



## Indexing Basics

Speaker: Paul Tuohy

## High Performance, Resilient APIs for Your IBM i Using Kafka

Speaker: Dan Magid

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Lunch & Learn March 2023

# Indexing Basics

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## Paul Tuohy

Paul Tuohy, author of "*Re-engineering RPG Legacy Applications*" and "*The Programmer's Guide to iSeries Navigator*", is one of the most prominent consultants and trainer/educators for application modernization and development technologies on the IBM Midrange. He currently holds positions as CEO of ComCon, a consultancy firm based in Dublin, Ireland, and founding partner of System i Developer, the consortium of top educators who produced the acclaimed *RPG & DB2 Summit* conference. Previously, he worked as IT Manager for Kodak Ireland Ltd. and Technical Director of Precision Software Ltd.

In addition to hosting and speaking at the RPG & DB2 Summit, Paul is an award-winning speaker at COMMON, COMMON Europe Congress and other conferences throughout the world. His articles frequently appear in iProDeveloper, The Four Hundred Guru, RPG Developer and other leading publications. Paul also hosts the popular *iTalk with Tuohy* podcast interviews.

This presentation may contain small code examples that are furnished as simple examples to provide an illustration. These examples have not been thoroughly tested under all conditions. We therefore, cannot guarantee or imply reliability, serviceability, or function of these programs.

All code examples contained herein are provided to you "as is". THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY DISCLAIMED.

# Agenda

Indexing on IBM i  
Indexes in action

Lunch & Learn March 2023



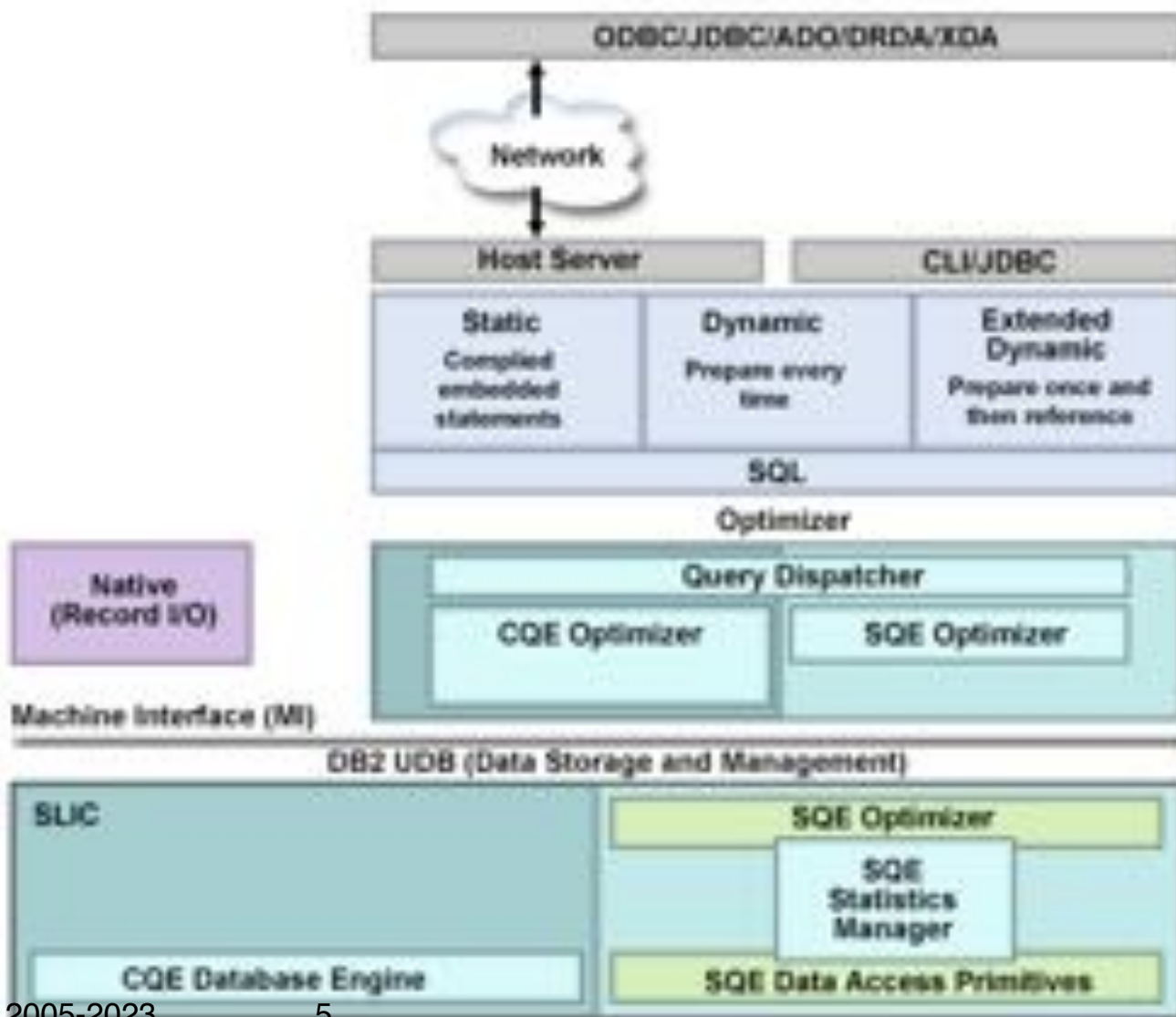
# Optimization

Identify the rows of interest while avoiding useless data

Optimizer makes use of access paths

Access paths come from

- ▶ Key constraints
- ▶ Keyed physical files
- ▶ Keyed logical files
- ▶ Indexes



# Indexes

## Binary Radix

- ▶ Traditional format
- ▶ A multilevel hybrid tree structure

## Encoded Vector Index (EVI)

- ▶ Unique to IBM i
- ▶ A variation on bitmap indexing

```
create index forindex02 on forindex (somevalue desc, keyid );  
create index forindex06 on forindex (keyid, somevalue) where somevalue <= 10000;  
create encoded vector index forindex08 on forindex  
      (somecode) include (count(*), sum(somevalue));
```

## Index Specifics

---

### Index by column value/sequence

- ▶ Order by

### Derived Key Index

- ▶ Index is a derived value of one or more columns
- ▶ Result of an expressions
- ▶ Result of a scalar function

### Sparse Indexes

- ▶ Content of index based on a WHERE clause

### Index only access

- ▶ All required column values are in an index
- ▶ Aggregate values maintained in an EVI

### Indexes are NOT

- ▶ Specifically for unique keys
  - That is what constraints are for
- ▶ Just for sequence

# Index Uses

---

## Native I/O

### Identify and process rows in a table

- ▶ Selection
- ▶ Joining
- ▶ Grouping
- ▶ Ordering

### Statistical Information

- ▶ Number of distinct values
- ▶ Distribution of values



# Index Strategies

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## Proactive and Reactive

### Proactive

- ▶ Anticipate column requirements
  - for selection, joining, grouping, and ordering
- ▶ Build indexes based on requirements
  - Views can provide a good indication of column requirements

### Reactive

- ▶ Build indexes based on  
Optimizer feedback, Query implementation plan, System performance measurements

A reactive approach will be required - how reactive depends on how proactive you were

The optimizer advises indexes that would be useful

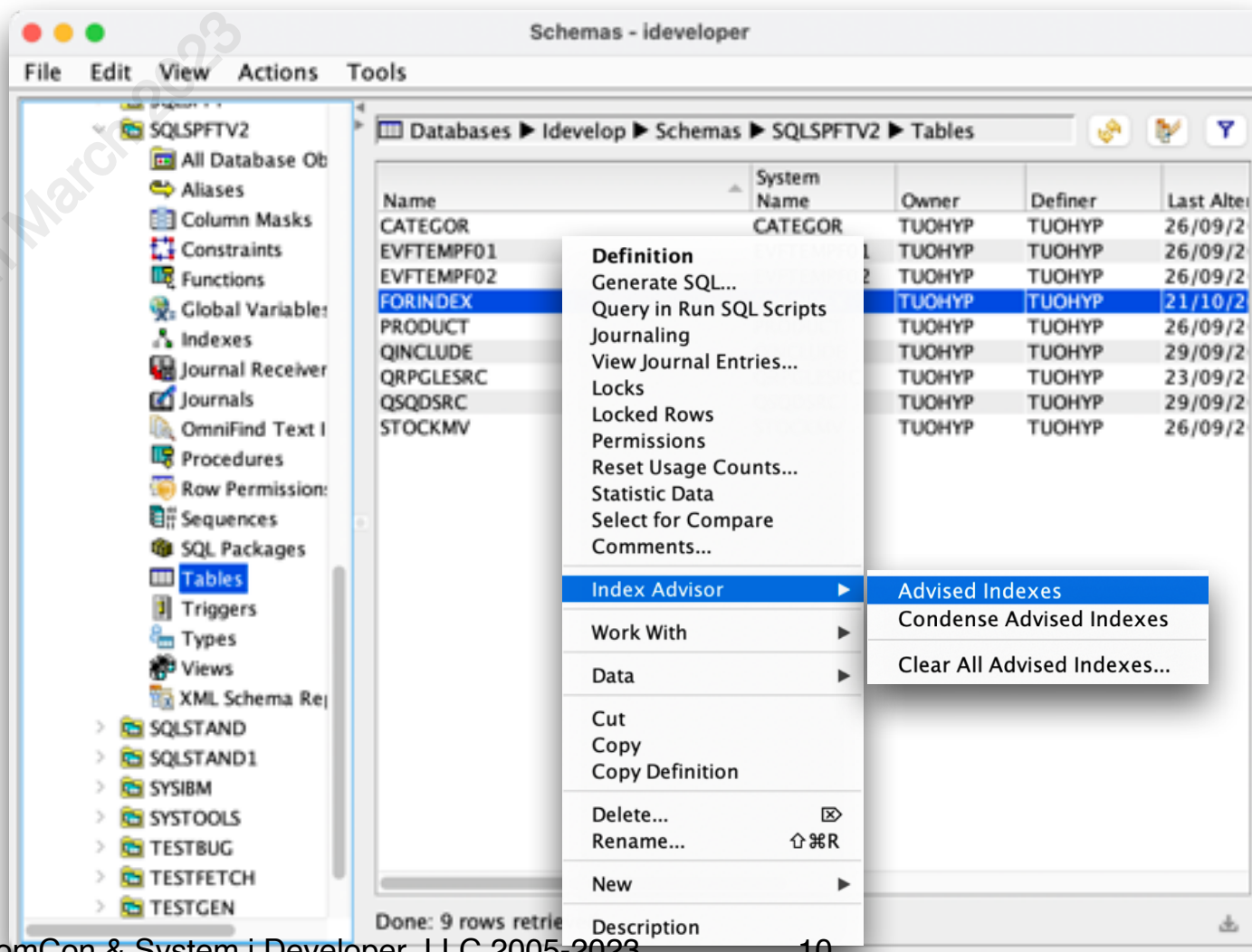
- ▶ But not all possible useful indexes are advised
- ▶ Not all advised indexes are required

Index advise is in the catalog table SYSIXADV

# index Advisor

Index advise is available for a table, schema or system

- ▶ In ACS schemas - right click on table, schema or system name and select Index Advisor
- ▶ Index advise also available for SQL statements
  - In Visual Explain - menu option *Actions>Index and Statistics Advisor*



# Index Advisor

This is a customized view

- ▶ View>Columns

Advised Indexes for SQLSPFTV2.FORINDEX - ideveloper(idevelop)

File Edit View Actions

Advised Indexes for SQLSPFTV2.FORINDEX

Table for Which Index was Advised	System Schema	Keys Advised	Leading Keys Order Independent	Advised Index Type	Last Advised for Query Use	First Advised for Query Use	Reason Advised	Times Advised for Query Use	Estimated Index Creation Time
FORINDEX	SQLSPFTV2	SOMEVALUE		Binary Radix	23/10/2022 10:47:48	20/10/2022 10:05:05	Row selection	1	9 00:00:01
FORINDEX	SQLSPFTV2	KEYID, SOMEVALUE		Binary Radix	23/10/2022 10:42:17	23/10/2022 10:13:57	Ordering/Grouping	1	3 00:00:01
FORINDEX	SQLSPFTV2	SOMECODE		Binary Radix	23/10/2022 10:57:44	21/10/2022 15:17:59	Ordering/Grouping	1	2 00:00:01
FORINDEX	SQLSPFTV2	SOMEVALUE, KEYID		Binary Radix	23/10/2022 10:10:00	23/10/2022 10:10:00	Ordering/Grouping	1	1 00:00:01

Done: 4 rows retrieved.

