31/2001',2000)
(123,'03/31/2001','12/31/2001',1000)

IBM Smart Analytics Optimizer Overview

Why Optimize Smart Analytics?

- **Today, performance of Business Intelligence (BI) queries is too unpredictable**
  - When an analyst submits a query, s/he doesn't know whether to:
    - Wait for the response
    - Go out for coffee
    - Go out for dinner
    - Go home for the night!
  - Response time depends upon "performance layer" of indexes & materializations
  - Depends critically on predicting the workload
  - But BI is inherently ***ad hoc!***

- **Goal of IBM Smart Analytics Optimizer:**

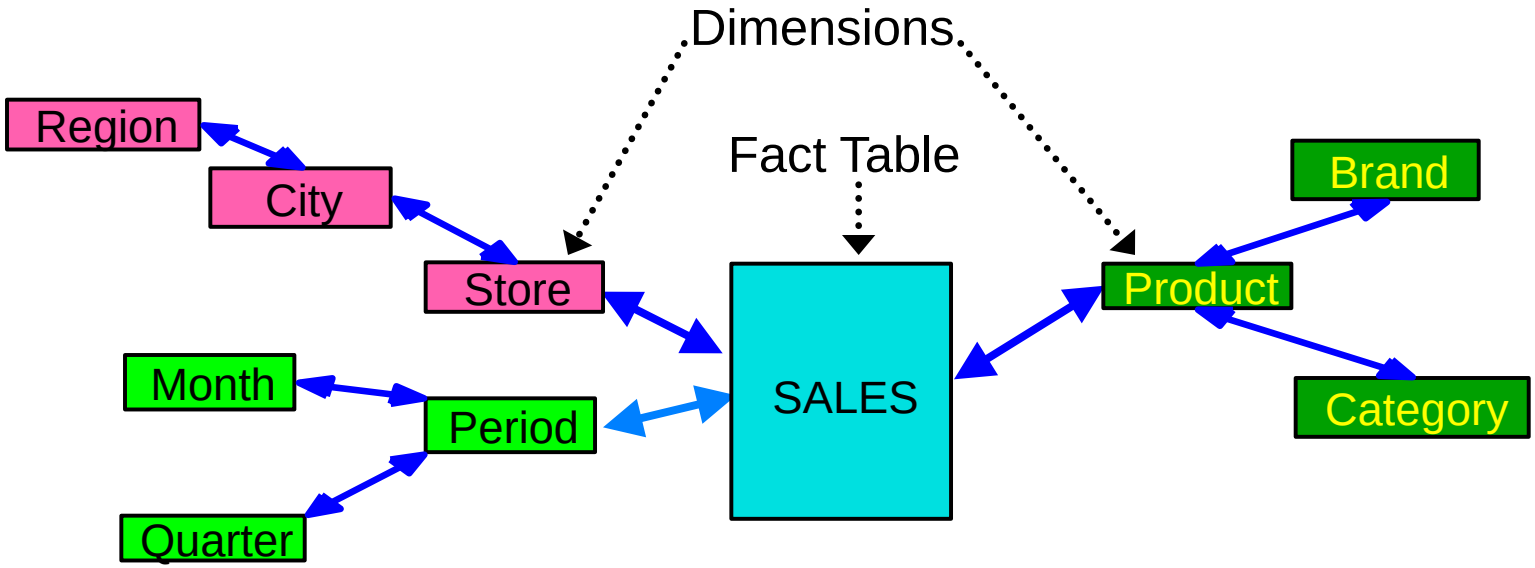
  Predictably Fast (i.e., Interactive) Ad Hoc Querying
  - **Any** query should run in about the same time
  - Permit an Analyst to interact with the data

What Is the IBM Smart Analytics Optimizer?

- **IBM Smart Analytics Optimizer for z/OS (ISAO)** is:
  - Network-attached accelerator to DB2 on z/OS
    - (Future: also DB2 for Linux, UNIX, and Windows and Informix IDS)
  - Exploits:
    - Large main memories
    - Commodity multi-core processors
    - Extreme compression
  - Speeds up typical Data Warehouse / Business Intelligence SQL queries by **10x to 100x**
  - Without requiring tuning of indexes, materialized views, etc.

Target Market: Business Intelligence (BI)

- Characterized by:
  - **“Star” or “snowflake” schema:**



  - **Complex, ad hoc queries that typically**
    - Look for trends, exceptions to make actionable business decisions
    - Touch large subset of the database (unlike OLTP)
    - Involve aggregation functions (e.g., COUNT, SUM, AVG,…)
    - **The “Sweet Spot” for IBM Smart Analytics Optimizer!**

What IBM Smart Analytics Optimizer is Designed For

- **OLAP-style SQL queries:**
  - Relational star schema (large **fact table** joined to multiple **dimensions**)
  - Large subset of data warehouse accessed, reduced significantly by...
  - **Aggregations** (SUM, AVG, COUNT) and optional **grouping** (GROUP BY)
  - **Looking for trends or exceptions**

- **EXAMPLE SQL**:

```
SELECT PRODUCT_DEPARTMENT, REGION, SUM(REVENUE)
FROM FACT_SALES F
     INNER JOIN DIM_PRODUCT P ON F.FKP = P.PK
     INNER JOIN DIM_REGION R ON F.FKR = R.PK
     LEFT OUTER JOIN DIM_TIME T ON F.FKT = T.PK
WHERE T.YEAR = 2007
GROUP BY PRODUCT_DEPARTMENT, REGION
```

Reference

- Redbooks at www.redbooks.ibm.com
  - DB2 9 for z/OS Technical Overview SG24-7330
  - DB2 9 for z/OS Performance Topics SG24-7473
- DB2 for z/OS home page at www.ibm.com/software/db2zos
  - E-support (presentations and papers) at www.ibm.com/software/db2zos/support.html

Key Details About DB2 10: Getting Ready

Prerequisites: migrate from DB2 9 for z/OS or DB2 for z/OS V8

- z/OS V1.10 SMS-managed DB2-managed DB2 catalog
- System z10, z9, z890, z990, and above (no z800, z900)
- DB2 Connect 9 FP1, 9.7 FP3 for many 10 functions, FP2 beta
- IMS 10 & 11 (not 9) CICS compilers (See announcement)
- Info APARs for migration II14477 (9), II14474 (8)
- SPE PK56922 PK69411 PK61766 PK85956 PM04680 PK87280 PK87281 PM08102 PM08105
- Premigration check DSNTIJPA PM04968

Items deprecated in earlier versions eliminated: more for V8 mig.

- Private protocol → DRDA (DSNTP2DP, PK92339, PK64045)
- Old plans and packages V5 or before → REBIND
- Plans containing DBRMs → packages PK62876 PK79925 (V8)
- ACQUIRE(ALLOCATE) → ACQUIRE(USE)
- Old plan table formats → DB2 V8 or 9, Unicode, 59 cols PK85068
- BookManager use for DB2 publications → Info Center, pdf

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Thank you

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