Couchbase

N1QL

What is N1QL?

Non-first (N1) Normal Form Query Language (QL)

It is based on ANSI 92 SQL

Its query engine is optimized for modern, highly parallel multi-core execution

SQL-like Query Language

Expressive, familiar, and feature-rich language for querying, transforming, and manipulating JSON data

N1QL extends SQL to handle data that is:

Nested: Contains nested objects, arrays

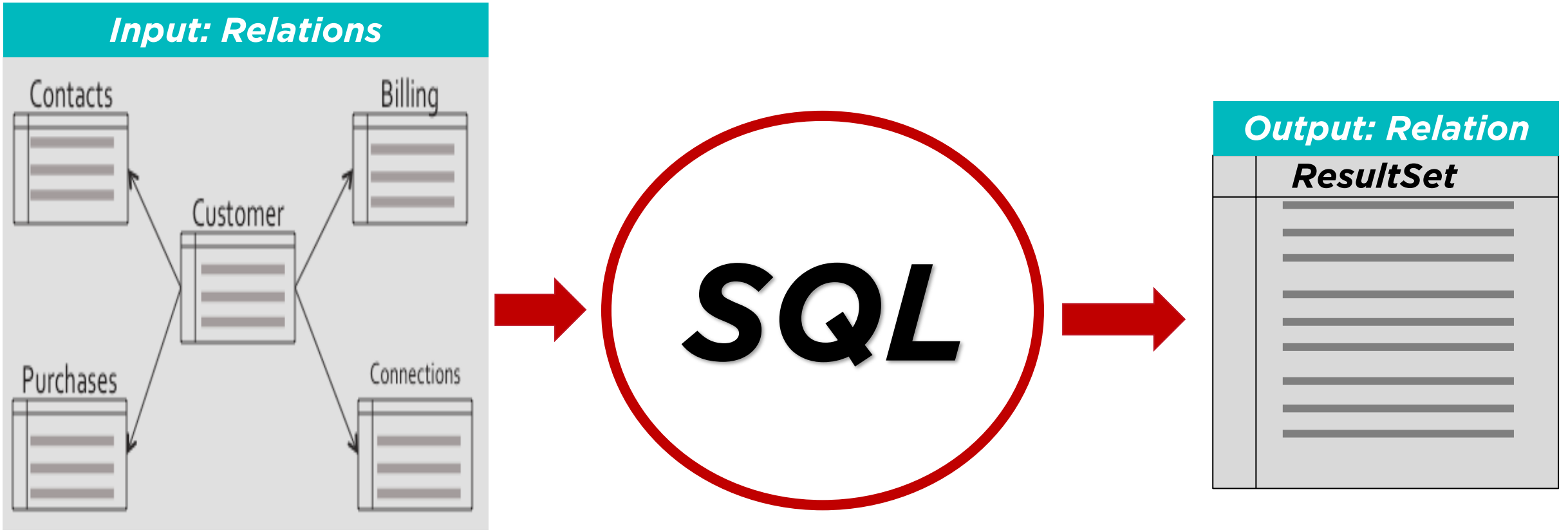
Heterogeneous: Schema-optional, non-uniform

Distributed: Partitioned across a cluster

Power of SQL

Flexibility of JSON

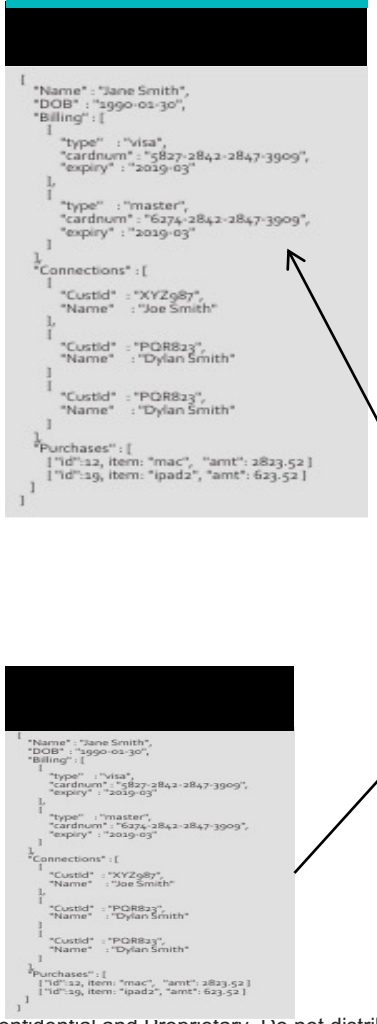
SQL



N1QL is Declarative: What Vs How

You specify WHAT Couchbase Server figures out HOW

Input: JSON



{N1QL}

Output: JSON

```
{
   "Name" : "Jane Smith",
   "DOB"  : "1990-01-30",
   "Billing" : [
      {
         "type"    : "visa",
         "cardnum" : "5827-2842-2847-3909",
         "expiry"  : "2019-03"
      },
      {
         "type"    : "master",
         "cardnum" : "6274-2842-2847-3909",
         "expiry"  : "2019-03"
      }
   ],
   "Connections" : [
      {
         "CustId"   : "XYZ987",
         "Name"     : "Joe Smith"
      },
      {
         "CustId"   : "PQR823",
         "Name"     : "Dylan Smith"
      }
      {
         "CustId"   : "PQR823",
         "Name"     : "Dylan Smith"
      }
   ],
   "Purchases" : [
      { "id":12, item: "mac",   "amt": 2823.52 }
      { "id":19, item: "ipad2", "amt": 623.52 }
   ]
}
```

N1QL (POWERFUL)

Access to every part of JSON document

JOINS, Aggregations, standard scalar functions

Aggregation on arrays

NEST & UNNEST operations

Covering Index

Give developers and enterprises an expressive, powerful, and complete language for querying, transforming, and manipulating JSON data.

N1QL (QUERYING)

INSERT

UPDATE

DELETE

MERGE

SELECT

EXPLAIN

Give developers and enterprises an expressive, powerful, and complete language for querying, transforming, and manipulating JSON data.

N1QL (TRANSFORMING & MANIPULATING)

Full Transformation of the data via Query.

INSERT

INSERT single & multiple documents

INSERT result a SELECT statement

DELETE documents based on complex filter

UPDATE any part of JSON document & use complex filter.

MERGE two sets of documents using traditional MERGE statement

SUBQUERIES

Give developers and enterprises an expressive, powerful, and complete language for querying, transforming, and manipulating JSON data.

N1QL (EXPRESSIVE)

Access to every part of JSON document

Scalar & Aggregate functions

Subqueries in the FROM clause

Aggregation on arrays

Expressive, familiar, and feature-rich language for querying, transforming, and manipulating JSON data

N1QL (FAMILIAR)

SELECT * FROM bucket WHERE …

INSERT single & multiple documents

UPDATE any part of JSON document & use complex filter

DELETE

MERGE two sets of documents using traditional MERGE statement

EXPLAIN to understand the query plan

EXPLAIN SELECT * FROM bucket WHERE …

Expressive, familiar, and feature-rich language for querying, transforming, and manipulating JSON data

N1QL (FEATURE-RICH)

Access to every part of JSON document

Functions (Date, Pattern, Array, Conditional, etc)

https://developer.couchbase.com/documentation/server/current/n1ql/n1ql-language-reference/functions.html

JOIN, NEST, UNNEST

Covering Index

Prepared Statements

USE KEYS, LIKE

Expressive, familiar, and feature-rich language for querying, transforming, and manipulating JSON data

N1QL (Example)

```
SELECT   customers.id,
         customers.NAME.lastname,
         customers.NAME.firstname
         Sum(orderline.amount)
FROM     orders UNNEST orders.lineitems AS orderline
         JOIN customers ON KEYS orders.custid
WHERE customers.state = 'NY'
GROUP BY customers.id,
         customers.NAME.lastname
HAVING   sum(orderline.amount) > 10000
ORDER BY sum(orderline.amount) DESC
```

