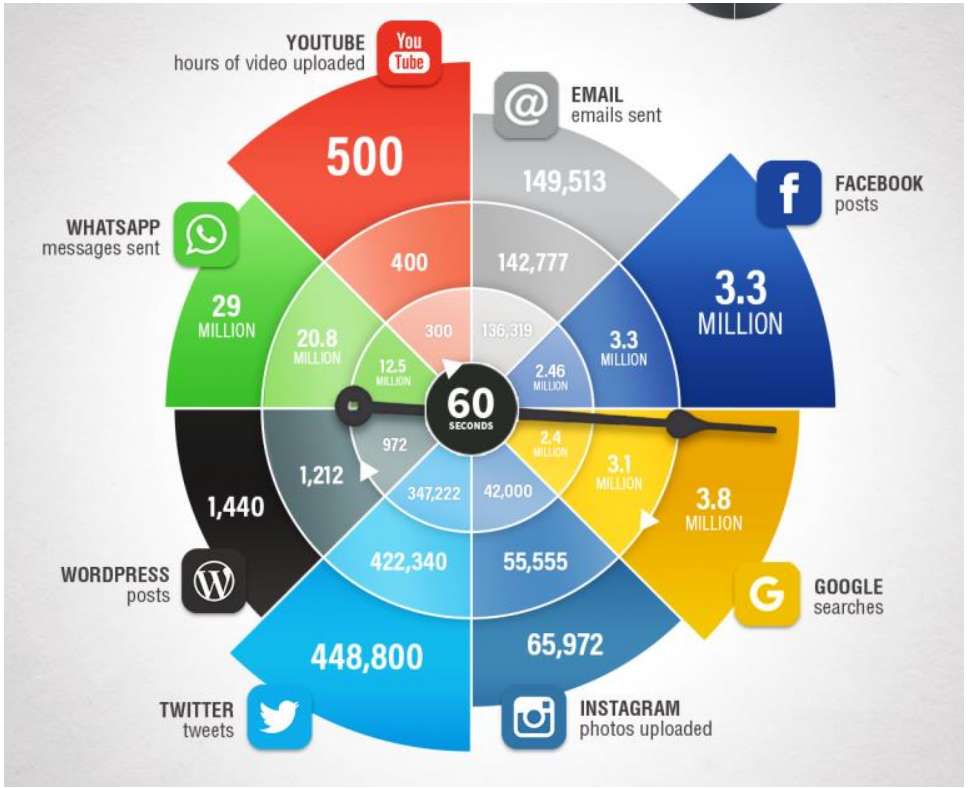
Real-time Analytics

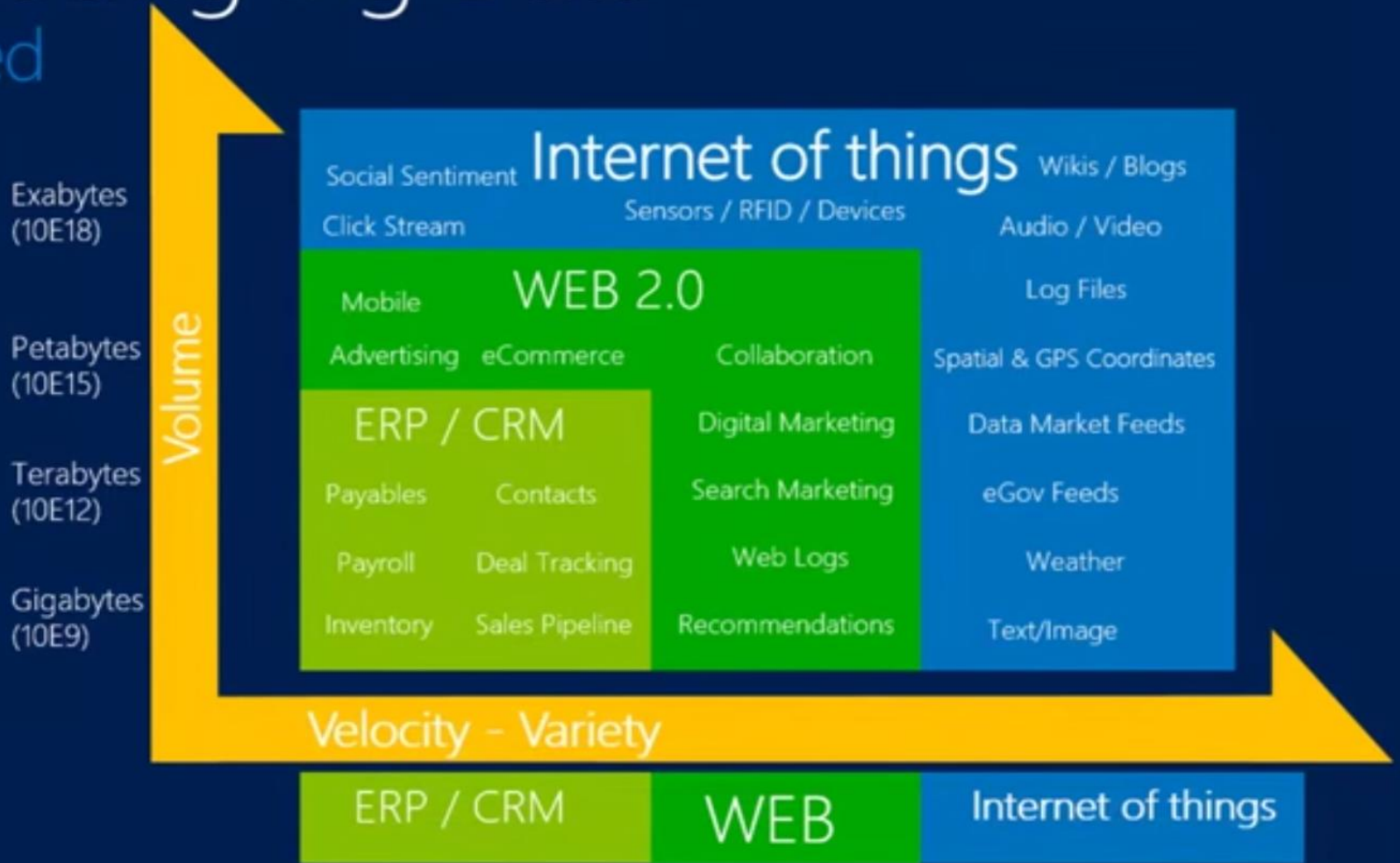
Data Science Dojo

What happens in 60 seconds?



Introducing Big Data

Continued



Defining Real-time

Within seconds…

or…

Within minutes…

of an event occurring

Up to 2 hours

Typical Event Processing

Applications

Cloud Gateways (WebAPIs)