Advised Indexes for SQLSPFTV2.FORINDEX - ideveloper(idevelop)

File Edit View Actions

Advised Indexes for SQLSPFTV2.FORINDEX

Most Expensive Query Estimate	Rows in Table when Advised	Times Advised Dependent on Other Advice	Logical Page Size Advised	Average of Query Estimates	NLSS Table Advised	NLSS Schema Advised	MTI Used	MTI Created	MTI Last Used	MTI Used for Statistics	MTI Last Used for Statistics	EVI Distinct Values	System Name	Schema
1	1000000	0	64	0.0000	*HEX		0	0	0	0	0		FORINDEX	SQLSPFTV2
1	1000000	0	64	0.0000	*HEX		0	0	0	0	0		FORINDEX	SQLSPFTV2
1	1000000	0	64	0.0000	*HEX		0	0	0	0	0		FORINDEX	SQLSPFTV2
1	1000000	0	64	0.0000	*HEX		0	0	0	0	0		FORINDEX	SQLSPFTV2

Done: 4 rows retrieved.

## *Index Advisor Information*

---

The advised key

The first and last time the index was advised

The number of times the index was advised

The longest and average execution times for the queries that generated the index advise

The estimated index creation time

The number of rows in the table the last time the index was advised

The reason the index was advised (row selection and/or ordering/grouping)

### Condensed Advised Indexes

- ▶ Condenses multiple like advised indexes to one

# Index Advisor - View Options

Customize Columns

Column	Width	Visible
Table for Which Index was Advised	102	<input checked="" type="checkbox"/>
System Schema	74	<input checked="" type="checkbox"/>
Keys Advised	131	<input checked="" type="checkbox"/>
Leading Keys Order Independent	97	<input checked="" type="checkbox"/>
Advised Index Type	91	<input checked="" type="checkbox"/>
Last Advised for Query Use	160	<input checked="" type="checkbox"/>
First Advised for Query Use	150	<input checked="" type="checkbox"/>
Reason Advised	119	<input checked="" type="checkbox"/>
Times Advised for Query Use	111	<input checked="" type="checkbox"/>
Estimated Index Creation Time	102	<input checked="" type="checkbox"/>
Most Expensive Query Estimate	95	<input checked="" type="checkbox"/>
Rows in Table when Advised	104	<input checked="" type="checkbox"/>
Times Advised Dependent on Other Advice	105	<input checked="" type="checkbox"/>
Logical Page Size Advised	71	<input checked="" type="checkbox"/>
Average of Query Estimates	79	<input checked="" type="checkbox"/>
NLSS Table Advised	72	<input checked="" type="checkbox"/>
NLSS Schema Advised	71	<input checked="" type="checkbox"/>
MTI Used	53	<input checked="" type="checkbox"/>

Move Up  
Move Down  
Top  
Bottom  
Default Order  
Show  
Hide

Width (pixels):  
102

OK Cancel Apply

Tables - Index Advisor - Include

General Date and Time

Advised index type: Any

Minimum times advised for query use: 1

Minimum average of query estimates: 0.0001

Minimum rows in table when advised: 0

Restore Defaults OK Cancel

Tables - Index Advisor - Include

General Date and Time

Last advised for query use

Any

Before: 23 Oct 2022

After: 23 Oct 2022

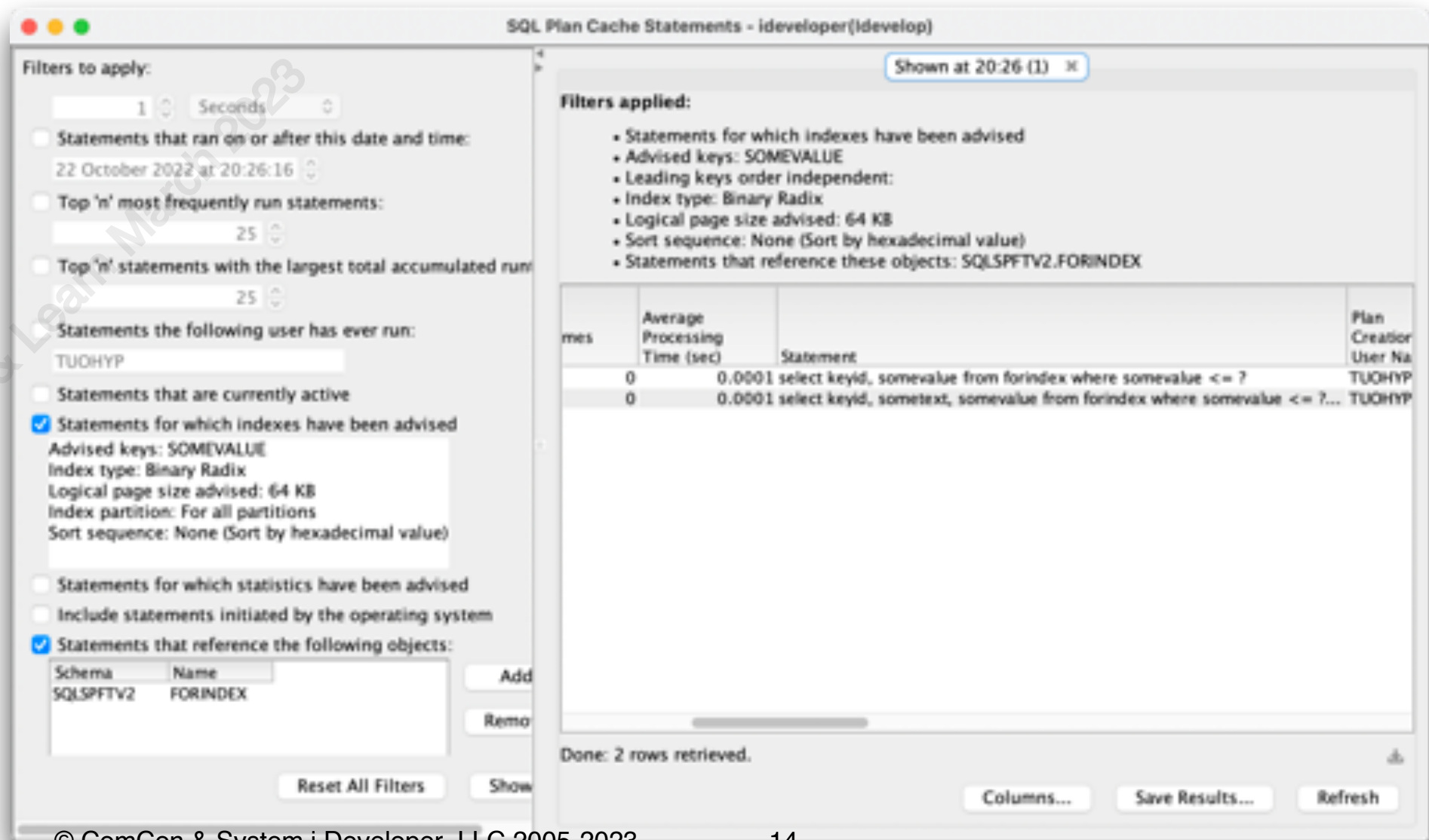
Between: 23 Oct 2022 and 23 Oct 2022

Restore Defaults OK Cancel

# Index Advisor - Actions > Work With

## SQL Plan Cache Statements

- ▶ If still available



SQL Plan Cache Statements - ideveloper(idevelop)

Filters to apply:

- 1 Seconds
- Statements that ran on or after this date and time: 22 October 2022 at 20:26:16
- Top 'n' most frequently run statements: 25
- Top 'n' statements with the largest total accumulated run: 25
- Statements the following user has ever run: TUOHYP
- Statements that are currently active
- Statements for which indexes have been advised
  - Advised keys: SOMEVALUE
  - Index type: Binary Radix
  - Logical page size advised: 64 KB
  - Index partition: For all partitions
  - Sort sequence: None (Sort by hexadecimal value)
- Statements for which statistics have been advised
- Include statements initiated by the operating system
- Statements that reference the following objects:
 

Schema	Name
SQLSPFTV2	FORINDEX

Reset All Filters Show

Filters applied:

- Statements for which indexes have been advised
- Advised keys: SOMEVALUE
- Leading keys order independent:
- Index type: Binary Radix
- Logical page size advised: 64 KB
- Sort sequence: None (Sort by hexadecimal value)
- Statements that reference these objects: SQLSPFTV2.FORINDEX

mes	Average Processing Time (sec)	Statement	Plan Creator User Na
0	0.0001	select keyid, somevalue from forindex where somevalue <= ?	TUOHYP
0	0.0001	select keyid, sometext, somevalue from forindex where somevalue <= ?...	TUOHYP

Done: 2 rows retrieved.

Columns... Save Results... Refresh

## Db2 for i Services

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### Services available to help with Index Maintenance

#### ACT\_ON\_INDEX\_ADVICE procedure

- ▶ Create new indexes for a table based on Index advise

#### REMOVE\_INDEXES procedure

- ▶ Drop any indexes meeting specified criteria

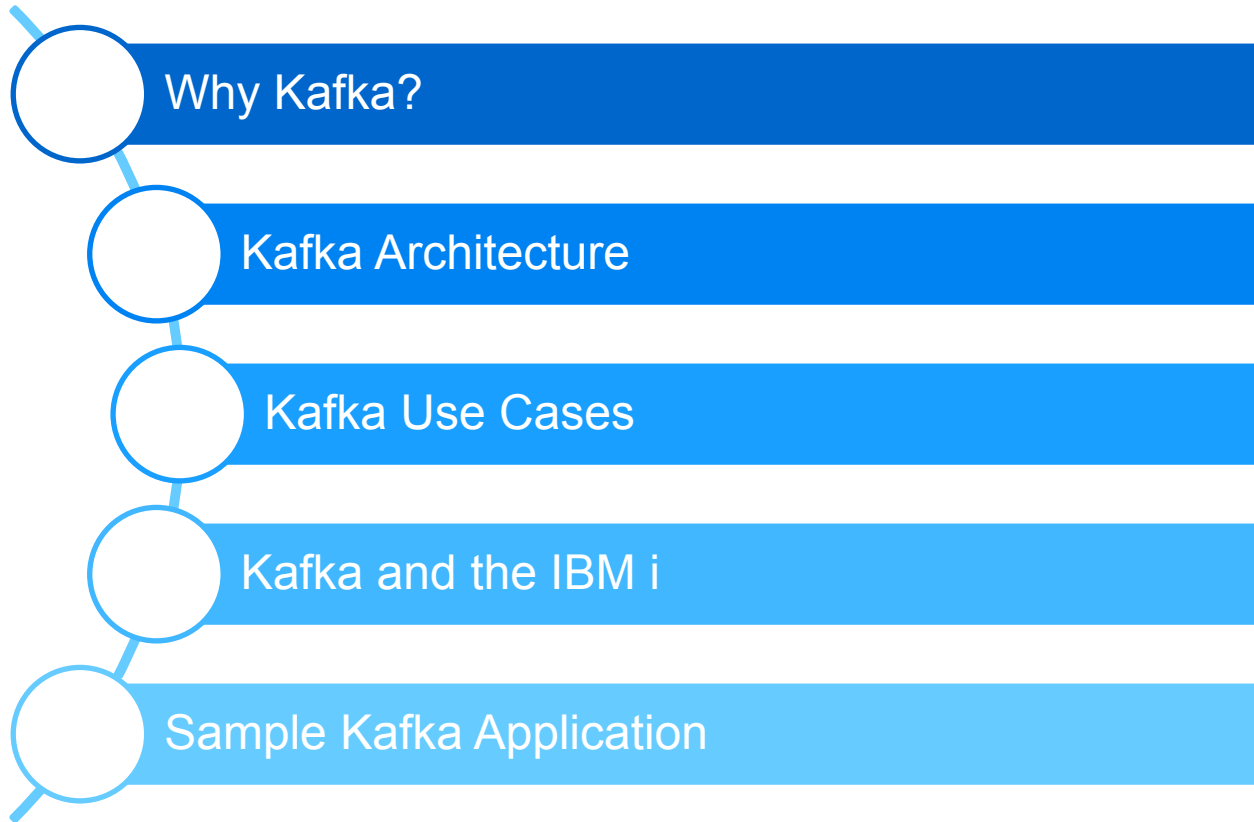
#### RESET\_TABLE\_INDEX\_STATISTICS procedure

- ▶ Clears usage statistics for indexes defined over tables
  - Optionally delete rows from the index advice table