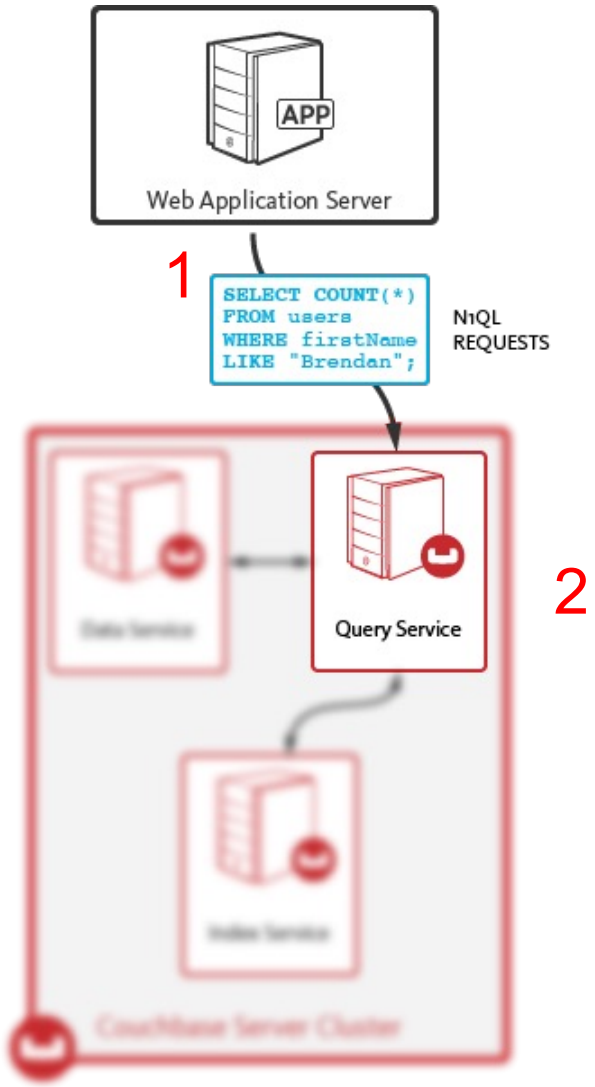
Dotted sub-document reference
Names are CASE-SENSITIVE

UNNEST to flatten the arrays

JOINS with Document KEY of customers

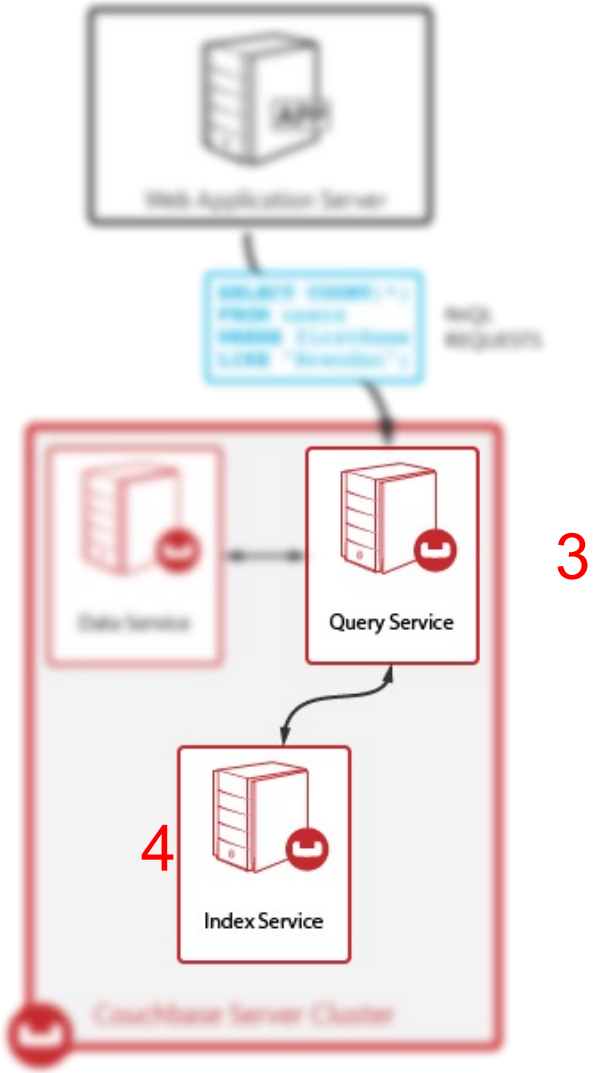
N1QL Query : Execution

Query Execution Flow



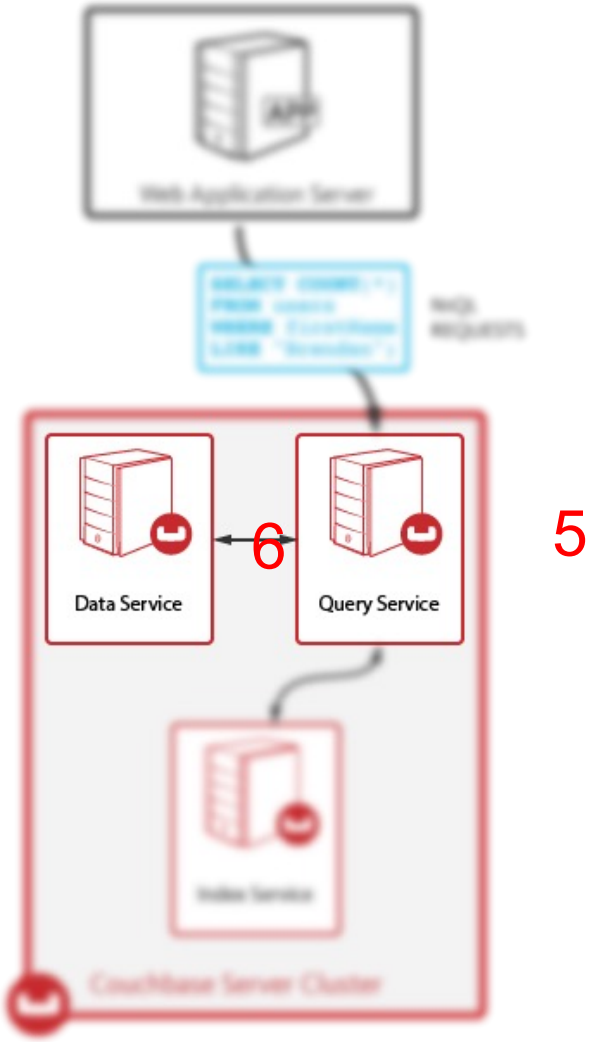
1. ***Application submits N1QL query***
2. ***Query is parsed, analyzed and plan is created***

Query Execution Flow



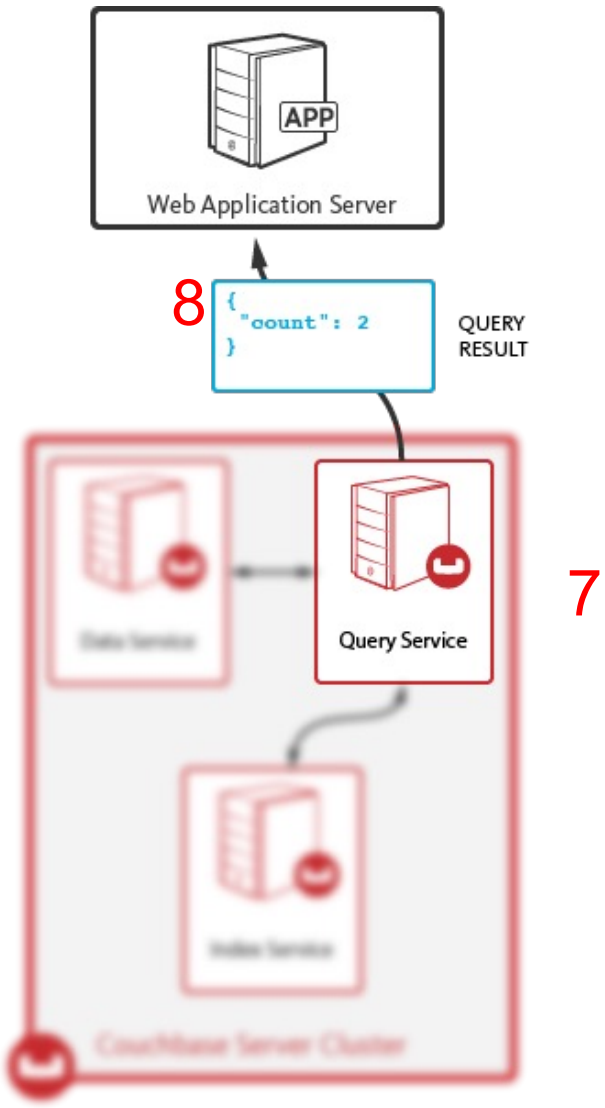
3. *Query Service makes request to Index Service*
4. *Index Service returns document keys and data*