Scalable Event Broker

Real-Time Analytics

External Data Sources

Web/Thick Client Dashboards

Devices

Field Gateways

Event Hub

Search And Query

Data Analytics

ETL Timespan

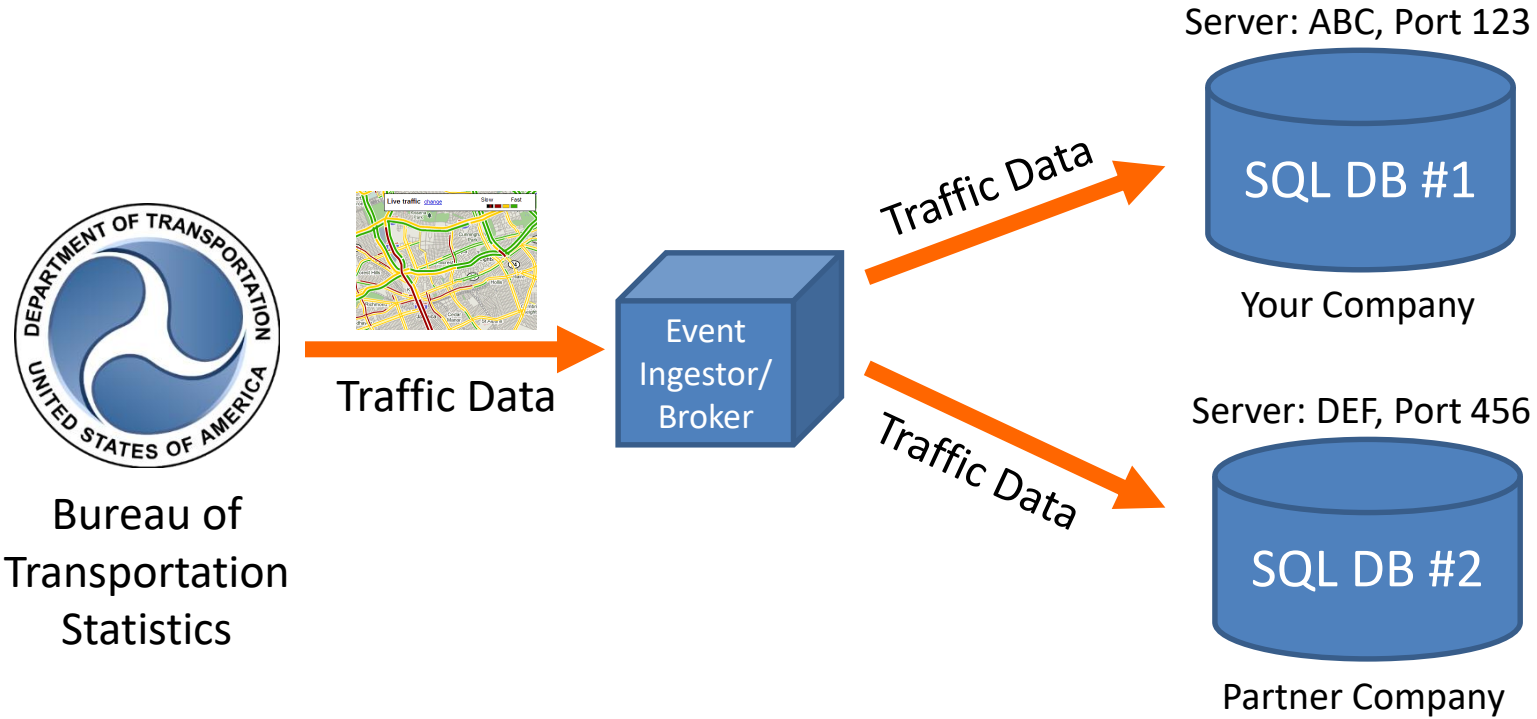
(Extract, Transform, Load)

Data Ingestion

The Post Office & Shipping Centers

- Tracks address changes
- Tries again tomorrow if send failed
- Holds packages in short term
  - Too many failed deliveries
  - Vacations
- Reduces complexity through specialization
- Optimized to send, receive, and temporarily house packages