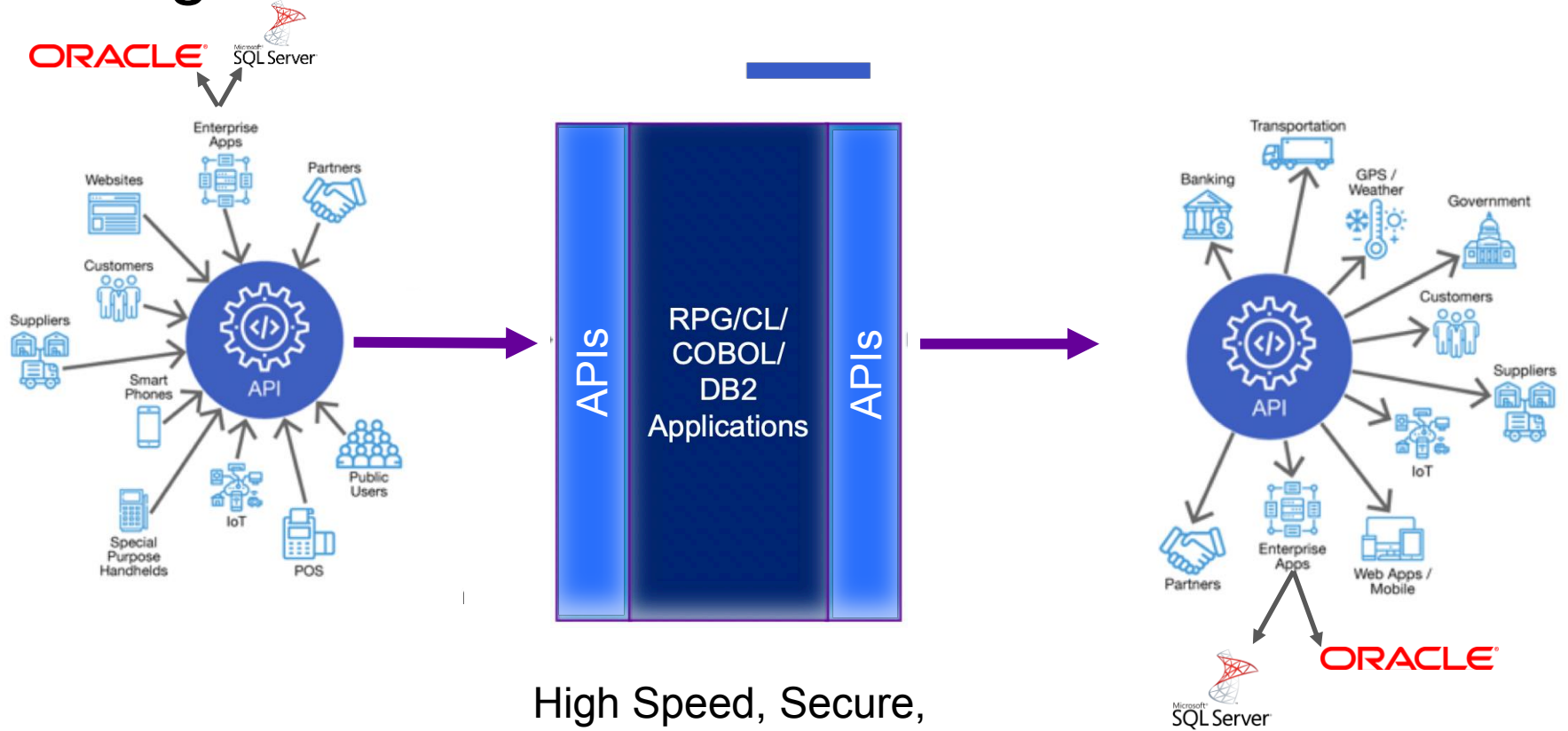
The background features a view of Earth from space, showing the blue and white horizon. Overlaid on this is a complex network of glowing blue nodes and arcs, representing a global or digital network. The nodes are of varying sizes and are connected by thin lines and larger, more prominent arcs that create a sense of depth and connectivity.

# High Performance, Resilient APIs for Your IBM i Using Kafka





# High Performance API Connections and IBM i



High Speed, Secure,  
Easy-to Maintain  
& Flexible Connections

# REST Services vs Apache Kafka

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## REST

- Call to URL using standard HTTP Methods (GET, PUT, Patch, Delete, etc.)
- Easy to setup and use
- Low latency for small payloads and relatively low call volumes
- Highly flexible connections
- Slow for high volume calls and large message payloads

## Apache Kafka

- High speed processing for large volume message streams
- Real time processing (replace batch & ETL processes)
- Handles large data messages
- Automated resilience
- Pub/Sub, Event Driven architecture
- More complex to setup and use

“Apache Kafka is a high-performance, resilient, open source-based, event-driven, streaming, pub-sub messaging application for providing loosely coupled connections between a variety of message producers and consumers.”



# Kafka Use is Exploding...

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- Over One Billion Downloads
- Used by More Than 80% of the Fortune 500
- 300% Growth in Companies Using More Than 50 Kafka Clusters
- LinkedIn is Processing 7 Trillion Messages a Day via Kafka
- Facilitating the Move to Stream Processing Rather Than Batch



# Event Driven Architecture

# Why Event Driven Architecture

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Procedural:

Check Database of Calls on  
a Scheduled Basis:

“Is there an emergency?”



Event Driven:

“There is an Emergency!”

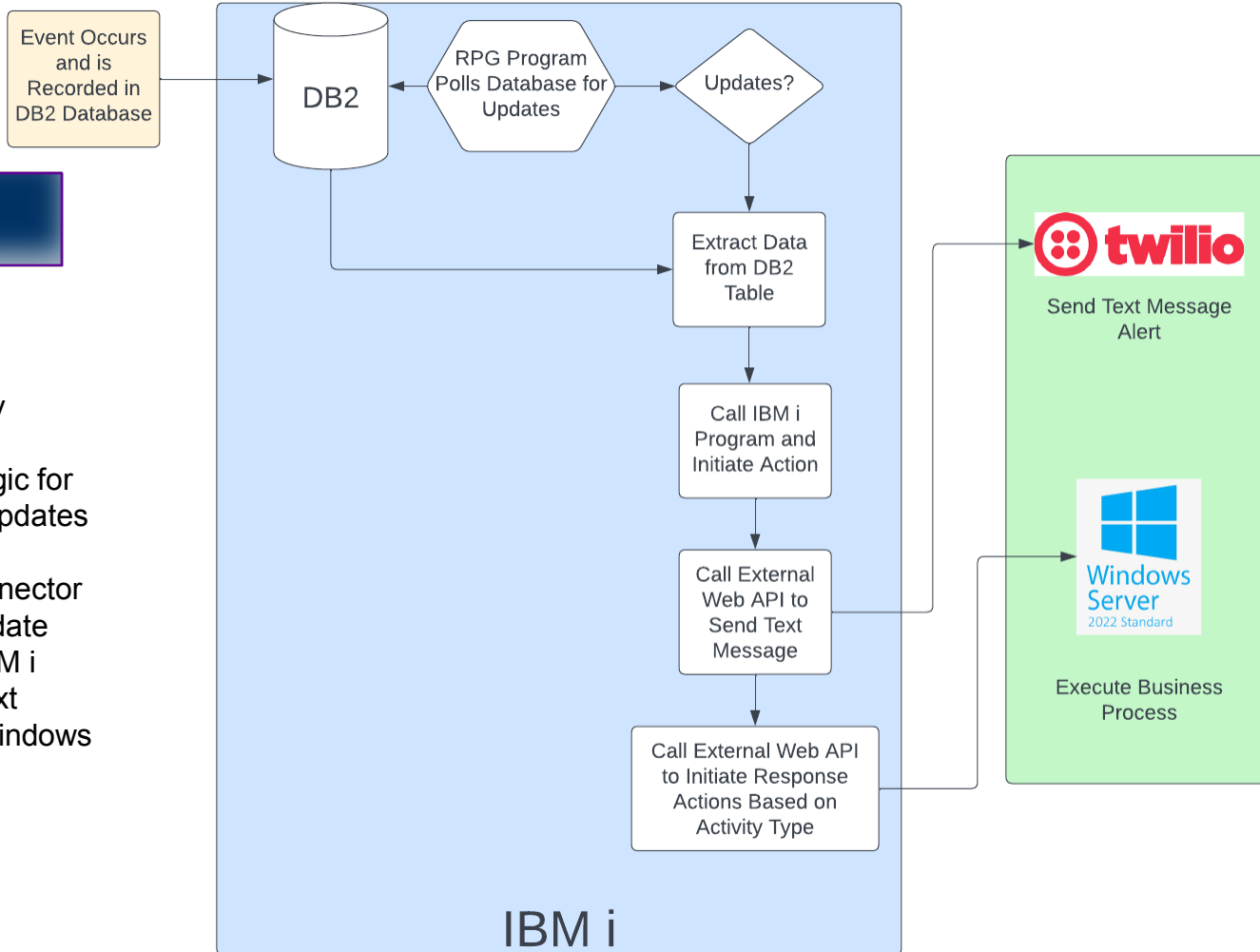
Event Driven:

- When Data Delivery is Continuous and/or Irregular and/or Unpredictable
- When Response is Potentially Required to Each Record Received
- When Response Must be Fast (Real time)

## Polling Approach

### Concerns:

- Polling Delay
- Complex Logic for Identifying Updates
- Custom Connector for Each Update Endpoint (IBM i Program, Text Message, Windows Process)





Event Occurs and is Recorded in DB2 Database



After-Update Trigger executes

Call IBM i Program and Initiate Action

Call External Web API to Send Text Message

Call External Web API to Initiate Response Actions Based on Activity Type



Send Text Message Alert



Execute Business Process

## Processing in Database Trigger

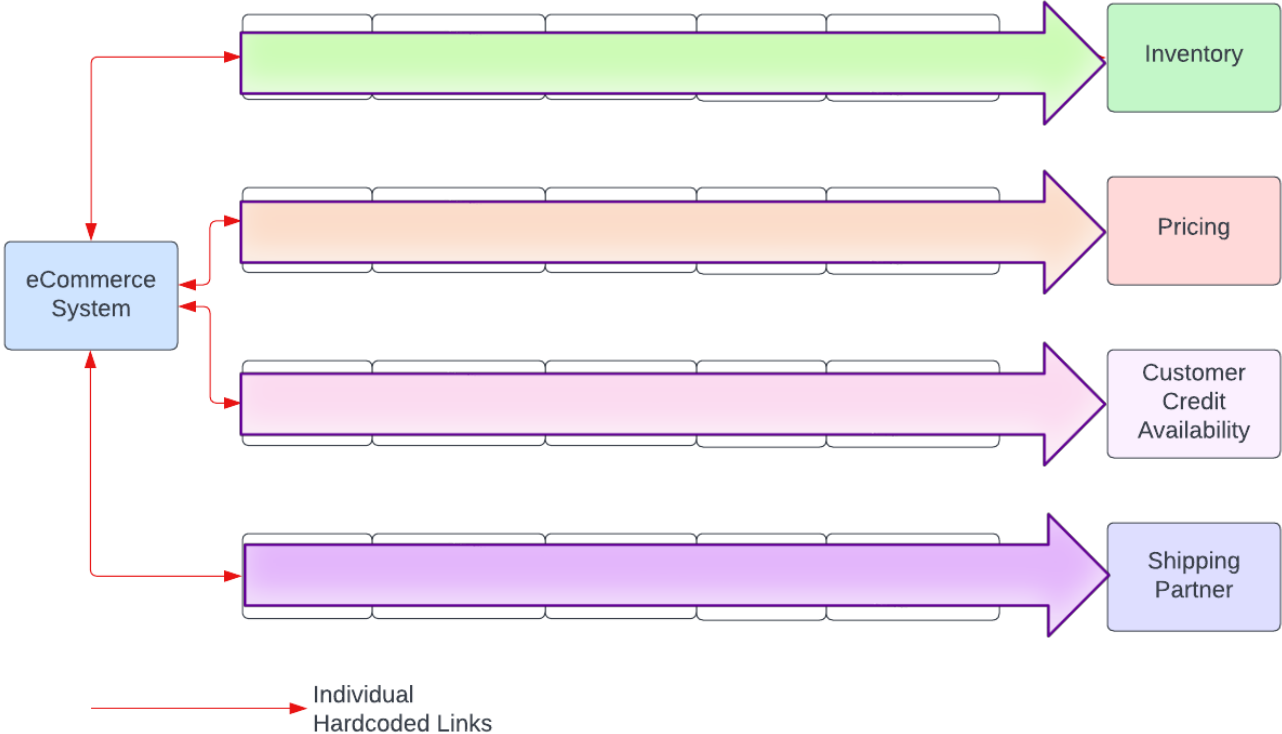
### Concerns:

- Custom Connector for Each Update Endpoint (IBM i Program, Text Message, Windows Process)
- Performance Impact of Putting Logic into the Database Trigger (Database Triggers were not really designed for creating an Event Driven architecture)