Query Execution Flow



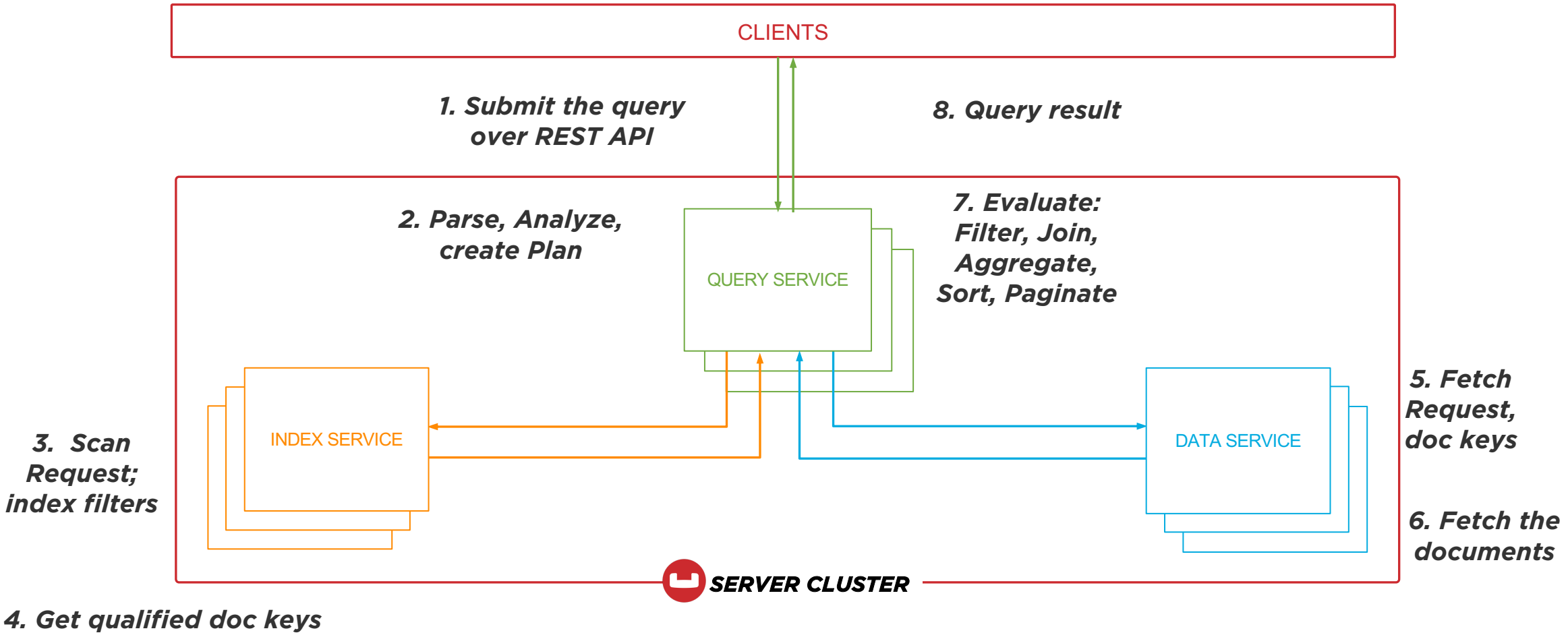
5. *If Covering Index, skip step 6*
6. *If filtering is required, fetch documents from Data Service*

Query Execution Flow

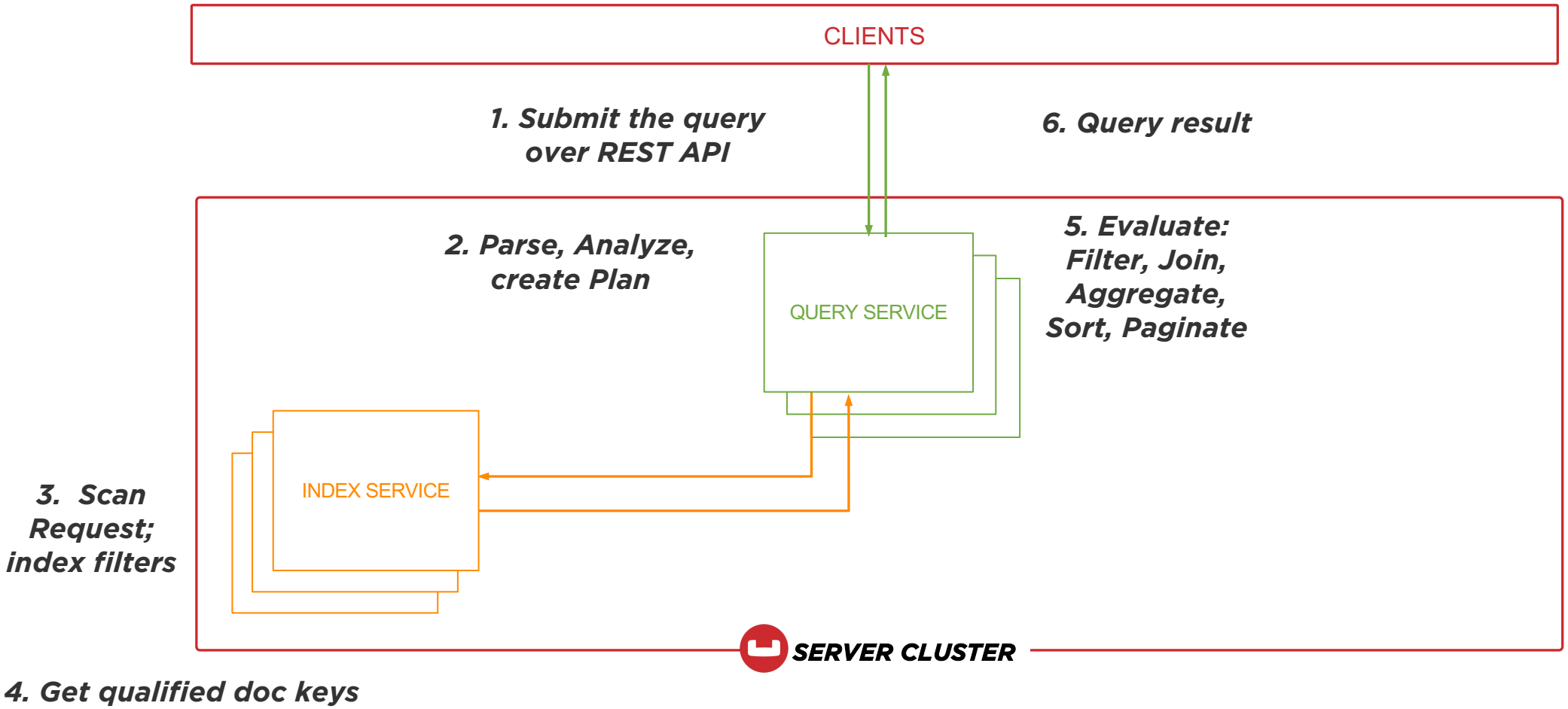


7. *Apply final logic (e.g. SORT, ORDER BY)*
8. *Return formatted results to application*