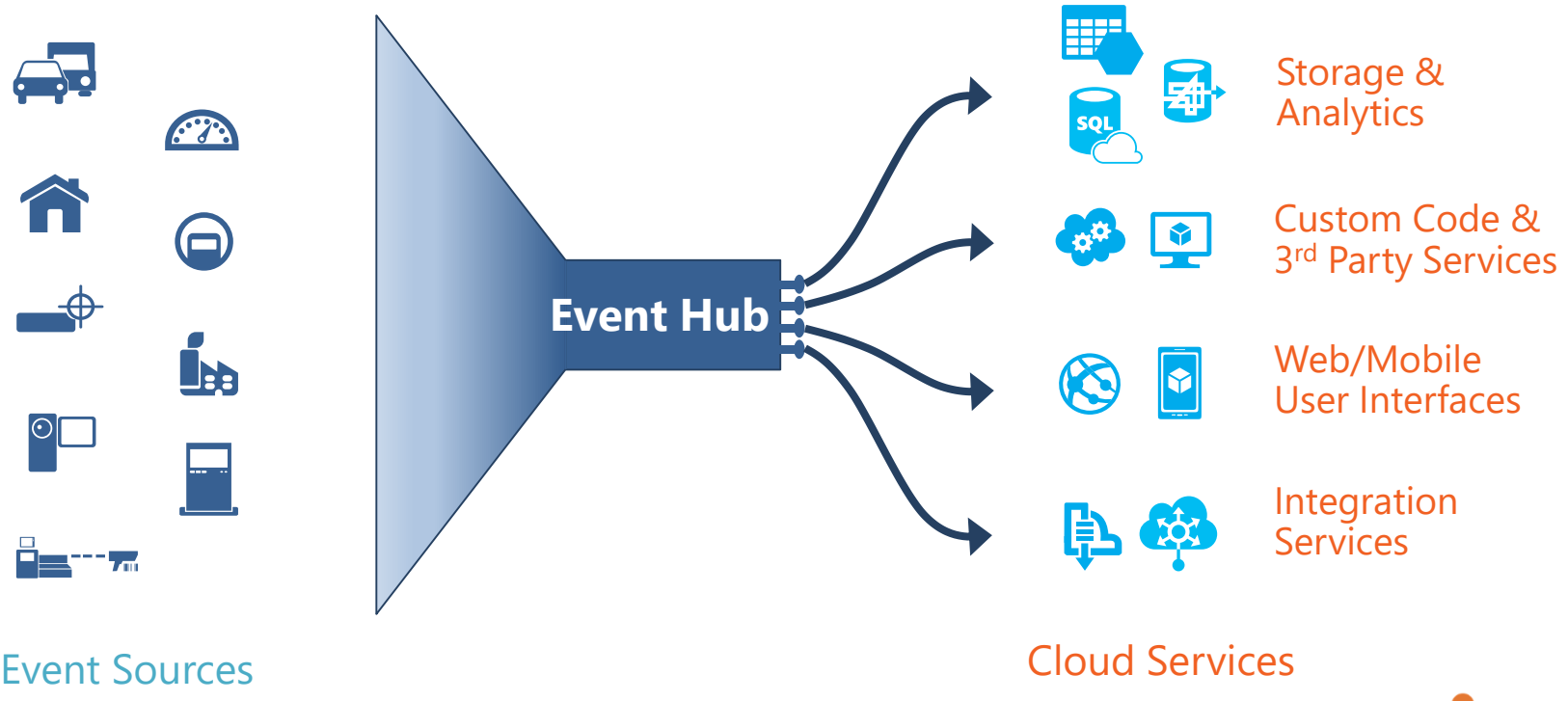
Preventative Solution: Middleware



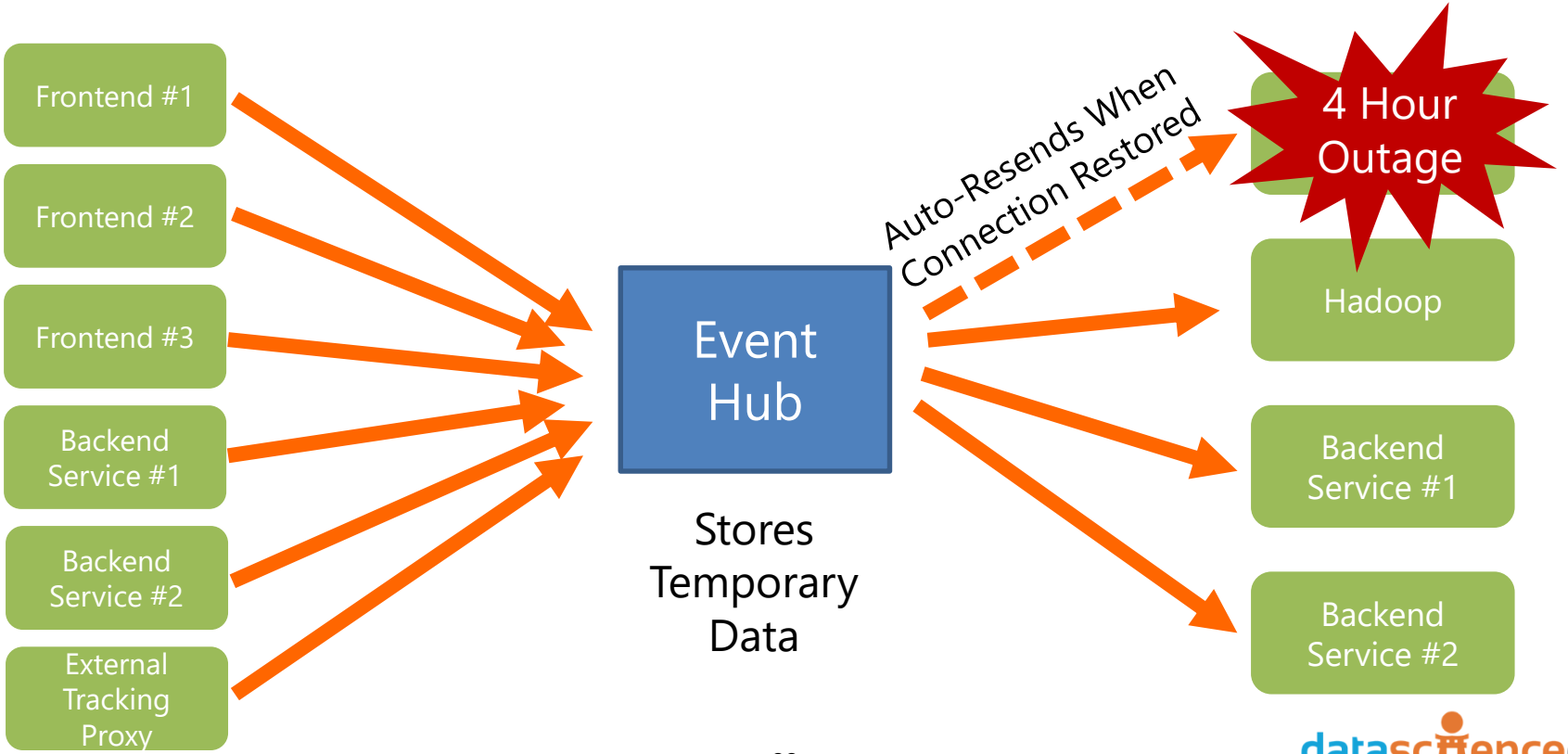
Popular Event Brokers

Azure Event Hubs

Event Hub for IoT: Big Data Ingestion

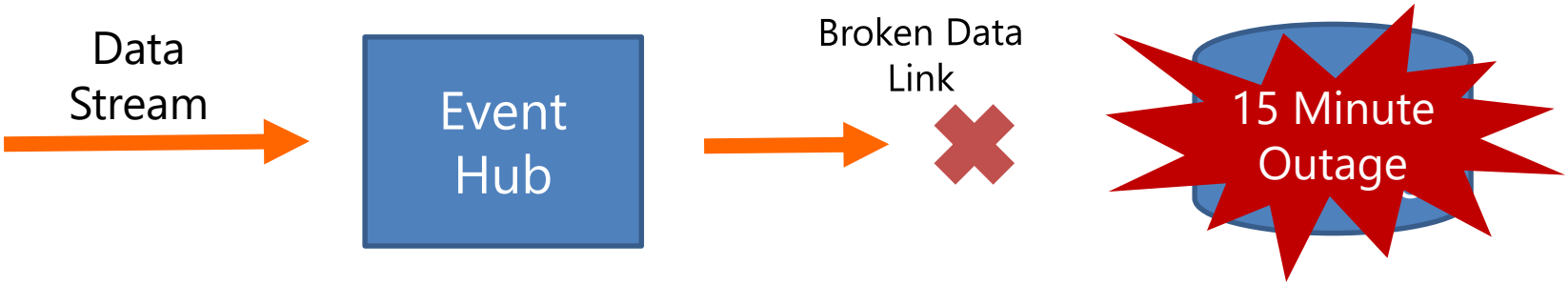


Temporary Storage

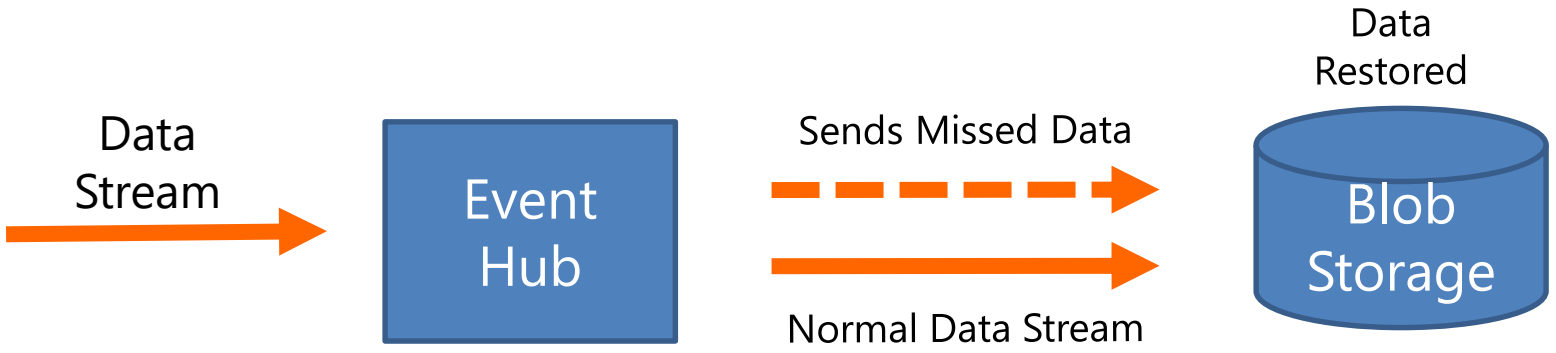


Demo: Normal Scenario

Demo: Output Downage



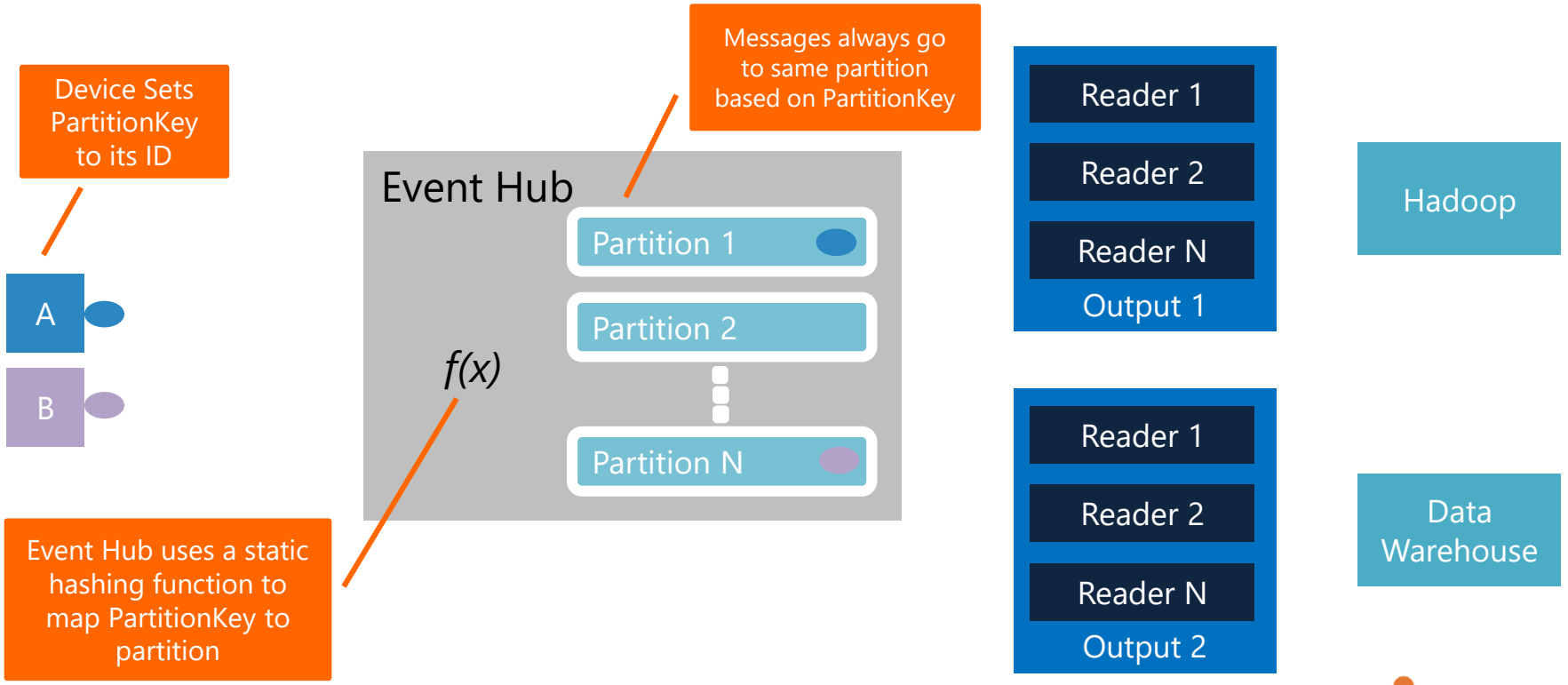
Demo: Output Restored



The Post Office

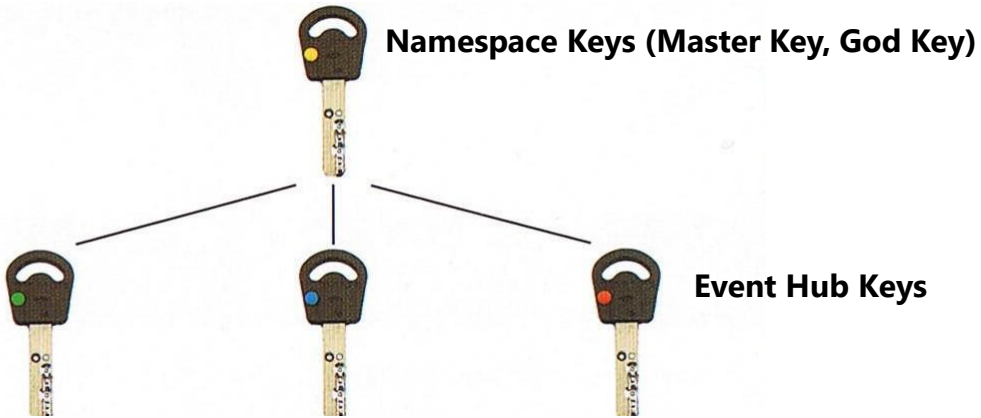
- Tracks address changes
- Tries again tomorrow if send failed
- Holds packages in short term