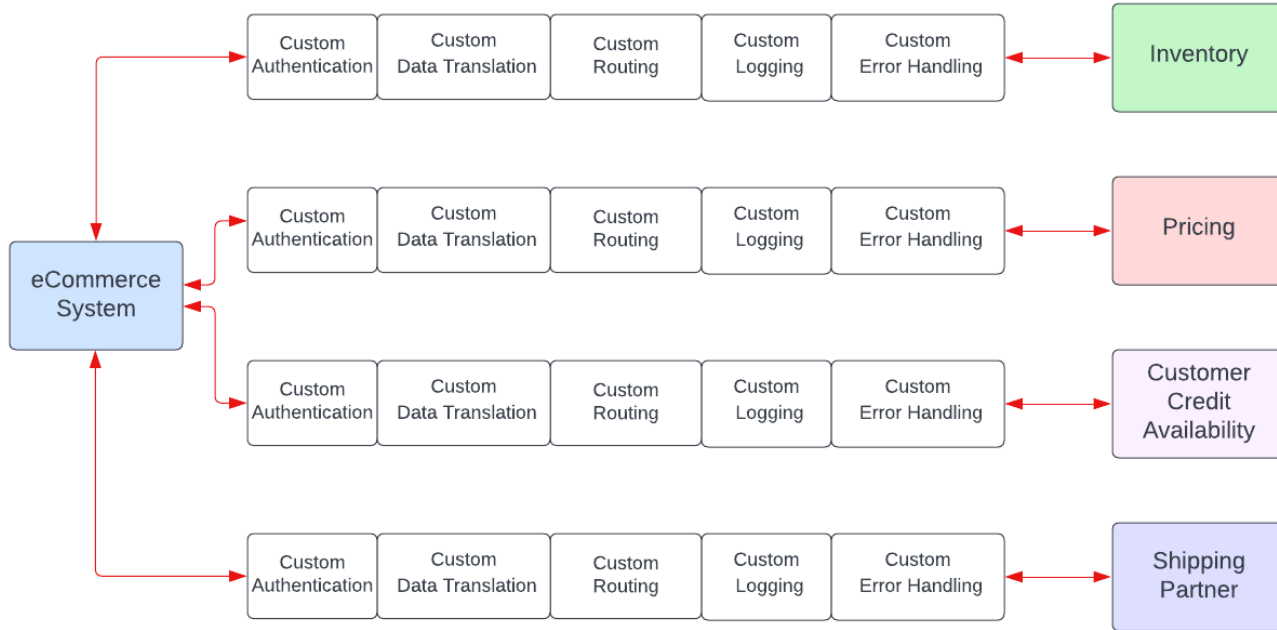


# What is the Alternative?

# Events Require Integration Regardless of Approach

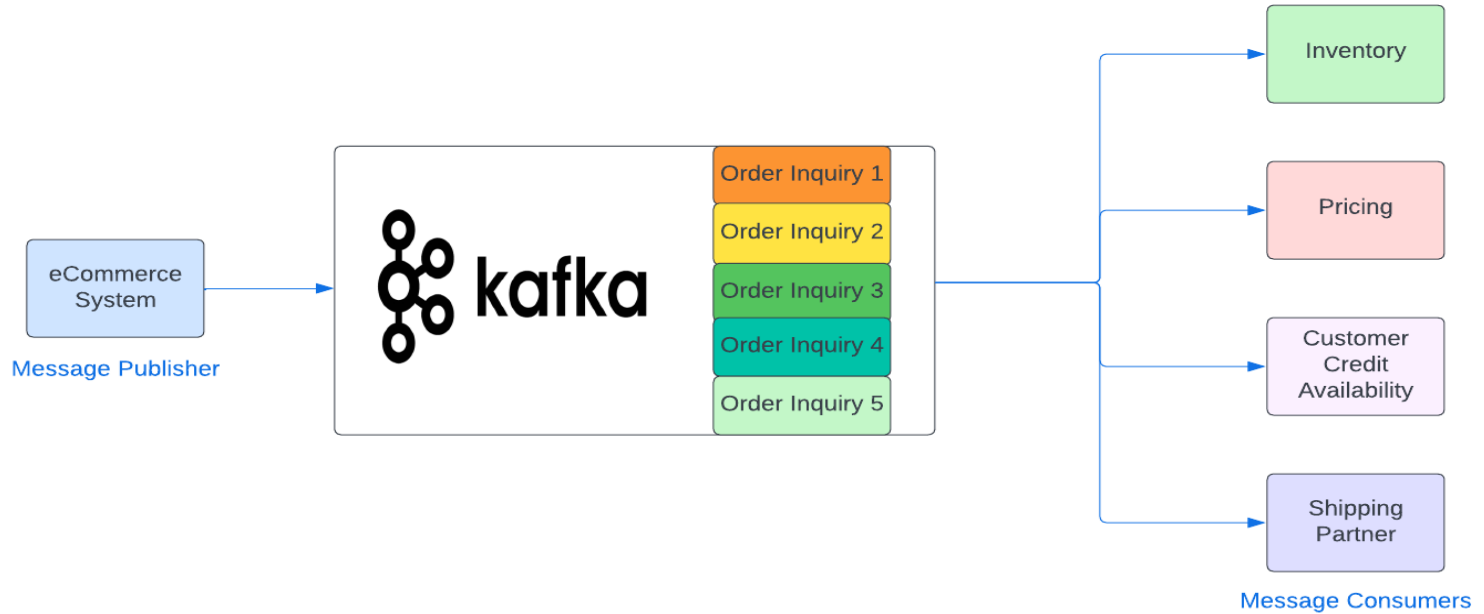


# Direct Integration without Kafka



→ Individual  
Hardcoded Links

# With Kafka Events are Posted Once



# Producers



Arrival  
Departure  
Geo Coordinates  
Fuel Stop



Deposit  
Loan Payment  
Withdrawal  
Electronic Transfer



Blood Pressure  
Oxygen Level  
Pulse  
Temperature



# Producers



Inventory Inquiry  
Request for Price  
Order Entry



Item Location  
Item Status  
Required Inventory

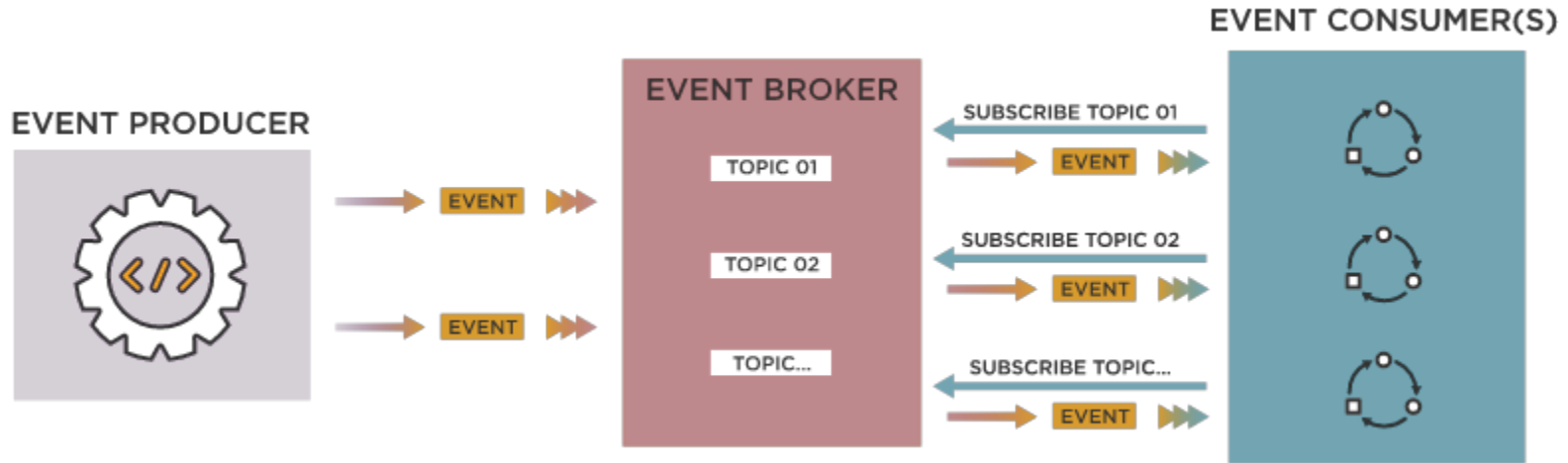


Location Services  
Ad Click  
App Open

A glowing network of nodes and arcs is superimposed over a view of Earth from space. The nodes are represented by small, bright blue circles of varying sizes, and the arcs are thin, glowing blue lines that connect these nodes in a complex, web-like pattern. The background shows the curvature of the Earth with a blue and white atmosphere against a dark, starry space.

# Publish/Subscribe (Pub/Sub) Architecture

# Publish/Subscribe (Produce/Consume) Model

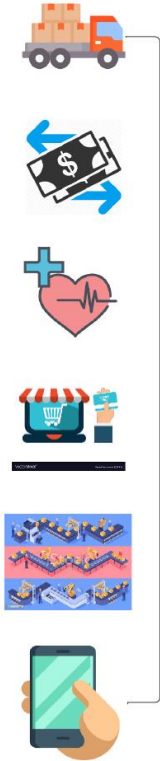




## Decoupled Interface

- Producers are Unaware of Consumers
- Consumers are Unaware of Producers
- Add Consumers without Affecting Producers
- Consumer Performance Does Not Affect Producers

Producers

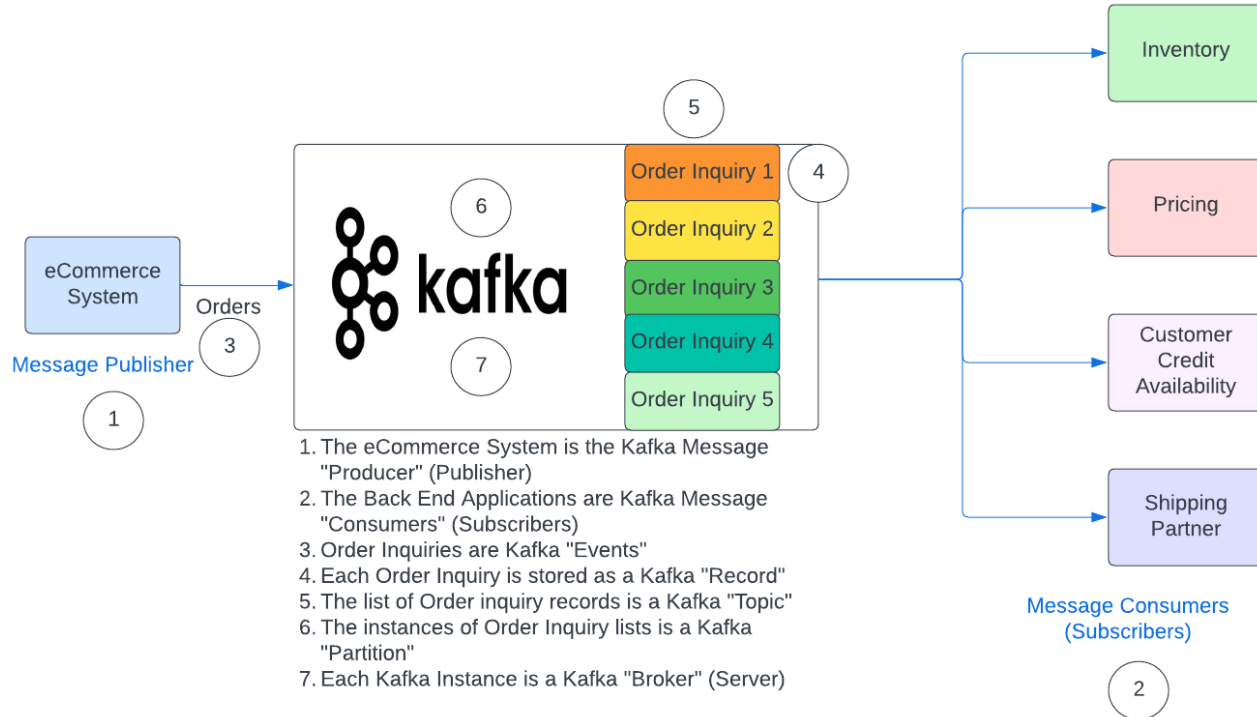


 kafka

Consumers



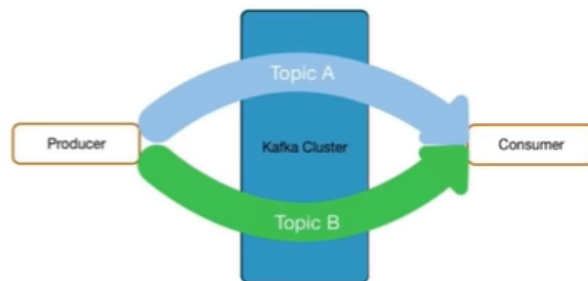
# Pub/Sub Architecture with Kafka



# Kafka Topics

## Topics

- **Topics:** Streams of "related" Messages in Kafka
  - Is a **Logical Representation**
  - **Categorizes Messages** into Groups
- Developers define Topics
- Producer  $\leftrightarrow$  Topic: N to N Relation
- Unlimited Number of Topics