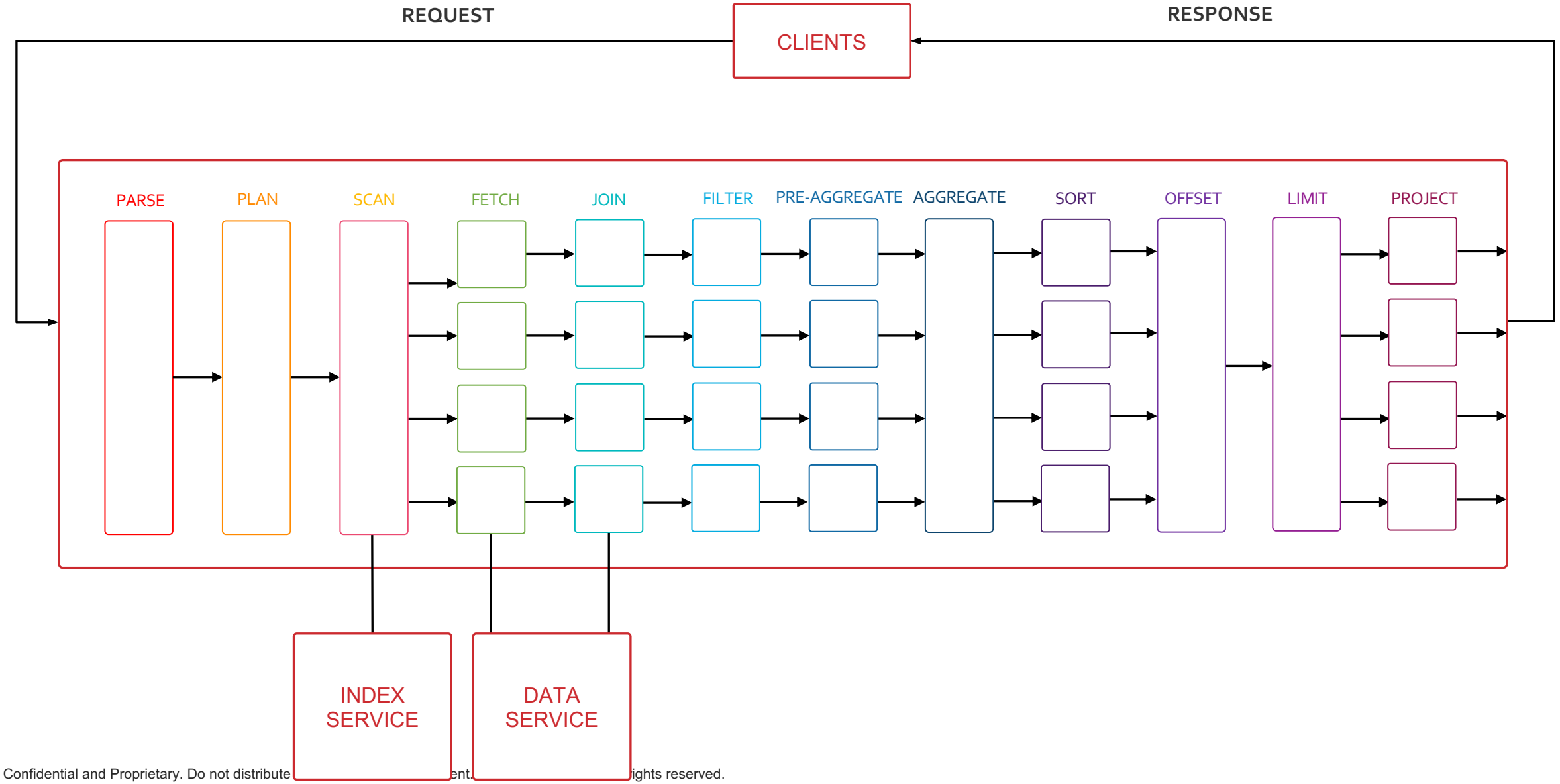
Query Execution Flow (KV Fetch)



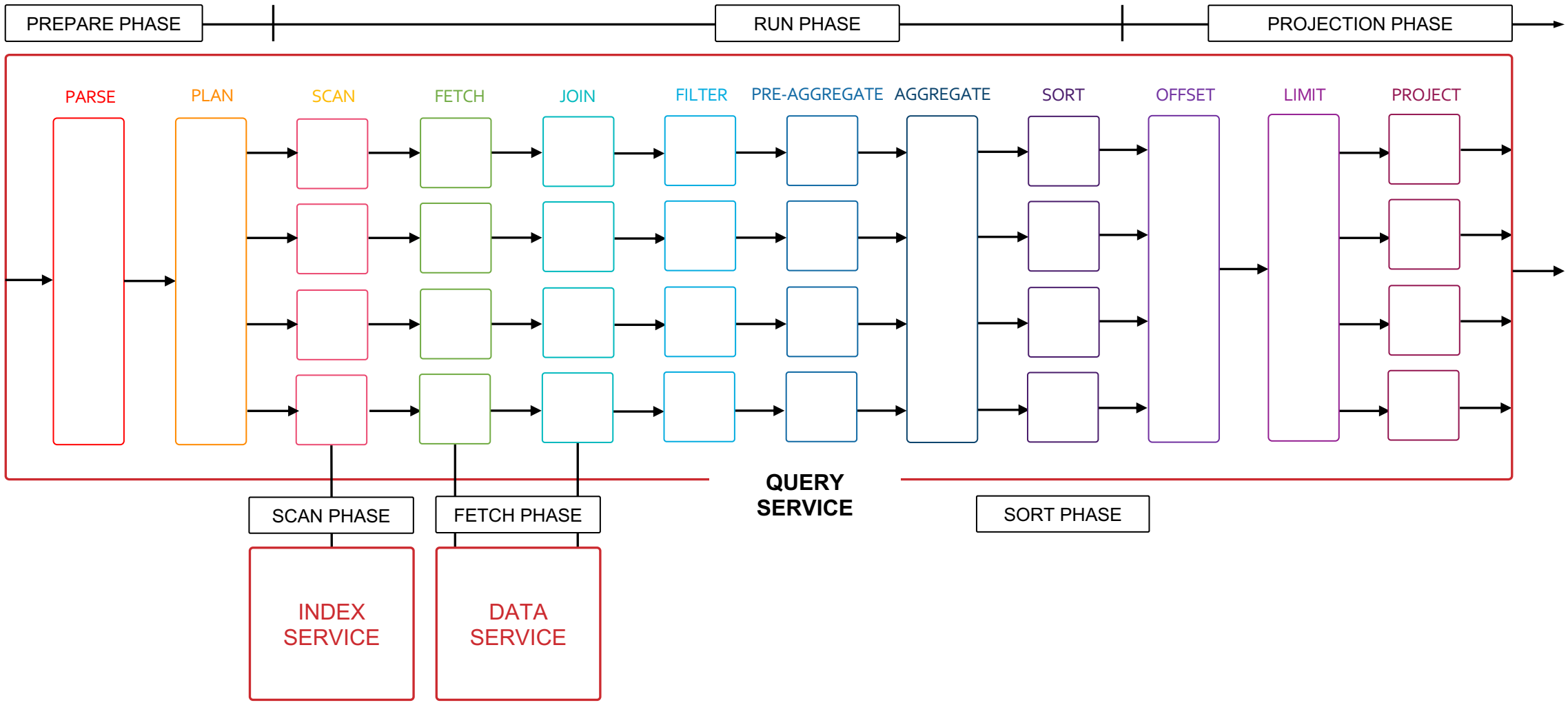
Query Execution Flow (Covering Index)