  - Too many failed deliveries
  - Vacations
- Reduces complexity through specialization

Event Hub, Stream Management

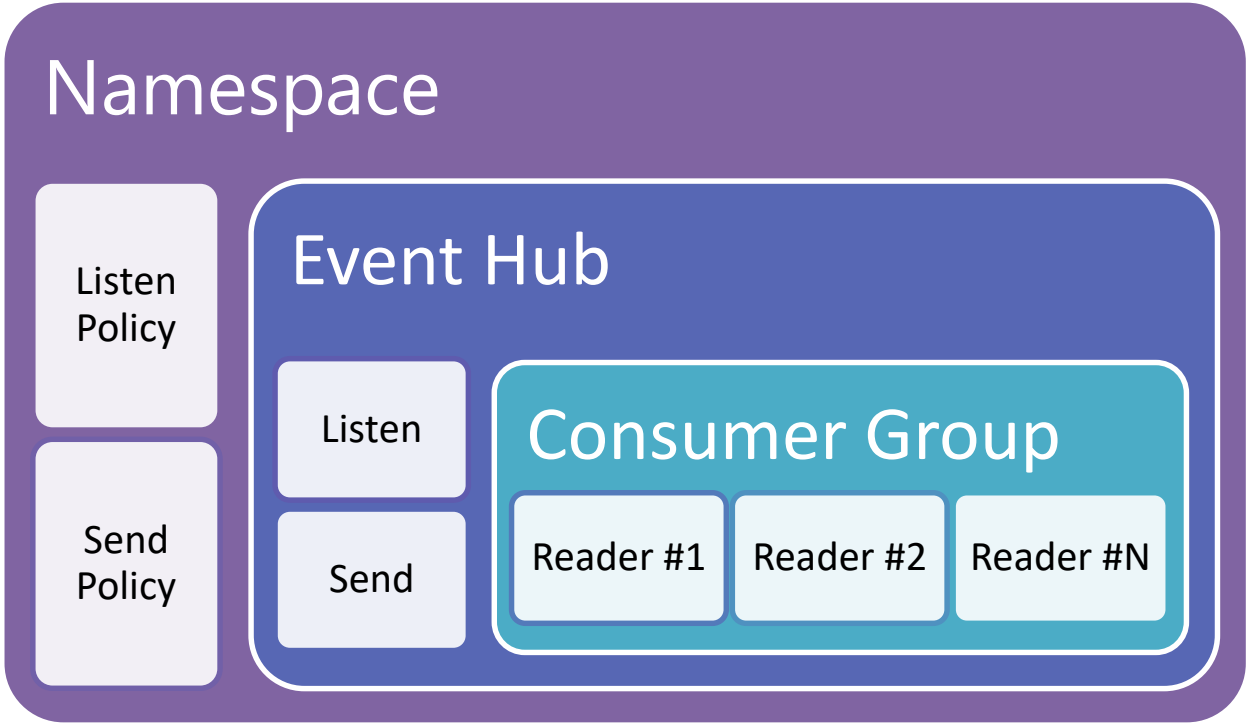


Service Bus Namespace

Access Rights, Policy, Keys



Access Rights



Access Rights

Hands-On Lab

Credit Card Transactions (swipes)

- Credit card transactions are usually done in batch as an end-of-the-day send.
- Stream process for insights now.
- US mainland transactions

Streaming to Event Hub

Swipes

data science dojo

Credit Card Reader (Synthetic)

Message Broker (DataScienceDojo's Webpage)