# Kafka Topics



## Blood Pressure Readings

3-3-2023, 04:00:00, 117, 72, 34567

3-3-2023, 06:00:00, 122, 81, 34567

3-3-2023, 08:00:00, 132, 83, 34567

3-3-2023, 10:00:00, 130, 80, 34567

3-3-2023, 12:00:00, 135, 78, 34567

3-3-2023, 14:00:00, 133, 81, 34567

3-3-2023, 16:00:00, 136, 79, 34567

## Truck Arrivals & Departures

3-3-2023, 10:00:00, ARR, CHI, TR334

3-3-2023, 10:05:00, DEP, ATL, TR867

3-3-2023, 11:00:00, DEP, CLE, TR255

3-3-2023, 11:25:00, ARR, DET, TR129

3-3-2023, 12:00:00, DEP, CHI, TR334

3-3-2023, 14:00:00, ARR, BRM, TR867

3-3-2023, 21:00:00, ARR, CHI, TR255

Immutable log of related messages

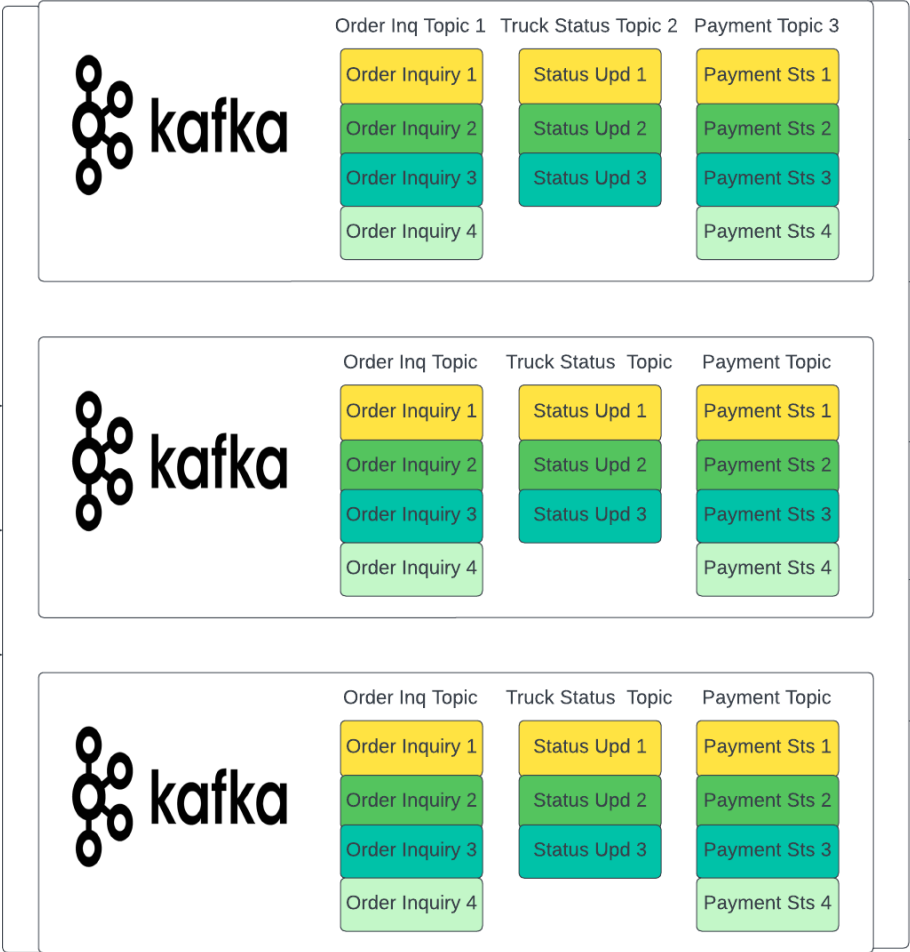
# Replication for Resilience & High Performance

Message Publisher

eCommerce System

Transportation Devices

Payment Processor



Message Consumers (Subscribers)

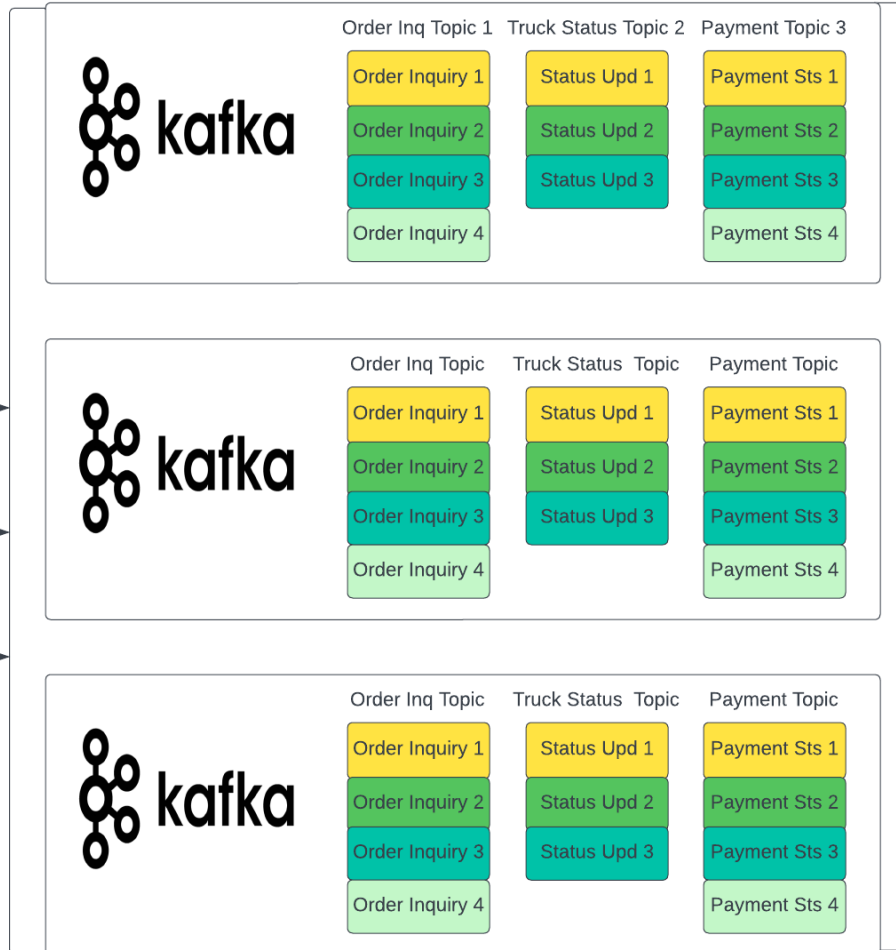
# Subscribers Can Subscribe to Multiple Topics

Message Publisher

eCommerce System

Transportation Devices

Payment Processor



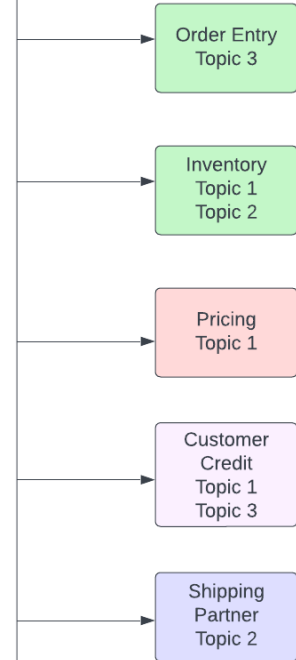
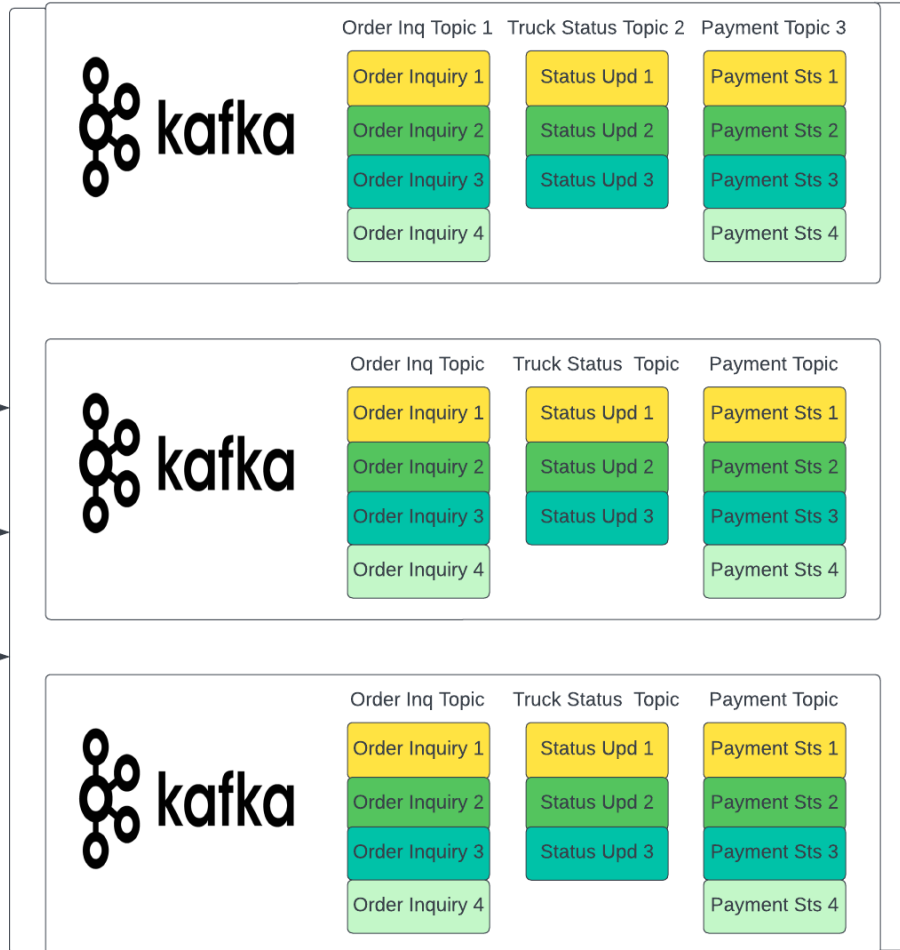
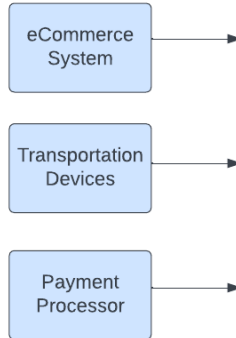
Message Consumers (Subscribers)

# Zookeeper

Kafka RAFT protocol

Manage the Clusters

Message Publisher



Message Consumers (Subscribers)



## Some Real World Kafka Use Cases





Trucking Company  
1M Rate Requests/Day



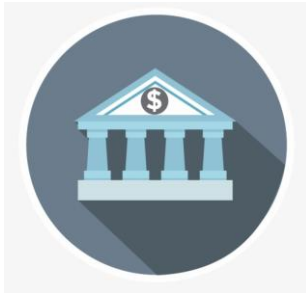
Distributor  
1 Million+ Transactions  
in FTP File