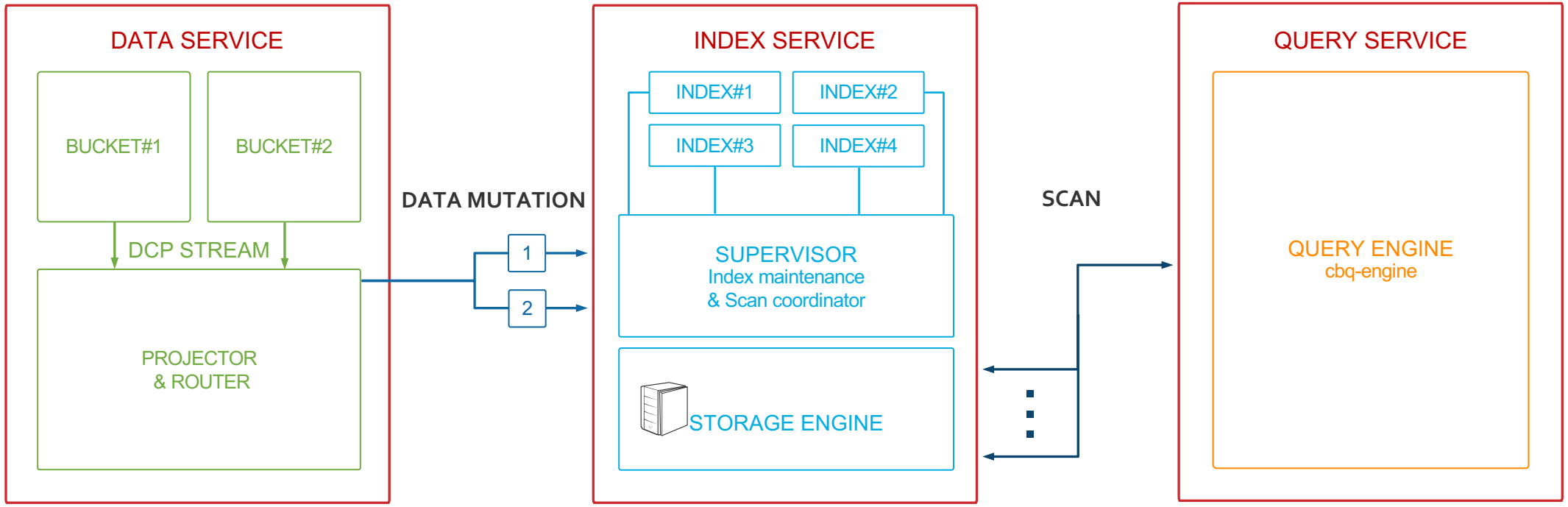
Full Query Pipeline



Inside a Query Service



Couchbase Services



Indexing

Why do we need indexes?

Indexes are used to

efficiently look up objects

meeting ***user specified criteria***

without having to

search ***every*** object

in the collection

Summary of Indexes

	Index Type	Description
1	**Primary**	Index on the document key on a whole bucket, to support full bucket scans
2	**Named**	Index with an assigned name, to allow multiple primary indexes in a cluster
3	**Secondary**	Index on a field (key-value pair) or document-key
4	**Composite**	Index on more than one field
5	**Functional**	Index on values resulting from a function or expression applied to a field
6	**Array**	Index on individual elements of array fields
7	**Partial**	Index on filtered subset of documents in a bucket
8	**Covering**	Describes any index which fully responds to a query without need for doc retrieval
9	**Duplicate**	Describes an indexing feature supporting load balancing, scale, and high availability
10	**Adaptive**	Describes an indexing feature providing an arrayed approach to generically indexing all or specified doc fields, to support increased query flexibility

Secondary Indexes

Global Secondary Indexes (GSI) – Released in 4.0 (Now called Legacy GSI / Deprecated in 5.0)

- Lower query latency and high throughput
- Isolate from KV operations – multidimensional scaling

Memory Optimized Indexes (MOI) – new in 4.5

- Complete index is stored in memory.
- Supports much higher mutations and better performance

New Standard Global Secondary Index(GSI) – new in 5.0 (AKA Plasma)

- New storage engine

N1QL (EXPLAIN)

EXPLAIN statement when used before any N1QL statement, provides the execution plan for the statement

EXPLAIN SELECT log, type, runtime FROM logger ORDER BY runtime

```
"results": [
  {
    "#operator": "Sequence",
    "~children": [
       {
          "#operator": "Sequence",
          "~children": [
             {
                "#operator": "PrimaryScan",
                "index": "#primary",
                "keyspace": "catalog",
                "namespace": "default"
             } ... and more...
```

N1QL Language

N1QL examples

```
SELECT d.C_ZIP, SUM(ORDLINE.OL_QUANTITY) AS  TOTALQTY
FROM CUSTOMER d
         UNNEST ORDERS as CUSTORDERS
             UNNEST CUSTORDERS.ORDER_LINE AS ORDLINE
WHERE d.C_STATE = "NY"
GROUP BY d.C_ZIP
ORDER BY TOTALQTY DESC;

INSERT INTO CUSTOMER("PQR847", {"C_ID":4723, "Name":"Joe"});

UPDATE CUSTOMER c
SET c.STATE="CA", c.C_ZIP = 94501
WHERE c.ID = 4723;
```

SELECT Statement

```
SELECT   customers.id,
         customers.NAME.lastname,
         customers.NAME.firstname
         Sum(orderline.amount)
FROM     orders UNNEST orders.lineitems AS orderline
         JOIN customers ON KEYS orders.custid
WHERE customers.state = 'NY'
GROUP BY customers.id,
         customers.NAME.lastname
HAVING   sum(orderline.amount) > 10000
ORDER BY sum(orderline.amount) DESC
```

Dotted sub-document reference
Names are CASE-SENSITIVE

UNNEST to flatten the arrays

JOINS with Document KEY of customers

Composable SELECT statement

```
SELECT *
FROM
       (          SELECT   a, b, c
                  FROM     us_cust
                  WHERE    x = 1
                  ORDER BY x LIMIT 100 OFFSET 0
                UNION ALL
                  SELECT   a, b, c
                  FROM     canada_cust
                  WHERE    y = 2
                  ORDER BY x LIMIT 100 OFFSET 0   ) AS newtab
LEFT OUTER JOIN contacts
     ON KEYS newtab.c.contactid
ORDER BY a, b, c
LIMIT 10 OFFSET 1oo
```

SELECT Statement Highlights

Querying across relationships

- JOINs
- Subqueries

Aggregation

- MIN, MAX
- SUM, COUNT, AVG, ARRAY_AGG [DISTINCT]

Combining result sets using set operators

- UNION, UNION ALL, INTERSECT, EXCEPT

N1QL Query Operators [1 of 2]

USE KEYS …

Direct primary key lookup bypassing index scans

Ideal for hash-distributed datastore

Available in SELECT, UPDATE, DELETE

JOIN … ON KEYS …

Nested loop JOIN using key relationships

Ideal for hash-distributed datastore

Current implementation supports INNER and LEFT OUTER joins

N1QL Query Operators [2 of 2]

NEST

Special JOIN that embeds external child documents under their parent

Ideal for JSON encapsulation

UNNEST

Flattening JOIN that surfaces nested objects as top-level documents

Ideal for decomposing JSON hierarchies

JOIN, NEST, and UNNEST can be chained in any combination

N1QL Expressions for JSON

Ranging over collections	• ***WHERE ANY c IN children SATISFIES c.age > 10 END*** • ***WHERE EVERY r IN ratings SATISFIES r > 3 END***
Mapping with filtering	• ***ARRAY c.name FOR c IN children WHEN c.age > 10 END***
Deep traversal, SET, and UNSET	• ***WHERE ANY node WITHIN request SATISFIES node.type = "xyz" END*** • ***UPDATE doc UNSET c.field1 FOR c WITHIN doc END***
Dynamic Construction	• ***SELECT { "a": expr1, "b": expr2 } AS obj1, name FROM … // Dynamic object*** • ***SELECT [a, b] FROM … // Dynamic array***
Nested traversal	• ***SELECT x.y.z, a[0] FROM a.b.c …***
IS [NOT] MISSING	• ***WHERE name IS MISSING***

N1QL Data Types from JSON

N1QL supports all JSON data types

Numbers

Strings

Booleans

Null

Arrays

Objects

N1QL Data Type Handling

Non-JSON data types

- MISSING
- Binary

Data type handling

Date functions for string and numeric encodings

Total ordering across all data types

- Well defined semantics for ORDER BY and comparison operators

Defined expression semantics for all input data types

- No type mismatch errors

Data Modification Statements

UPDATE … SET … WHERE …

DELETE FROM … WHERE …

INSERT INTO … (KEY, VALUE) VALUES …

INSERT INTO … (KEY …, VALUE …) SELECT …

MERGE INTO … USING … ON …

WHEN [NOT] MATCHED THEN …

Note: Couchbase provides per-document atomicity.

Data Modification Statements

JSON literals can be used in any expression

```
INSERT INTO ORDERS (KEY, VALUE)
VALUES ("1.ABC.X382", {"O_ID":482, "O_D_ID":3, "O_W_ID":4});

UPDATE ORDERS
   SET O_CARRIER_ID = ”ABC987”
WHERE O_ID = 482 AND O_D_ID = 3 AND O_W_ID = 4

DELETE FROM NEW_ORDER
WHERE NO_D_ID = 291 AND
     NO_W_ID = 3482 AND
     NO_O_ID = 2483
```

Index Statements

CREATE INDEX ON ...

DROP INDEX ...

EXPLAIN ...