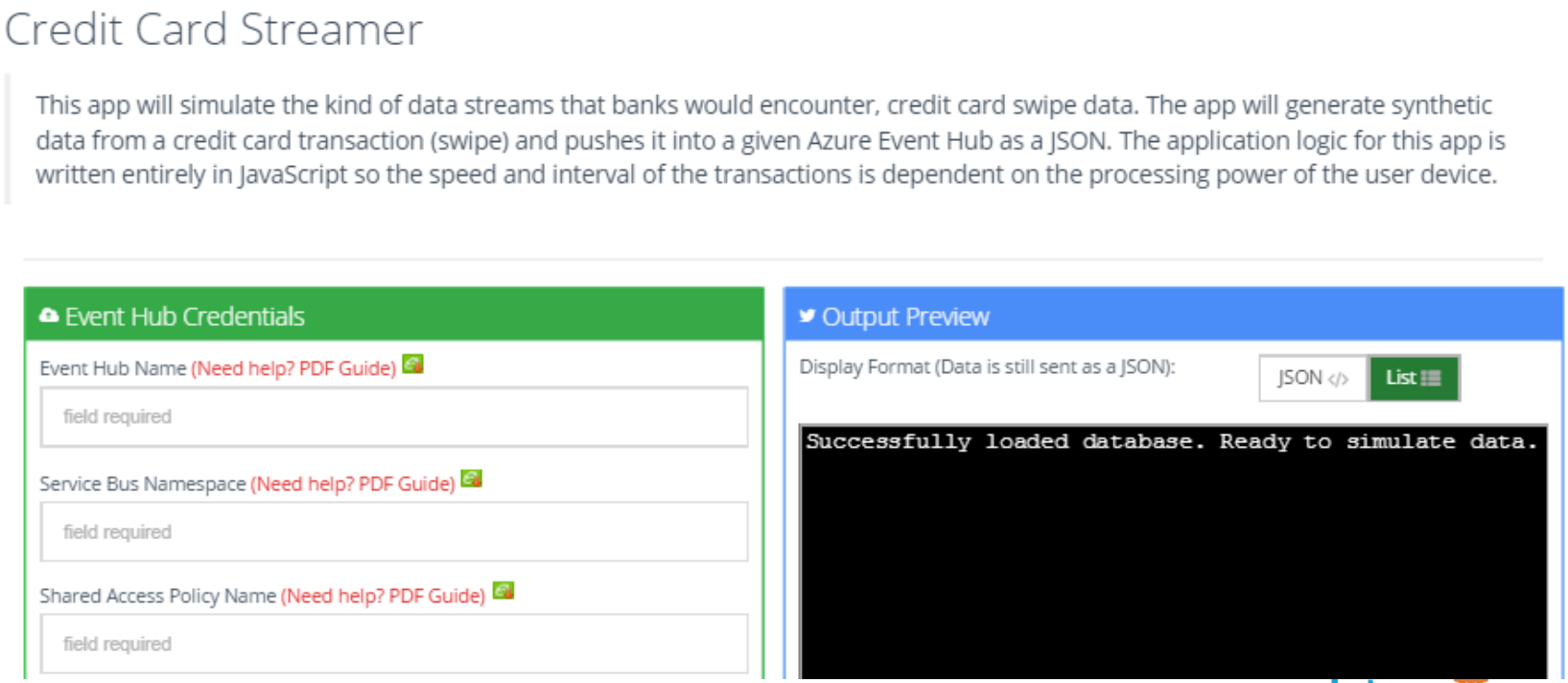
Data Ingestor (Azure Event Hub)

The Data


```
{
  "swipe_date":"2015-05-22T20:16:27.122Z",
  "transaction_id":3127484,
  "card_type":"VISA",
  "card_number":"4913419738164560",
  "expiration_month":"02",
  "expiration_year":"18",
  "cvv_code":"520",
  "user_id":"972288",
  "user_gender":"male",
  "user_first_name":“Alexander",
  "user_last_name":“Hamilton",
  "merchant":“McDonald’s",
  "transaction_amount":13.64,
  "balance":336.48,
  "merchant_fee":.5,
  "swipe_city":"New York",
  "swipe_state":"New York",
  "swip_city_state":"New York, NY",
  "InstanceNo":1
}
```

The Streamer

- http://demos.datasciencedojo.com/app/credit-card-streamer/



Inside the Event Hub

Swipes

data science dojo

Service Bus Namespace:
YourNameSpace

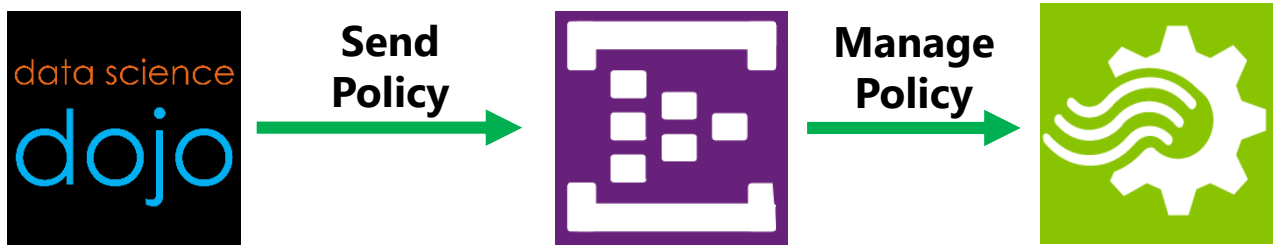
Event Hub 1:

- Credit Card Swipes

Credit Card Reader (Synthetic)

Message Broker (DataScienceDojo's Webpage)

Setting Policies



Message Broker (DataScienceDojo's Webpage)

Data Ingestor (Azure Event Hub)

Stream Processor (Azure Stream Analytics)

Stream Processing

Typical Event Processing


Applications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Scalable Event Broker


Real-Time Analytics


External Data Sources


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Field Gateways


Event Hub


Search And Query

ETL Timespan

(Extract, Transform, Load)


Data Analytics

Popular Up and Coming Event Processors

APACHE STORM™

Distributed • Resilient • Real-time

Google DataFlow

Azure Stream Analytics

Amazon Kinesis

datasciencedojo
data science for everyone

Demo

Credit Card Transactions (swipes)

- Credit card transactions are usually done in batch as an EOTD send.
- Stream process for insights now.
- US mainland transactions

Previously…

Swipes

data science dojo

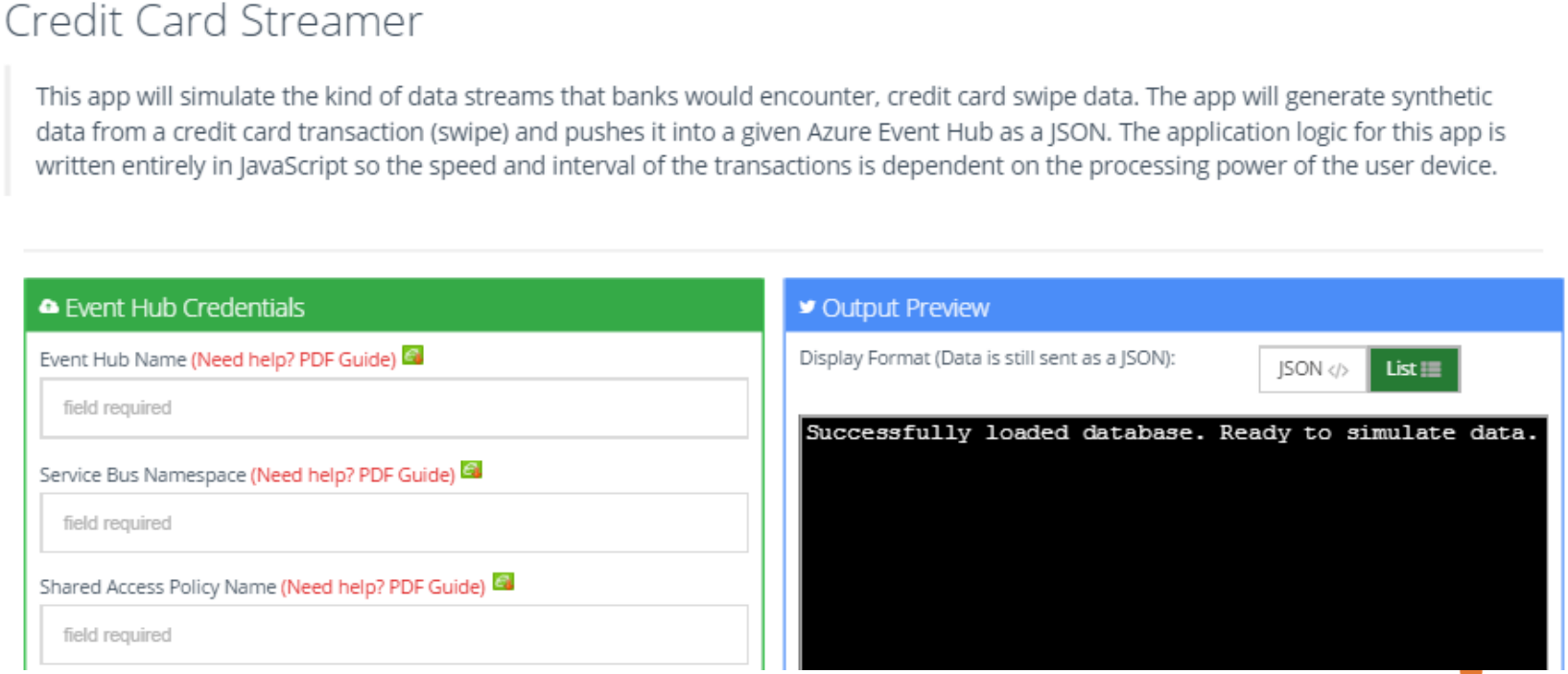
Credit Card Reader (Synthetic)