eCommerce  
Query 80 Warehouses  
With Sub 2 Second Response



Real-Time Patient  
Monitoring



Financial Services  
12,000 Transactions/Second



Retail Chain  
Peak Load of  
80,000 Transactions/Second



Insurance  
Query Multiple Outside APIs  
& Provide Instant Quotes

# This is an IBM i Application - eCommerce



Occasions   Cooking   **Sale**   About Us   Contact Us



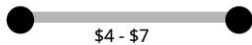
## FILTER

### Price

\$4.00 - \$6.99 ×

Clear All

### Price



### Color

### Material

### Cool Attribute



Gold Knives

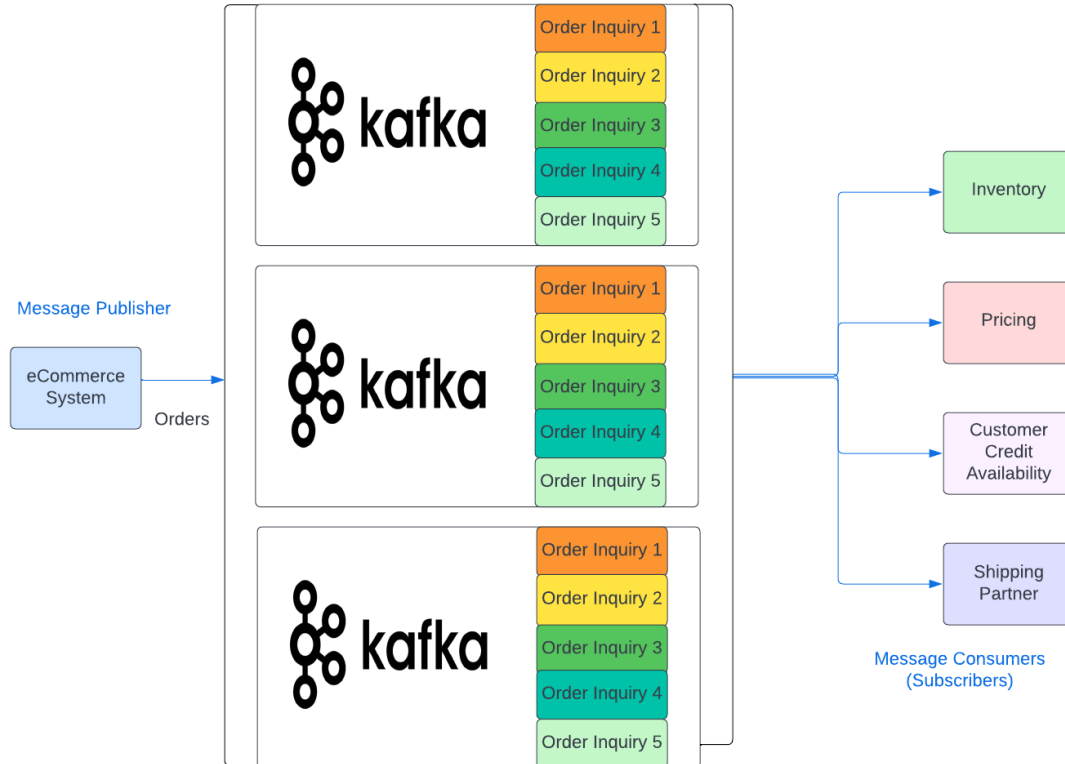
Starting at:  
\$7.00



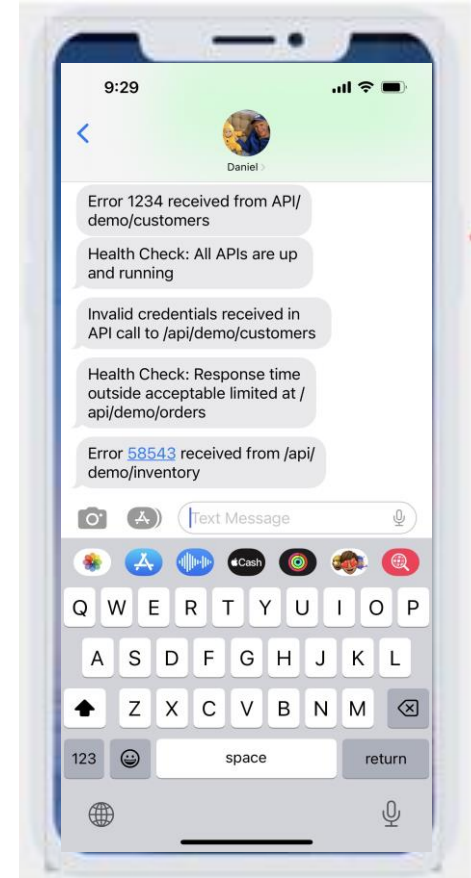
Flat Spatula

As low as: \$4.00

# Resilience & Performance with Kafka Replication



# Add High Speed Inbound and Outbound Text Messaging to Any Application



# Open Source Cost Savings Automate Business Processes



Integrate  
Form with  
IBM i Data



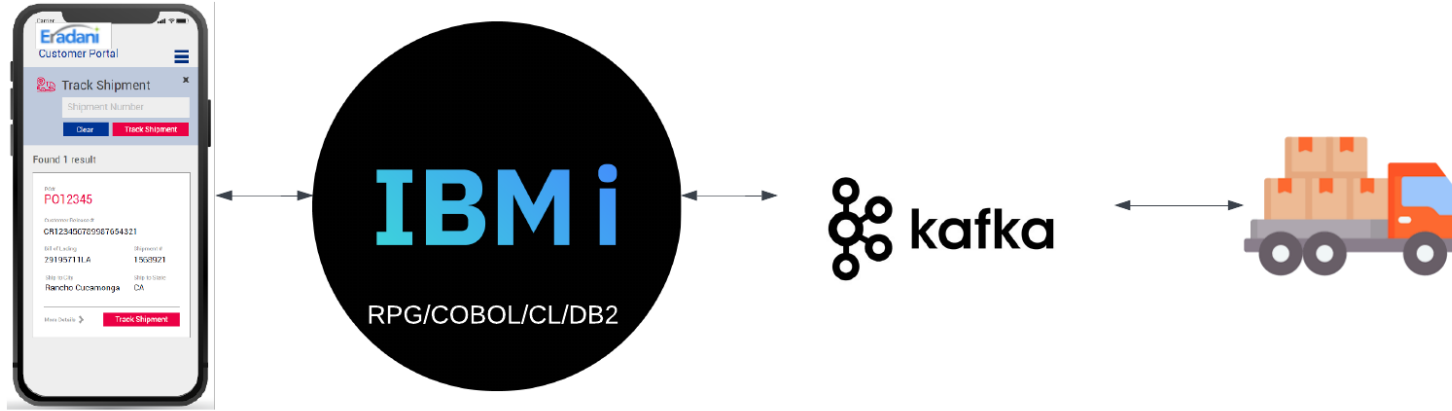
Generate  
Documents



Post  
Documents  
to Kafka

Kafka can manage very large message payloads  
The Message can include the document or simply a  
pointer to the document

# Real Time Vehicle Tracking



# Sample Code in JavaScript for Sending Kafka Messages

```
const { Kafka } = require('kafkajs');

// Create a Kafka client instance
const kafka = new Kafka({
  clientId: 'my-app',
  brokers: ['kafka1:9092', 'kafka2:9092']
});

// Create a producer instance
const producer = kafka.producer();

// Connect to Kafka
await producer.connect();

// Produce a message to a topic
await producer.send({
  topic: 'my-topic',
  messages: [
    { value: 'Hello Kafka!' }
  ]
});

// Disconnect from Kafka
await producer.disconnect();
```

Use the JavaScript  
Kafka Module  
FREE CODE!!

Identify Broker

Create Producer &  
Connect to Kafka

Send a Message to  
Kafka

# Sample Kafka Messages

---

1.{"customer\_id": "12345", "product\_id": "67890", "action": "purchase", "timestamp": "2022-03-16T10:30:00Z"}

2.{"sensor\_id": "9876", "measurement": 20.5, "unit": "Celsius", "timestamp": "2022-03-16T12:15:00Z"}

3.{"user\_id": "abcd1234", "event\_type": "click", "page\_url": "<https://example.com/home>", "timestamp": "2022-03-16T14:20:00Z"}

4.{"order\_id": "o123456", "customer\_id": "c7890", "product\_id": "p2345", "quantity": 2, "timestamp": "2022-03-16T16:45:00Z"}

5.{"sensor\_id": "2345", "measurement": 80.2, "unit": "Fahrenheit", "timestamp": "2022-03-16T18:30:00Z"}





How do You Tie this to the IBM i?

# You Must...

---

- Produce Messages for Kafka from RPG/COBOL
- Format the Messages for Kafka
- Consume Messages from Kafka
- Translate Messages Coming From Kafka
- Handle the Event Driven to Procedural Transition
- Authenticate and Authorize
- Use the Kafka Communication Modules

# Setting up Kafka with RPG

---

- Need a Kafka Client
- Kafka Clients are very complex -> use open source!
- Major Kafka Clients sadly do not include RPG
- Connect RPG to Open Source and use open source Kafka clients!

# Align with IBM's IBM i Development Strategy

The future of IBM i development is a blended environment

## IBM i

World's Best RDBMS

COBOL+RPG

Lowest cost of ownership  
(TCO)

Reliability, securability,  
efficiency

Protection of investment



## Open Source

Artificial Intelligence

Quantum Computing

Microservices / APIs

DevOps

Internet of Things

Web Technologies

**Using the right tools for the job  
will do more for your productivity  
than hacking tools to do jobs  
they were not designed to do.**

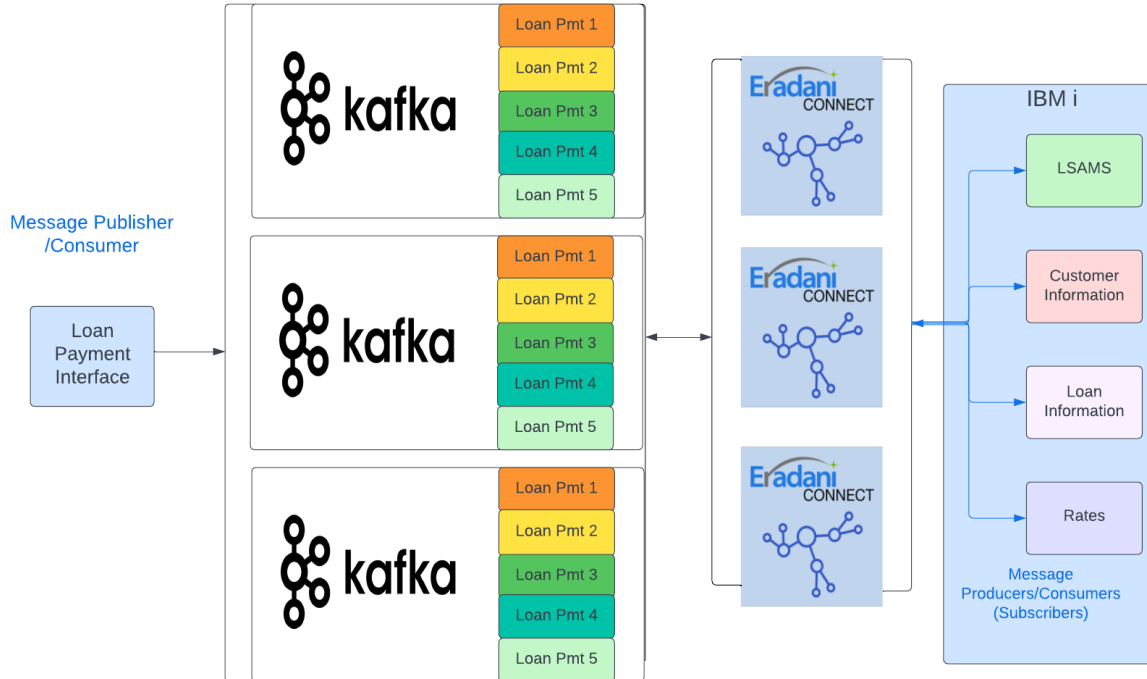


# Why JavaScript for Kafka?

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- Use Kafka Modules
- Popular (easy to find resources)
- Easy to Learn
- Handle Kafka Objects
  - Very High Performance Transformations
- Designed for Event Driven, Asynchronous Processing

# Managing Kafka Communications to IBM i



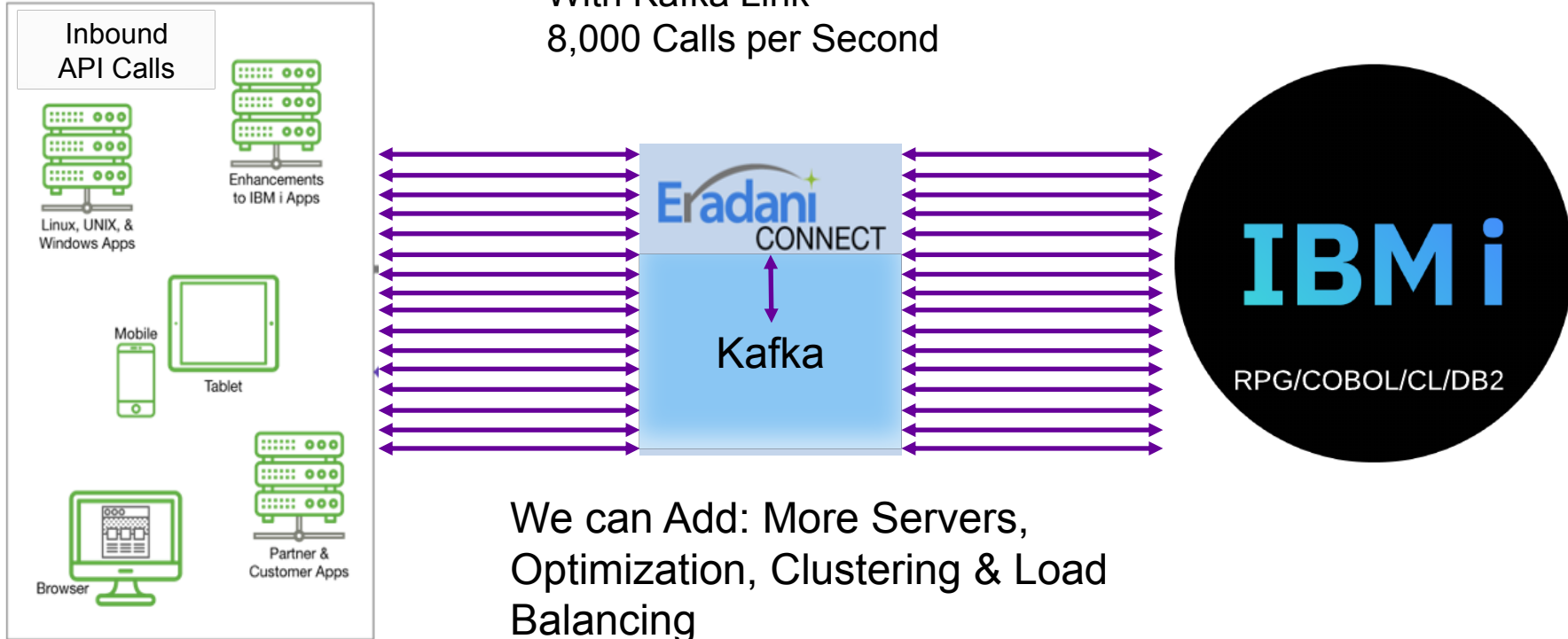
## Eradani:

- Generate RPG Code and JavaScript Code to Send Kafka Messages
- Data Transformations
- IBM i Connections
- Kafka Message Formatting
- Monitoring
- Error Handling
- Event Driven to Procedural Translation
- Asynchronous Communication Management

High Performance to Match Kafka Performance!