Highlights

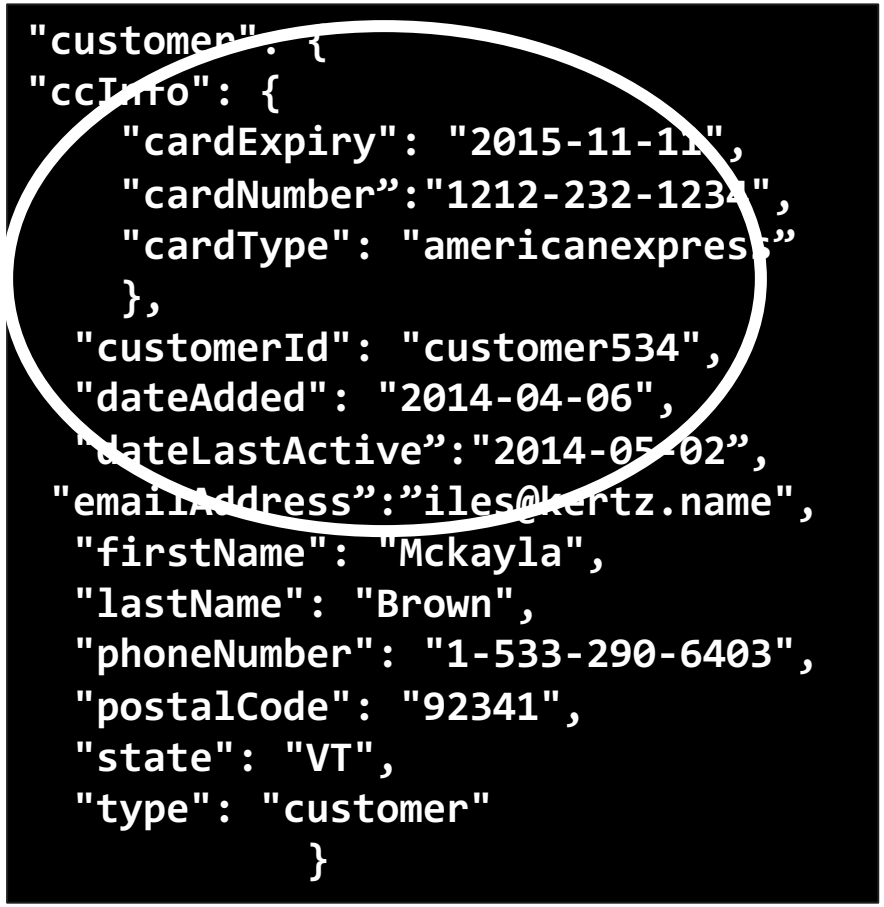
Functional indexes

- ***on any data expression***

Partial indexes

Index Overview: Secondary Index

Document key: "customer534"

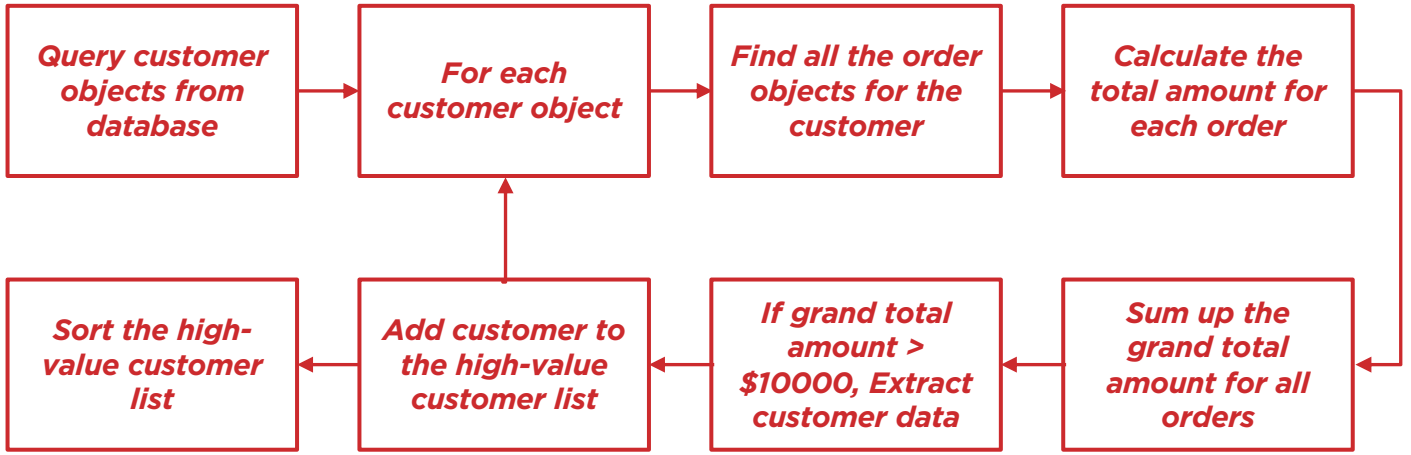


- ***Secondary Index can be created on any combination of expressions.***
  - ***CREATE INDEX idx_cust_cardnum customer(ccInfo.cardNumber, postalcode)***
- ***Useful in speeding up the queries.***
- ***Need to have matching indexes with matching key-ordering***
  - ***(ccInfo.cardExpiry, postalCode)***
  - ***(type, state, lastName firstName)***

Find High-Value Customers with Orders > $10000

API QUERY

LOOPING OVER MILLIONS OF CUSTOMERS IN APPLICATION!!!



- Complex codes and logic
- Inefficient processing on client side

VS.

SQL for JSON

```
SELECT    Customers.ID, Customers.Name, SUM(OrderLine.Amount)
FROM      Orders UNNEST Orders.LineItems AS OrderLine
          JOIN Customers ON KEYS Orders.CustID
GROUP BY  Customers.ID, Customers.Name
HAVING    SUM(OrderLine.Amount) > 10000
ORDER BY  SUM(OrderLine.Amount) DESC
```

- Proven and expressive query language
- Leverage SQL skills and ecosystem
- Extended for JSON

Summary: SQL & N1QL

Query Features	SQL	N1QL
Statements	▪ SELECT, INSERT, UPDATE, DELETE, MERGE	▪ SELECT, INSERT, UPDATE, DELETE, MERGE
Query Operations	▪ Select, Join, Project, Subqueries ▪ Strict Schema ▪ Strict Type checking	▪ Select, Join, Project, Subqueries ✓ Nest & Unnest ✓ Look Ma! No Type Mismatch Errors! ▪ JSON keys act as columns
Schema	▪ Predetermined Columns	✓ Fully addressable JSON ✓ Flexible document structure
Data Types	▪ SQL Data types ▪ Conversion Functions	▪ JSON Data types ▪ Conversion Functions
Query Processing	▪ INPUT: Sets of Tuples ▪ OUPUT: Set of Tuples	▪ INPUT: Sets of JSON ▪ OUTPUT: Set of JSON

Using N1QL: Index Scan

```
CREATE INDEX `idx_id` ON `travel-sample`(`id`);


EXPLAIN SELECT meta().id FROM `travel-sample` WHERE id = 10;
EXPLAIN SELECT meta().id FROM `travel-sample` WHERE id >=10 AND id <
25;
EXPLAIN SELECT meta().id FROM `travel-sample` WHERE id IN [10, 20];
```

Predicate	Span Low	Span High	Inclusion
id = 10	10	10	3 (Both)
id >= 10	10	None	0 (Neither)
id <= 10	Null	10	2 (High)

Using N1QL: LIKE

```
select SUFFIXES("Baltimore Washington Intl")

create index suffixes_airport_name on `travel-sample`

(DISTINCT ARRAY array_element FOR array_element IN

SUFFIXES(LOWER(airportname)) END)

WHERE type = "airport";
```

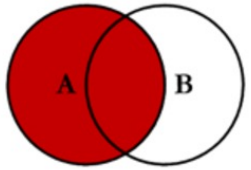
```
SELECT airportname FROM `travel-
sample`
WHERE airportname LIKE
“%Washington%”
AND type = “airport”
```