Message Broker (DataScienceDojo's Webpage)

Data Ingestor (Azure Event Hub)

The Streamer

- http://demos.datasciencedojo.com/app/credit-card-streamer/



The Data


```
{
  "swipe_date":"2015-05-22T20:16:27.122Z",
  "transaction_id":3127484,
  "card_type":"VISA",
  "card_number":"4913419738164560",
  "expiration_month":"02",
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  "user_id":"972288",
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  "user_first_name":“Alexander",
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  "merchant":“McDonald’s",
  "transaction_amount":13.64,
  "balance":336.48,
  "merchant_fee":.5,
  "swipe_city":"New York",
  "swipe_state":"New York",
  "swip_city_state":"New York, NY",
  "InstanceNo":1
}
```

Data vs Events

{
"swipe_date": 2015-05-22T20:16:27.122Z",
"transaction_id":3127484,
"card_type":"VISA",
"card_number":"4913419738164560",
"expiration_month":"02",
"expiration_year":"18",
"cvv_code":"520",
"user_id":"972288",
"user_gender":"male",
"user_first_name":"Alexander",
"user_last_name":"Hamilton",
"merchant":"McDonald's",
"transaction_amount":13.64,
"balance":336.48,
"merchant_fee":.5,
"swipe_city":"New York",
"swipe_state":"New York",
"swip_city_state":"New York, NY",

An event is just data with a timestamp

Inside the Event Hub

Swipes

data science dojo

Service Bus Namespace:
YourNameSpace

Event Hub 1:

- Credit Card Swipes

Credit Card Reader (Synthetic)

Message Broker (DataScienceDojo's Webpage)

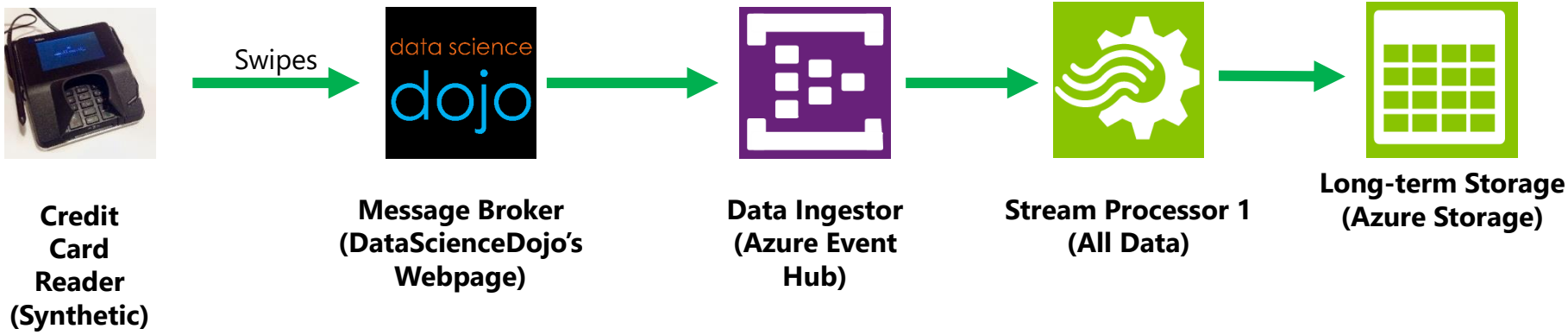
Setting Policies

Message Broker (DataScienceDojo's Webpage)

Data Ingestor (Azure Event Hub)

Stream Processor (Azure Stream Analytics)

With Stream Processor



More Processors

Credit Card Reader (Synthetic)

Swipes

Message Broker (DataScienceDojo's Webpage)

Data Ingestor (Azure Event Hub)

Stream Processor 1 (All Data)

Long-term Storage (Azure Storage)

Dashboard (PowerBI)

Stream Processor 2 (Filter/Aggregate)

Anomaly Detection Event Hub

SQL with Data at Rest

- **Question** "Show me VISA transactions from last month."
- **Answering with a relational database** No problem! Here you go!
- **SELECT** *
  FROM credit_db
  WHERE card_type **like** 'VISA'

SQL Data in Motion

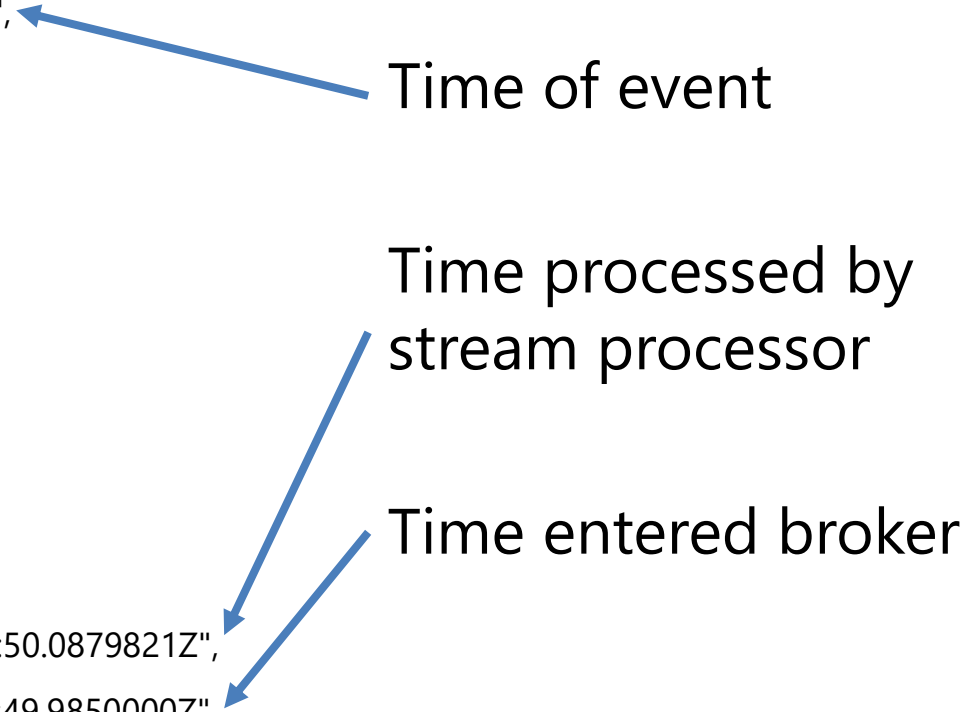
- **Different Question** "Show me VISA transactions in the past 2 minutes."
- **Answering with a relational database**
  I'm not ready yet… Ask again later…. Or tomorrow (after batch)…
- **Not a great solution…**

Temporal System

- Every event is a point in time, and thus must come with a timestamp
  - Remember how relational DBs need a PK? Temporal systems need a timestamp as its unique identifier.
  - Temporal integrity and referential integrity
- Stream Analytics can append your events with a timestamp (bad practice if standalone)
  - The default timestamp will be when the event enters Stream Analytics
  - Can be skewed by network and hardware latency, or legacy processing
- Users can define application time stamps with the TIMESTAMP BY clause

Which Timestamp?


```
{
  "swipe_date":"2015-05-21T22:47:55.0770000Z",
  "transaction_id":222301082,
  "card_type":"VISA",
  "card_number":"40265691066025560",
  "expiration_month":"06",
  "expiration_year":"22",
  "cvv_code":"3310",
  "user_id":"690548",
  "user_gender":"male",
  "user_first_name":"Caden",
  "user_last_name":"Hatton",
  "merchant":"Macy's",
  "transaction_amount":4.98,
  "balance":7223.9,
  "merchant_fee":0.5,
  "swipe_city":"New York",
  "swipe_state":"New York",
  "swip_city_state":"New York, NY",
  "InstanceNo":1,
  "EventProcessedUtcTime":"2015-05-21T22:47:50.0879821Z",
  "PartitionId":3,
  "EventEnqueuedUtcTime":"2015-05-21T22:47:49.9850000Z"
}
```

Same Event…


```
{
    "swipe_date":"2015-05-21T22:47:55.0770000Z",
    "EventProcessedUtcTime":"2015-05-21T22:47:50.0879821Z",
    "EventEnqueuedUtcTime":"2015-05-21T22:47:49.9850000Z"
}
```


According to these timestamps, the event happened 5 seconds AFTER the event was processed and queued.