# Performance

With Kafka Link  
8,000 Calls per Second



We can Add: More Servers,  
Optimization, Clustering & Load  
Balancing





## Indexing Basics

Speaker: Paul Tuohy

## High Performance, Resilient APIs for Your IBM i Using Kafka

Speaker: Dan Magid

Sponsored by



[dan@eradani.com](mailto:dan@eradani.com)

Paul's handout at

<https://cutt.ly/IndexingBasics>

or

[https://cutt.ly/IndexingBasics\\_SiD](https://cutt.ly/IndexingBasics_SiD)

See more Summit Lunch & Learn webinars at  
[SystemiDeveloper.com/LunchLearn](https://SystemiDeveloper.com/LunchLearn)

## A Sample Table

Primary Key constraint provides an access path

Populated with a million rows

- ▶ Examples are only using the KEYID, SOMETEXT, SOMECODE and SOMEVALUE columns
- ▶ SOMETEXT values begin with 'Low', 'Hit', 'Medium' or 'High'
  - 100 rows have a SOMETEXT value beginning with 'Hit'
- ▶ SOMECODE has only 4 values - "AA", 'BB', 'CC' and 'DD'

Stored procedure *fillindex()* used to populate table

- ▶ Code for stored procedure in notes

```
create or replace table forindex
(keyid integer generated always as identity,
 sometext varchar(20) allocate(20) not null default,
 somecode char(2) not null default,
 somevalue decimal(15, 0) not null default,
 other1 decimal(3, 0) not null default,
 other2 decimal(3, 0) not null default,
 other3 decimal(3, 0) not null default,
 constraint pk_forindex primary key (keyid)) ;
```

## Stored procedure used to populate test table

```
create or replace procedure fillindex
(in numrows integer)
begin
declare ii integer default 0;
declare sometext varchar(20) default '';
declare somecode char(2) default '';

while (ii < numrows) do
  set ii = ii + 1;
  case
    when ii < 10000 then
      set sometext = 'Low ' || char(ii);
      set somecode = 'AA';
    when ii < 10100 then
      set sometext = 'Hit ' || char(ii);
      set somecode = 'BB';
    when ii < 500000 then
      set sometext = 'Medium ' || char(ii);
      set somecode = 'CC';
    else
      set sometext = 'High ' || char(ii);
      set somecode = 'DD';
  end case;
  insert into forindex (sometext, somevalue, somecode)
    values (sometext, ii * 10, somecode);
end while;
end;
```

# Visual Explain

Run SQL Scripts - ideveloper(Idevelop)

File Edit Search View Connection Run Explain Monitor Editor Tools Help

indexing.sql

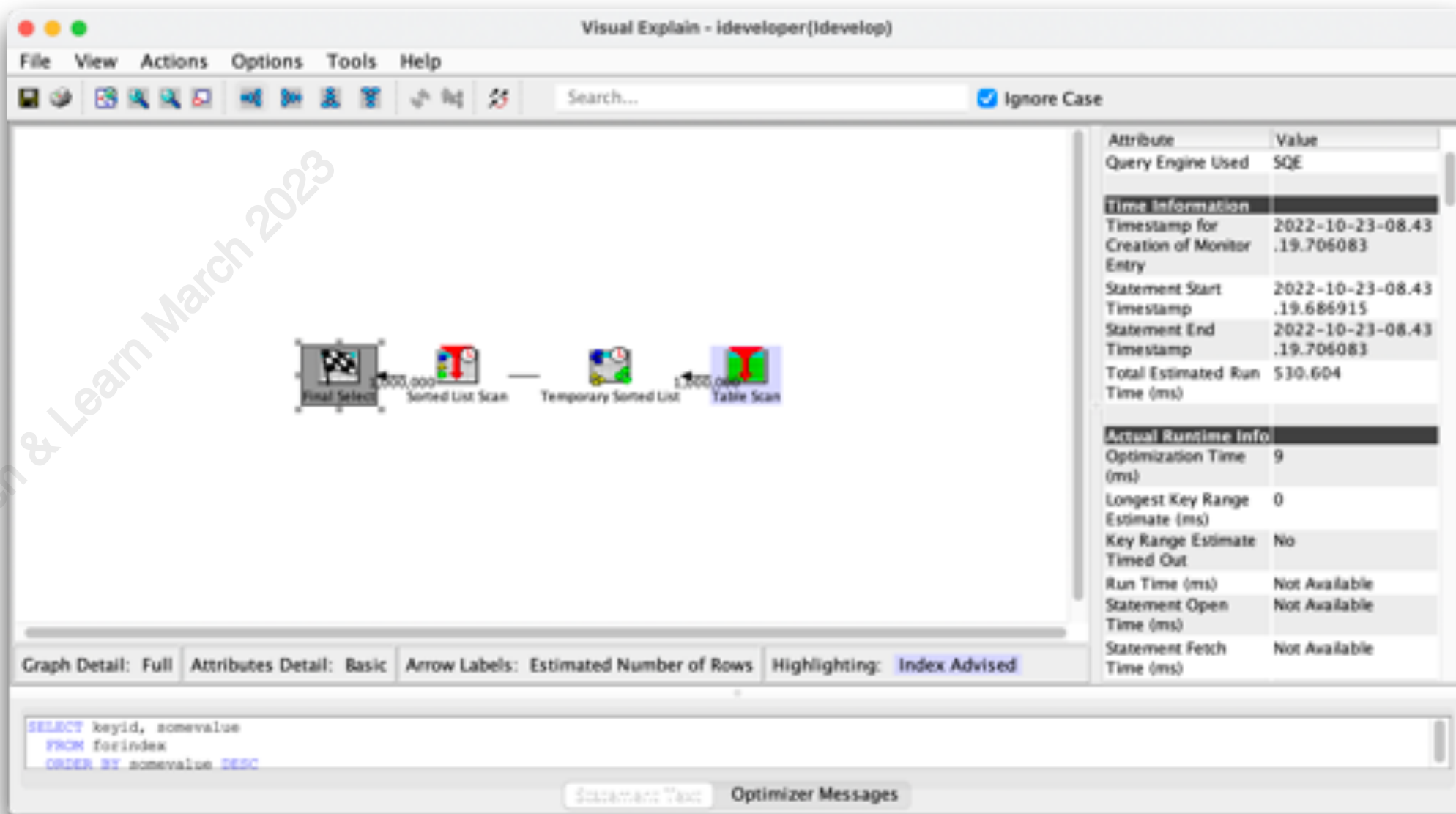
```
43 call fillindex (1000000);
44 -- select * from forindex;
45 -- select max(keyid) from forindex;
46
47 -- Normal Index - all columns in index
48 select keyid, somevalue from forindex order by somevalue desc;
49
50 create index forindex01 on forindex (somevalue);
51
52 create index forindex02 on forindex (somevalue desc, keyid );
53
54 drop index forindex01;
55 drop index forindex02;
```

[ 23/10/2022, 16:17:32 ] Explain...  
select somecode, count(\*), sum(somevalue) from forindex group by somecode

Messages Environment

ational database Idevelop on ideveloper as TUOHYP - 142829/QUSER/QZDASOINIT using JDBC configuration 'Defa Lines: 86 Ln: 48 Col: 18

# Visual Explain



Visual Explain - ideveloper(idevelop)

File View Actions Options Tools Help

Search...  Ignore Case

Visual Select (1,000,000) → Sorted List Scan → Temporary Sorted List (1,000,000) → Table Scan

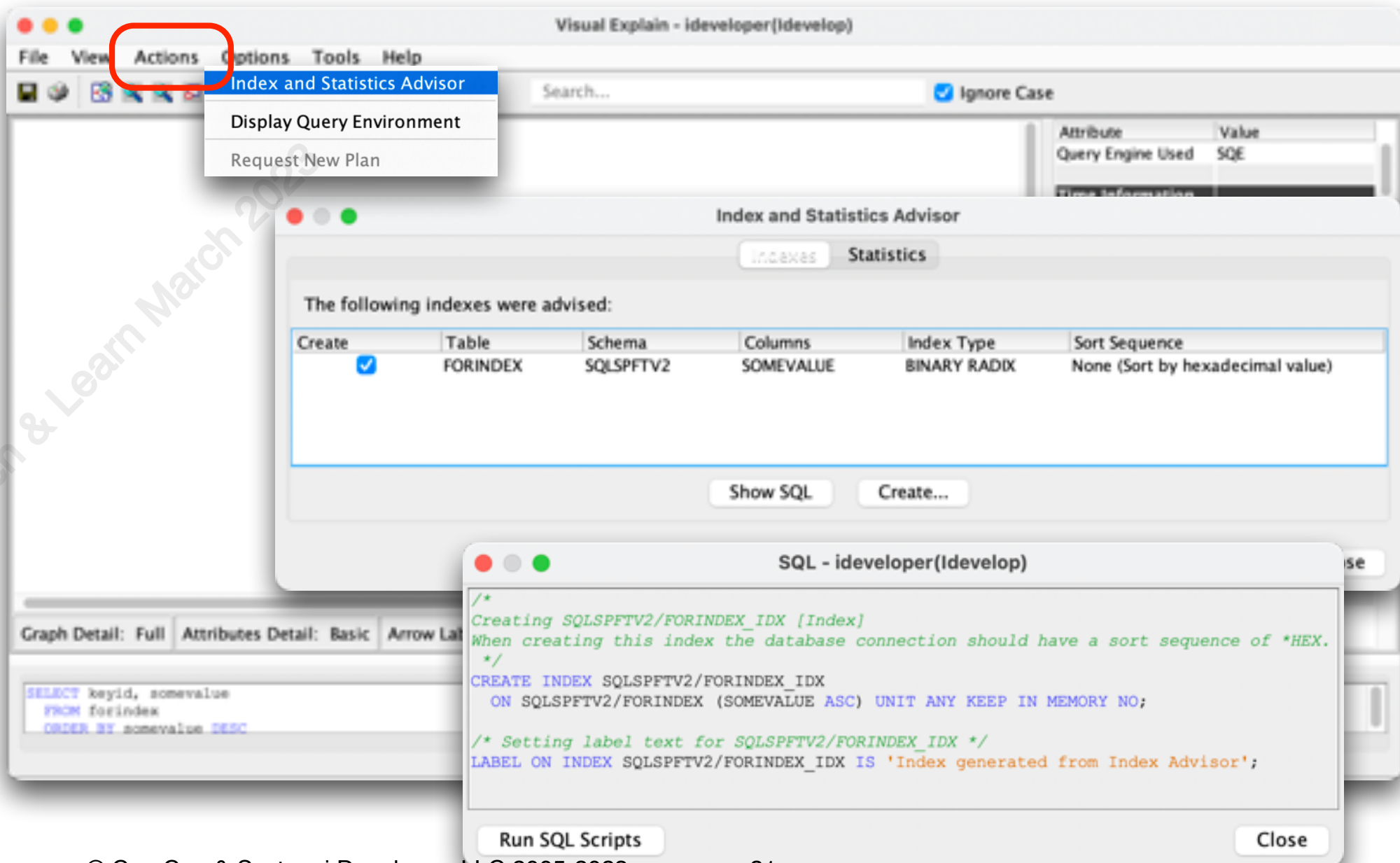
Attribute	Value
Query Engine Used	SQE
<b>Time Information</b>	
Timestamp for Creation of Monitor Entry	2022-10-23-08.43 .19.706083
Statement Start Timestamp	2022-10-23-08.43 .19.686915
Statement End Timestamp	2022-10-23-08.43 .19.706083
Total Estimated Run Time (ms)	530.604
<b>Actual Runtime Info</b>	
Optimization Time (ms)	9
Longest Key Range Estimate (ms)	0
Key Range Estimate Timed Out	No
Run Time (ms)	Not Available
Statement Open Time (ms)	Not Available
Statement Fetch Time (ms)	Not Available

Graph Detail: Full | Attributes Detail: Basic | Arrow Labels: Estimated Number of Rows | Highlighting: Index Advised

```
SELECT keyid, somevalue
FROM forindex
ORDER BY somevalue DESC
```

Statement Text | Optimizer Messages

# Visual Explain and Advised Indexes



The screenshot shows the Oracle SQL Developer interface. The 'Actions' menu is open, highlighting 'Index and Statistics Advisor'. Below it, the 'Index and Statistics Advisor' window is displayed, showing a table of advised indexes. The 'SQL - ideveloper(idevelop)' window is also open, showing the SQL script generated for the index.