Using N1QL: JOIN

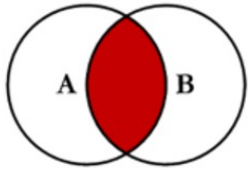
Inner, Left, Right, Outer, Exclude,

SELECT <select_list>
FROM bucket A
LEFT JOIN bucket B
ON KEYS <keys-clause(A)>

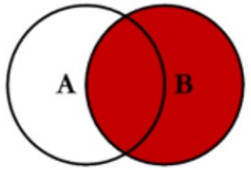
N1QL JOINs



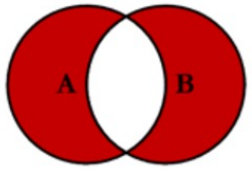
SELECT <select_list>
FROM Table_A A
LEFT JOIN Table_B B
ON KEYS <keys-clause(A)>



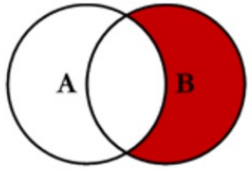
SELECT <select_list>
FROM Table_A A
INNER JOIN Table_B B
ON KEYS <keys-clause(A)>



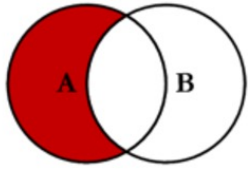
SELECT <select_list>
FROM Table_B B
LEFT JOIN Table_A A
ON KEYS <keys-clause(B)>



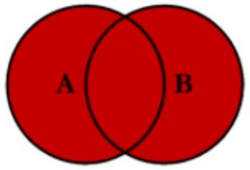
SELECT <select_list>
FROM Table_B B
LEFT JOIN Table_A A
ON KEYS <keys-clause(B)>
WHERE META(A**)**.id **IS MISSING**
UNION ALL
SELECT <select_list>
FROM Table_A A
LEFT JOIN Table_B B
ON KEYS <keys-clause(A)>
WHERE META(B**)**.id **IS MISSING**



SELECT <select_list>
FROM Table_B B
LEFT JOIN Table_A A
ON KEYS <keys-clause(B)>
WHERE META(B**)**.id **IS MISSING**



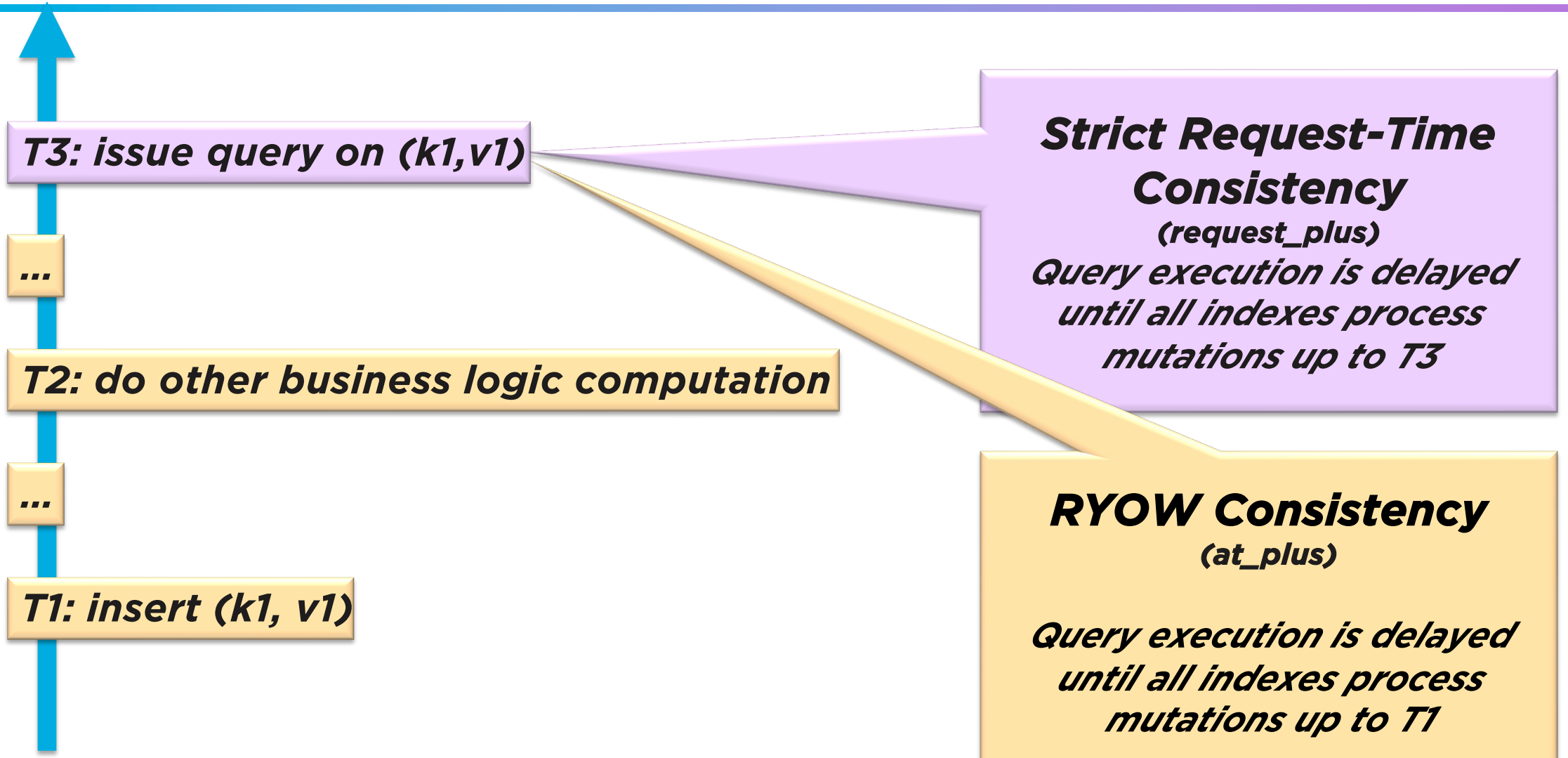
SELECT <select_list>
FROM Table_A A
LEFT JOIN Table_B B
ON KEYS <keys-clause(A)>
WHERE META(B**)**.id **IS MISSING**



SELECT <select_list>
FROM Table_B B
LEFT JOIN Table_A A
ON KEYS <keys-clause(B)>
UNION ALL
SELECT <select_list>
FROM Table_A A
LEFT JOIN Table_B B
ON KEYS <keys-clause(A)>
WHERE META(B**)**.id **IS MISSING**