- How can that be?
- The event was not confined to the physical laws of space and time.

The clock on your device matters.

Azure Stream Query Language

- Show me transactions as they happen. Write it to a blob AND powerBI.

```
SELECT *
INTO MyBlob
FROM SwipeStream TIMESTAMP BY swipe_date;
SELECT *
INTO PowerBI
FROM SwipeStream TIMESTAMP BY swipe_date;
```

StreamQL: Calculations

- What was our commission on each transaction?

```
SELECT
   transaction_id,
   merchant_fee / transaction_amount AS Commision
FROM SwipeStream
   TIMESTAMP BY swipe_date
```

StreamQL: Filter Queries

- Show me only VISA transactions that made over $5 revenue.

```
SELECT
        swipe_date,
        card_type,
        merchant_fee AS revenue
FROM SwipeStream
        TIMESTAMP BY swipe_date
WHERE card_type LIKE 'VISA'
AND merchant_fee < 5
```

SWIPE_DATE	CARD_TYPE	REVENUE
2015-05-21T2...	VISA	6.2
2015-05-21T2...	VISA	10.31
2015-05-21T2...	VISA	11.72
2015-05-21T2...	VISA	7.82
2015-05-21T2...	VISA	9.91
2015-05-21T2...	VISA	7.62
2015-05-21T2...	VISA	5.25

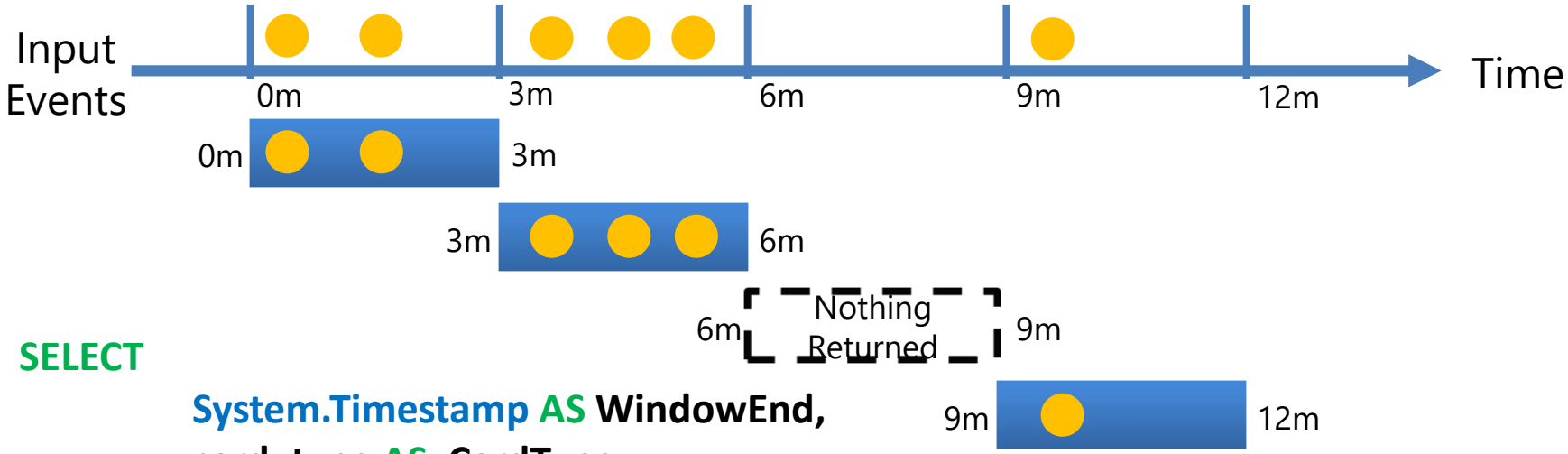
Temporal Questions

Count the number of transactions….

- When should the counting of transactions begin?
- When should the counting of transactions end?
- How long should the transactions be counted for?
- How often do transactions need to be counted?

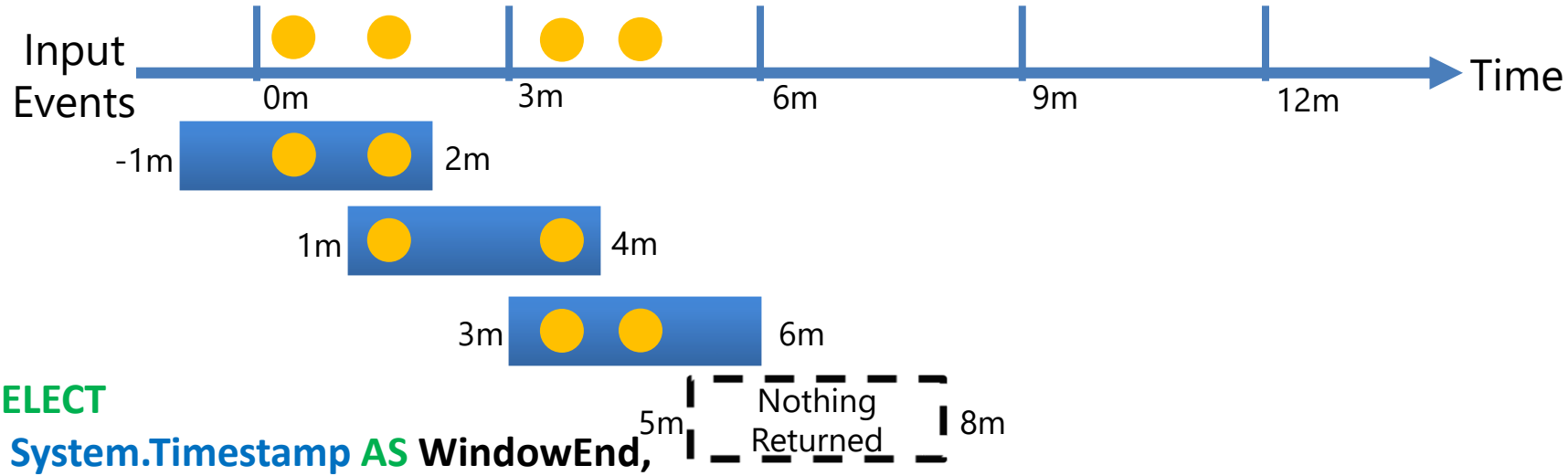
Tumbling Window

How many transactions were made for each card type every 3 minute?