**Index and Statistics Advisor**

The following indexes were advised:

Create	Table	Schema	Columns	Index Type	Sort Sequence
<input checked="" type="checkbox"/>	FORINDEX	SQLSPFTV2	SOMEVALUE	BINARY RADIX	None (Sort by hexadecimal value)

**SQL - ideveloper(idevelop)**

```

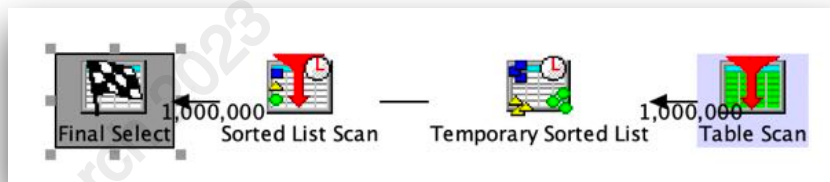
/*
Creating SQLSPFTV2/FORINDEX_IDX [Index]
When creating this index the database connection should have a sort sequence of *HEX.
*/
CREATE INDEX SQLSPFTV2/FORINDEX_IDX
ON SQLSPFTV2/FORINDEX (SOMEVALUE ASC) UNIT ANY KEEP IN MEMORY NO;

/* Setting label text for SQLSPFTV2/FORINDEX_IDX */
LABEL ON INDEX SQLSPFTV2/FORINDEX_IDX IS 'Index generated from Index Advisor';

```

## Basic Index

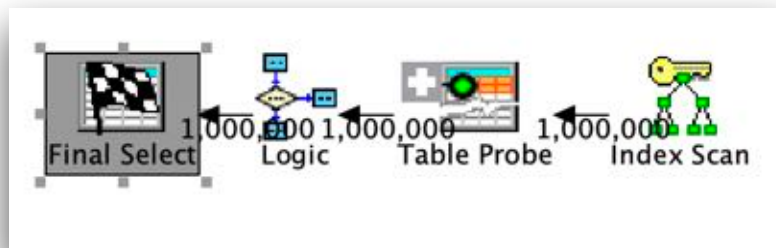
select keyid, somevalue from forindex order by **somevalue desc**;



Total Estimated Run 530.604  
Time (ms)

Index Advised

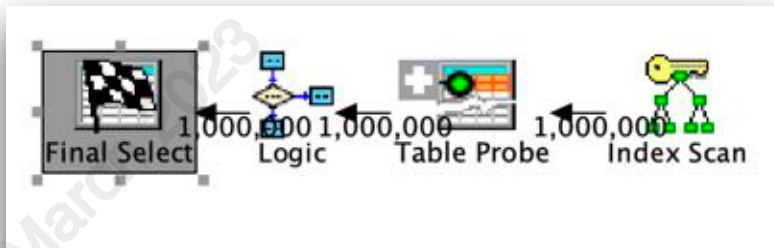
*create index forindex01 on forindex (somevalue);*



Total Estimated Run 1.711  
Time (ms)

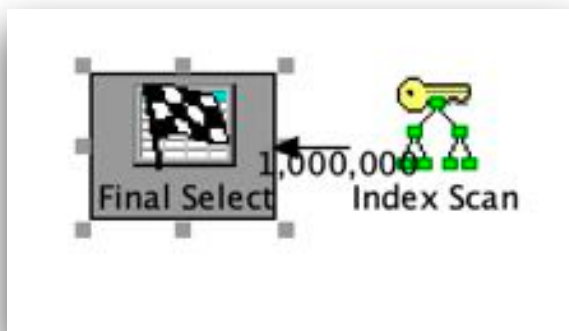
## Basic Index - Beyond Advise

select keyid, somevalue from forindex order by somevalue desc;  
*create index forindex01 on forindex (somevalue);*



Total Estimated Run 1.711  
Time (ms)

*create index forindex02 on forindex (somevalue desc, keyid );*



Total Estimated Run .43  
Time (ms)

Total Estimated Run 530.604  
Time (ms)



## Derived Key Index

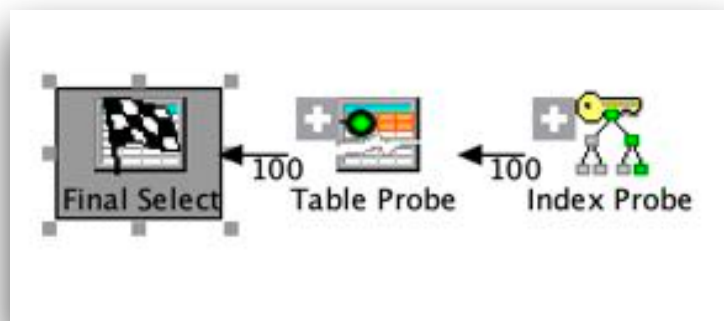
select \* from forindex where **lower(sometext)** like 'hit%';



Total Estimated Run Time (ms) 83.966

No Index Advised

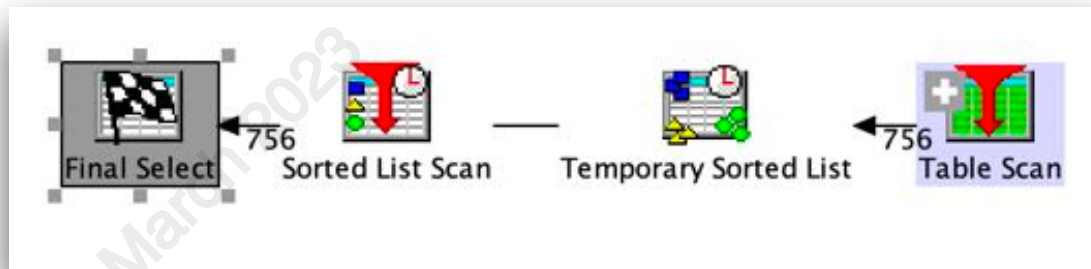
*create index forindex03 on forindex (lower(sometext));*



Total Estimated Run Time (ms) 1.287

## Sparse Index

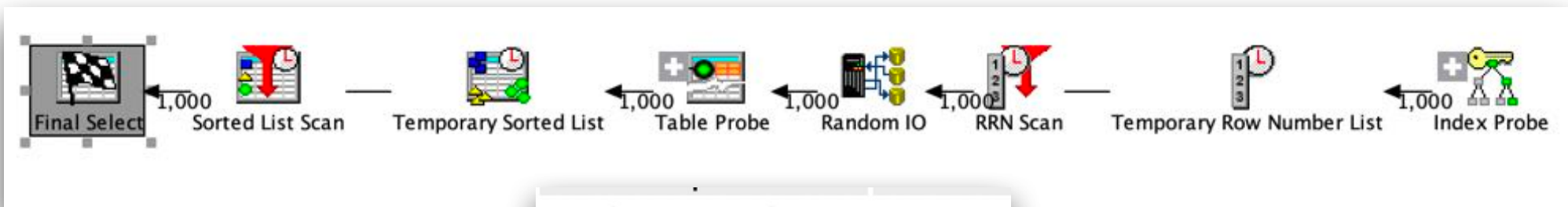
select keyid, sometext, somevalue from forindex  
where **somevalue** <= 10000 order by **keyid, somevalue**;



Total Estimated Run 86.307  
Time (ms)

### Indexes Advised

*create index forindex04 on forindex (somevalue);*  
*create index forindex05 on forindex (keyid, somevalue);*



Total Estimated Run 5.956  
Time (ms)

## Sparse Index

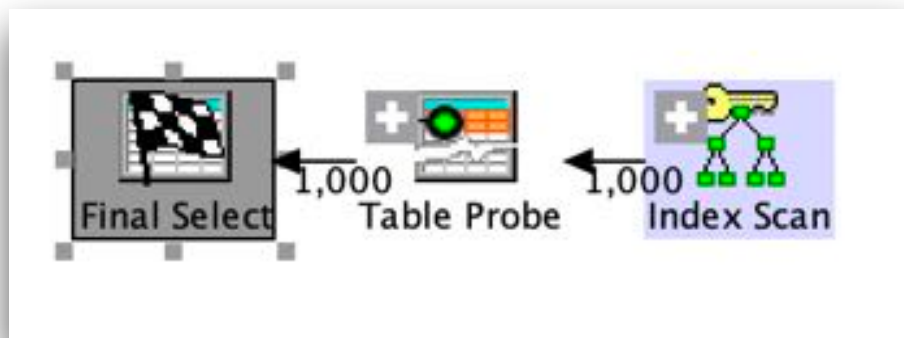
select keyid, sometext, somevalue from forindex  
where **somevalue** <= 10000 order by **keyid, somevalue**;

*drop index forindex04;*

*drop index forindex05;*

*create index forindex06 on forindex (**keyid, somevalue**)*

*where **somevalue** <= 10000;*



Total Estimated Run 1.291  
Time (ms)

Total Estimated Run 86.307  
Time (ms)

## EVI With Aggregate Info

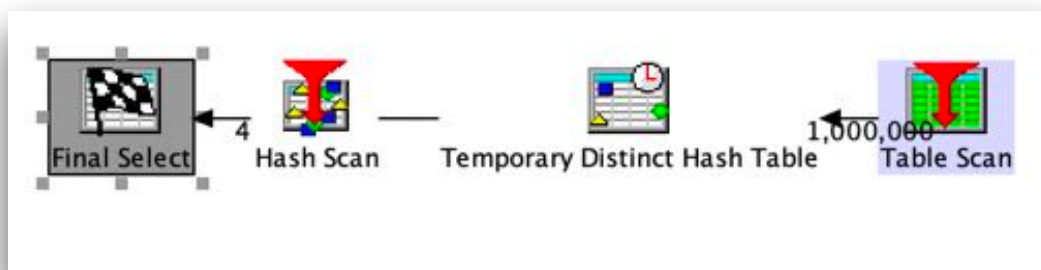
select somecode, **count(\*)**, **sum(somevalue)** from forindex  
group by **somecode**;



Total Estimated Run Time (ms)	394.32
-------------------------------	--------

Index Advised

*create index forindex07 on forindex (somecode);*



Total Estimated Run Time (ms)	394.32
-------------------------------	--------

## EVI With Aggregate Info

Indexes for SQLSPFTV2.FORINDEX - ideveloper(idevelop)

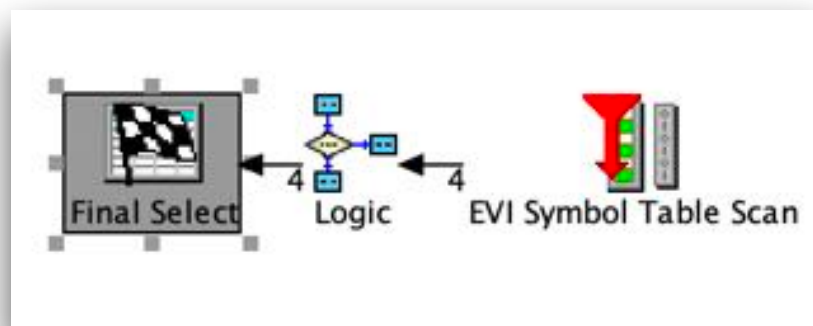
File Edit View Actions

Indexes for SQLSPFTV2.FORINDEX

Name	Type	Date Created	Last Build	Last Query Use	Last Query Statistics Use	Q C
FORINDEX07	Index	23/10/2022 11:06:14	23/10/2022 11:06:15		23/10/2022 11:06:38	
PK_FORINDEX	Primary Key Constraint	21/10/2022 15:12:17	21/10/2022 15:12:16		23/10/2022 10:56:36	

Done: 2 rows retrieved.

*create encoded vector index forindex08 on forindex  
(somecode) include (count(\*), sum(somevalue));*



Total Estimated Run .426  
Time (ms)

Total Estimated Run 394.32  
Time (ms)

## Last Bits

### Avoid the following in WHERE and/or ORDER BY clauses

- ▶ numeric conversions
- ▶ arithmetic expressions
- ▶ character string padding
- ▶ the use of LIKE patterns beginning with % or \_

### References

- ▶ IBM Db2 for i indexing methods and strategies
  - [https://www.ibm.com/support/pages/system/files/inline-files/Indexing%20and%20Statistics\\_1.pdf](https://www.ibm.com/support/pages/system/files/inline-files/Indexing%20and%20Statistics_1.pdf)
- ▶ Creating an index strategy
  - <https://www.ibm.com/docs/en/i/7.5?topic=optimization-creating-index-strategy>
- ▶ Db2 for i Services
  - <https://www.ibm.com/docs/en/i/7.5?topic=optimization-db2-i-services>



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