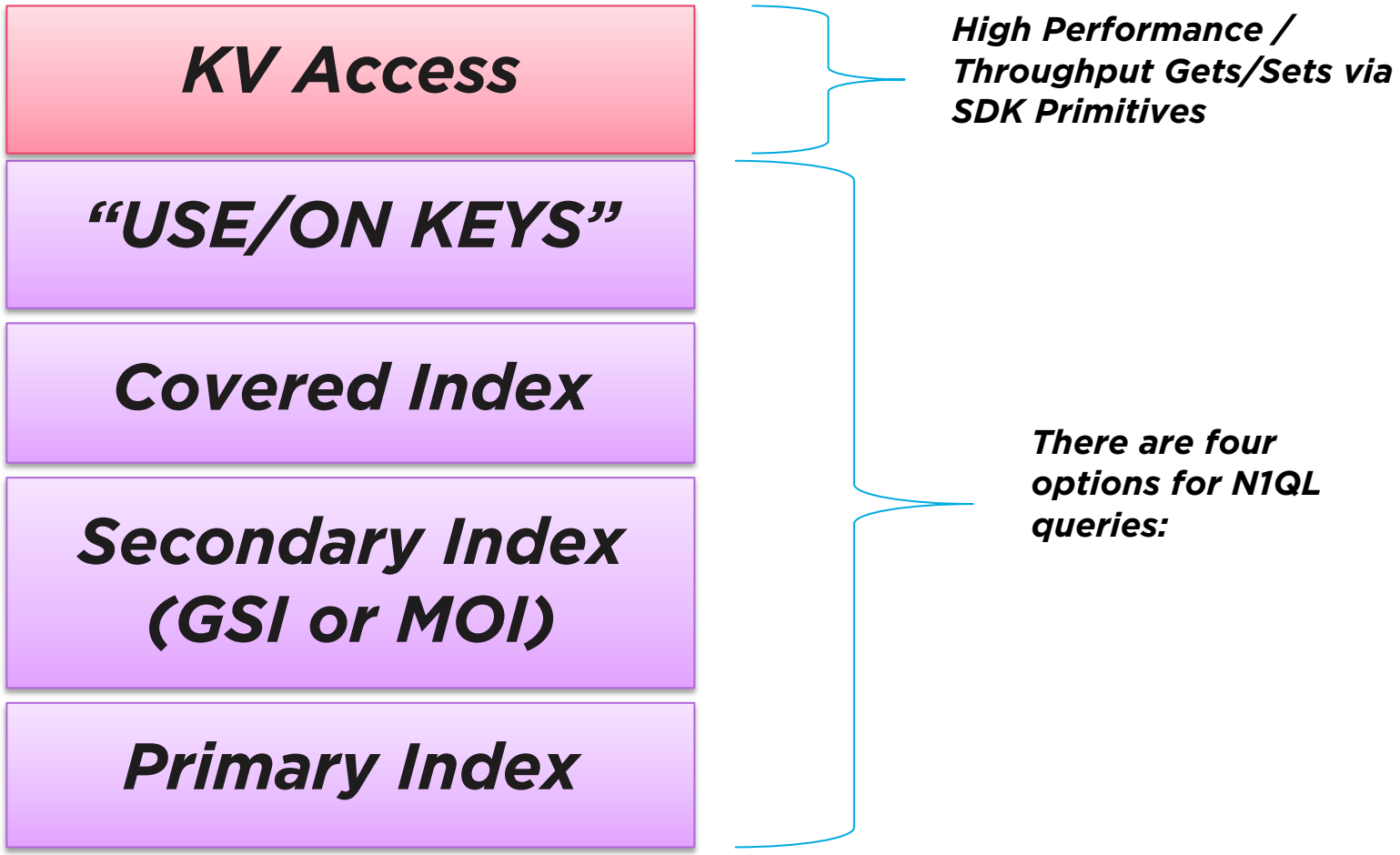
@atom_yang, 2017

Query Consistency



Query Tuning

Optimizing Query Speed



Query Tuning

- Rule based optimization
- Optimal indexes for optimal performance
- EXPLAIN to understand and tune
- Examine configuration for Data, Indexer, Query

Query Tuning List

- Query should have predicates to avoid primary index scan.
- Explore all index options (composite secondary index, partial composite index, covered partial composite index ,…)
- Include as many predicate keys as possible in leading index keys
  - Query processing is bit more efficient when there is equality predicates on leading index keys
- Explore avoiding Intersect scan. If required provide hint with USE INDEX
- For ANY predicate clause, use ARRAY index keys.
- Explore using index key order and pushing limit, offset to indexer
- Rewrite query if required
- Use array fetch when possible
- Execute query and look the monitoring stats for each phase of query (ex: system:completed_requests) and tune it.
- Check the final query plan through the explain
- Set pretty=false in Query Service or query parameter
- Increase parallel processing via max_parallelism
- Fetching large set of data for non covered index increase pipeline-cap, pipeline-batch in Query-Service
- Duplicate indexes and memory optimized indexes
- Add more Query nodes or Indexer nodes

Pattern “USE KEYS”

USE KEYS provides facility Query Service to access Data Service directly

No index required

Scales independent of bucket size

```
SELECT b.destinationairport, b.sourceairport,
  (SELECT c.name
    FROM `travel-sample` c
      USE KEYS b.airlineid
      LEFT UNNEST c.name) as theAirline
FROM `travel-sample` b
USE KEYS "route_5966"
```

Pattern “Covering Index”

Index selection for a query solely depends on the query predicates

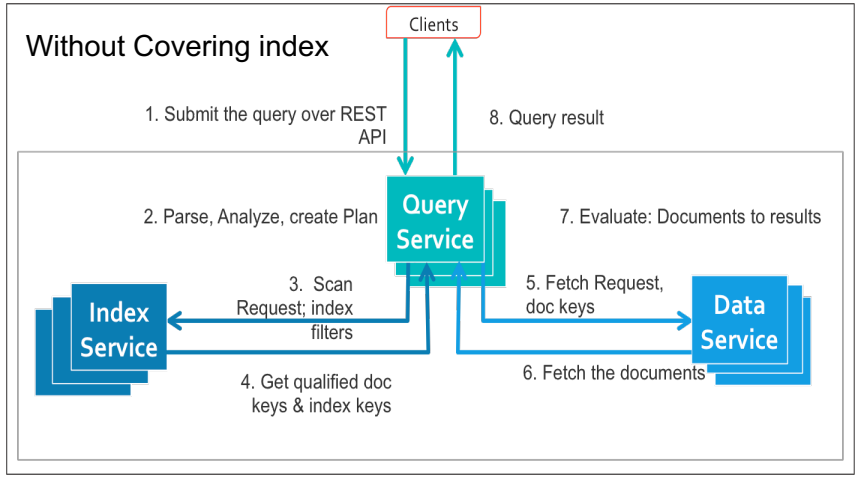
Index keys cover predicates and all attribute references

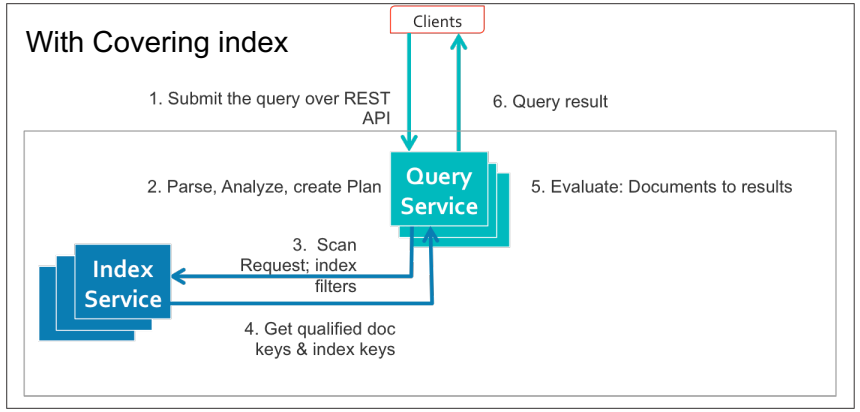
Avoids fetching the whole document

Performance

```
CREATE INDEX ts_airline ON `travel-sample`(name, id)
WHERE type = "airline";

SELECT name, id
FROM `travel-sample`
WHERE type = "airline" AND name = "United Airlines”;
```





Pattern “Array Index and Query”

Ad Targeting System

- Raw Logs
- User Interaction Log
- User Profile (Ref Doc)

Add an Index (you can do this at any time!)

```
CREATE INDEX iArray ON default(distinct (array v for v in
    interactions end))
SELECT meta().id from default WHERE ANY v IN interactions
    SATISFIES v.last_interaction='Wait' END;
```

```
Hailie20.Doyle34@hotmail.com::interactions
[
 {
  "default": {
   "interactions": [
    {
     "interaction_id": "04ec514a-d6c2-42b7-962a-
bf8976677e79",
     “interaction_type": ”wait"
    }
    {
     "interaction_id": "04ec514a-d6c2-42b7-962a-
ac9467788e88",
     “interaction_type": ”email"
    }
...
```

Monitoring: Active requests

List / Delete requests currently being run by the query service

Through N1QL

SELECT * FROM system:active_requests

DELETE FROM system:active_requests WHERE…

Through REST

GET http://localhost:8093/admin/active_requests

GET http://localhost:8093/admin/active_requests/<request_id>

DELETE http://localhost:8093/admin/active_requests/<request_id>

Monitoring: Prepared statements

List / Delete requests prepared on the query node

Through N1QL

SELECT * FROM system:prepareds

DELETE FROM system:prepareds WHERE…

Through REST

GET http://localhost:8093/admin/prepareds

GET http://localhost:8093/admin/prepareds/<request_id>

DELETE http://localhost:8093/admin/prepareds/<request_id>

Monitoring: Completed requests

List / Delete completed requests deemed to be of high cost

Through N1QL

SELECT * FROM system:completed_requests

DELETE FROM system:completed_requests where…

Through REST

GET http://localhost:8093/admin/completed_requests

GET http://localhost:8093/admin/completed_requests/<request_id>

DELETE http://localhost:8093/admin/completed_requests/<request_id>

Provide an overall health picture of the query service

Using REST: GET http://localhost:8093/admin/vitals

Thank You