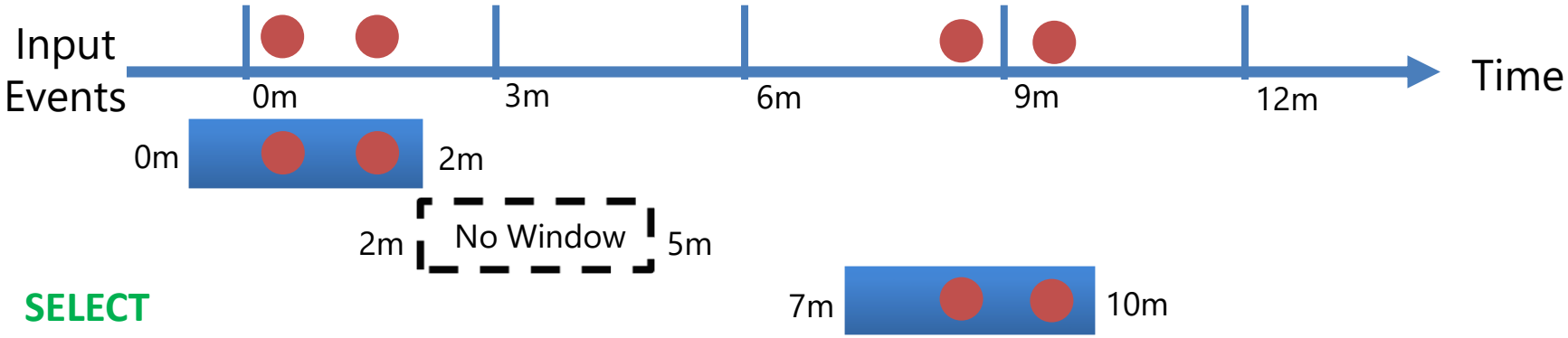

```
SELECT
        System.Timestamp AS WindowEnd,
        card_type AS  CardType,
        Count(*) AS Frequency
FROM SwipeStream TIMESTAMP BY swipe_date
GROUP BY TUMBLINGWINDOW(minute, 3), card_type
```

Hopping Window



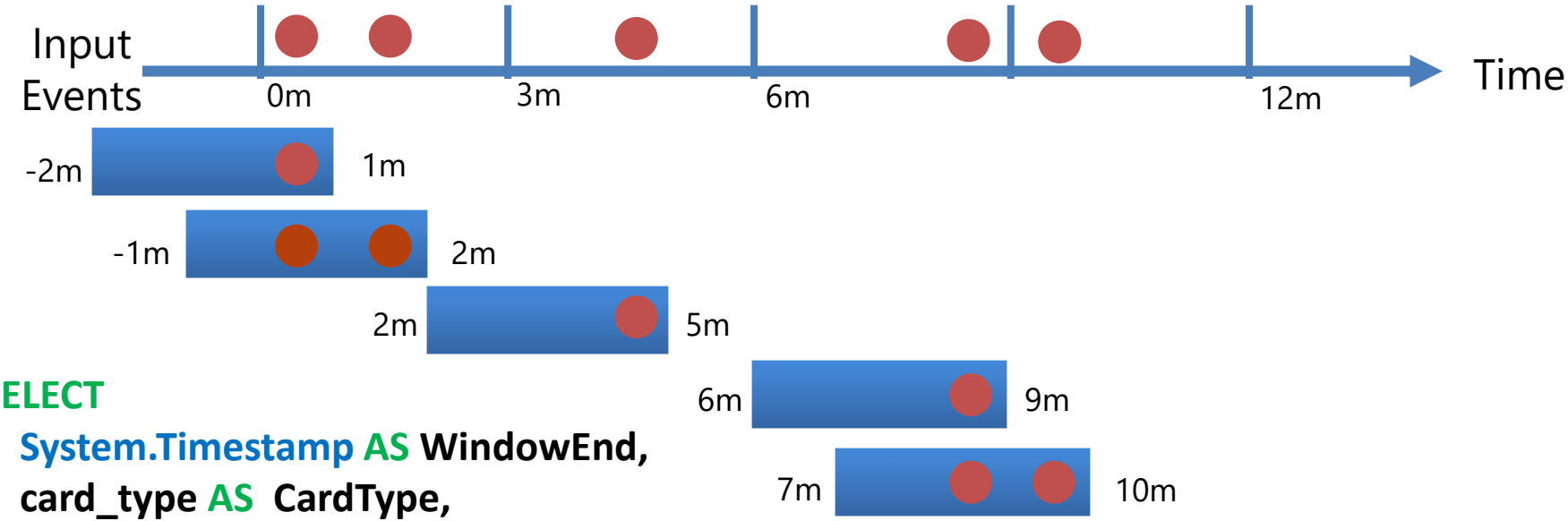

```
SELECT
   System.Timestamp AS WindowEnd,
   card_type AS  CardType,
   Count(*) AS Frequency
FROM SwipeStream TIMESTAMP BY swipe_date
GROUP BY HoppingWindow(minute, 3, 2), card_type
```

Sliding Window




```
SELECT
        System.Timestamp AS WindowEnd,
        card_type AS  CardType,
        Count(*) AS Frequency
FROM SwipeStream TIMESTAMP BY swipe_date
GROUP BY SlidingWindow(minute, 3), card_type
HAVING Frequency > 2
```

Sliding Window: Without 'Having' Clause




```
SELECT
    System.Timestamp AS WindowEnd,
    card_type AS  CardType,
    Count(*) AS Frequency
FROM SwipeStream TIMESTAMP BY swipe_date
GROUP BY SlidingWindow(minute, 3), card_type
```

Sum Aggregation

- How much revenue is being accumulated from merchants every 3 minutes?

```
SELECT
   System.Timestamp AS WindowEnd,
   Sum(merchant_fee) AS IntervalRevenue
FROM SwipeStream TIMESTAMP BY swipe_date
GROUP BY TUMBLINGWINDOW(minute, 3), WindowEnd
```

Sum Aggregation: With Filtering

- Which 3-minute time interval made more than $10?

```
SELECT
    System.Timestamp AS WindowEnd,
    Sum(merchant_fee) AS IntervalRevenue
FROM SwipeStream TIMESTAMP BY swipe_date
GROUP BY TUMBLINGWINDOW(minute, 3), WindowEnd
Having IntervalRevenue > 10
```

Descriptive Statistics

- Generate descriptive statistics for revenue every 3 minutes (car count, min, max, average, standard deviation, and total revenue).

```
SELECT
        System.Timestamp AS WindowEnd,
        count(merchant_fee) AS CarCount,
        min(merchant_fee) AS MinRev,
        max(merchant_fee) AS MaxRev,
        avg(merchant_fee) AS AvgRev,
        stdev(merchant_fee) AS VarRev,
        sum(merchant_fee) AS TotalRev
FROM SwipeStream TIMESTAMP BY swipe_date
GROUP BY TUMBLINGWINDOW(minute, 3)
```

DateDiff and Time

- What is the duration between the first transaction in the window and the last transaction in the window? What was the duration between the first transaction in the window and the end of the window?

```
SELECT
   System.Timestamp AS WindowEnd,
   count(*) AS Frequency,
   datediff(second, min(swipe_date), max(swipe_date)) AS FirstLastDuration,
   datediff(second, min(swipe_date), System.Timestamp) AS FirstEndDuration
FROM SwipeStreamTIMESTAMP BY swipe_date
GROUP BY TUMBLINGWINDOW(minute, 3)
```

Joining Stream with Reference Data

- Say we had a list of stolen credit card numbers. Let's run each transaction against this list and get the locations.

```
SELECT
        SwipeStream.swipe_date as SwipeTime,
        SwipeStream.card_number as CardNumber,
        SwipeStream.merchant as Store,
        SwipeStream.swipe_city_state as Location,
        StoleList.Stolen as Stolen
FROM SwipeStream TIMESTAMP BY swipe_date
JOIN StolenList
ON SwipeStream.card_number = StolenList.card_number
WHERE StolenList.Stolen = '1'
```

Joining Streams, Temporally

- How long did it take for each transaction to get approval from the bank?
  - Joining on events through time
  - JOIN operator requires specifying a temporal wiggle room describing an acceptable time difference between the joined events
  - If two transactions occurred within the same join interval, then consider them the same event.

Joining Streams

- How long did it take for each transaction to get approval from the bank?

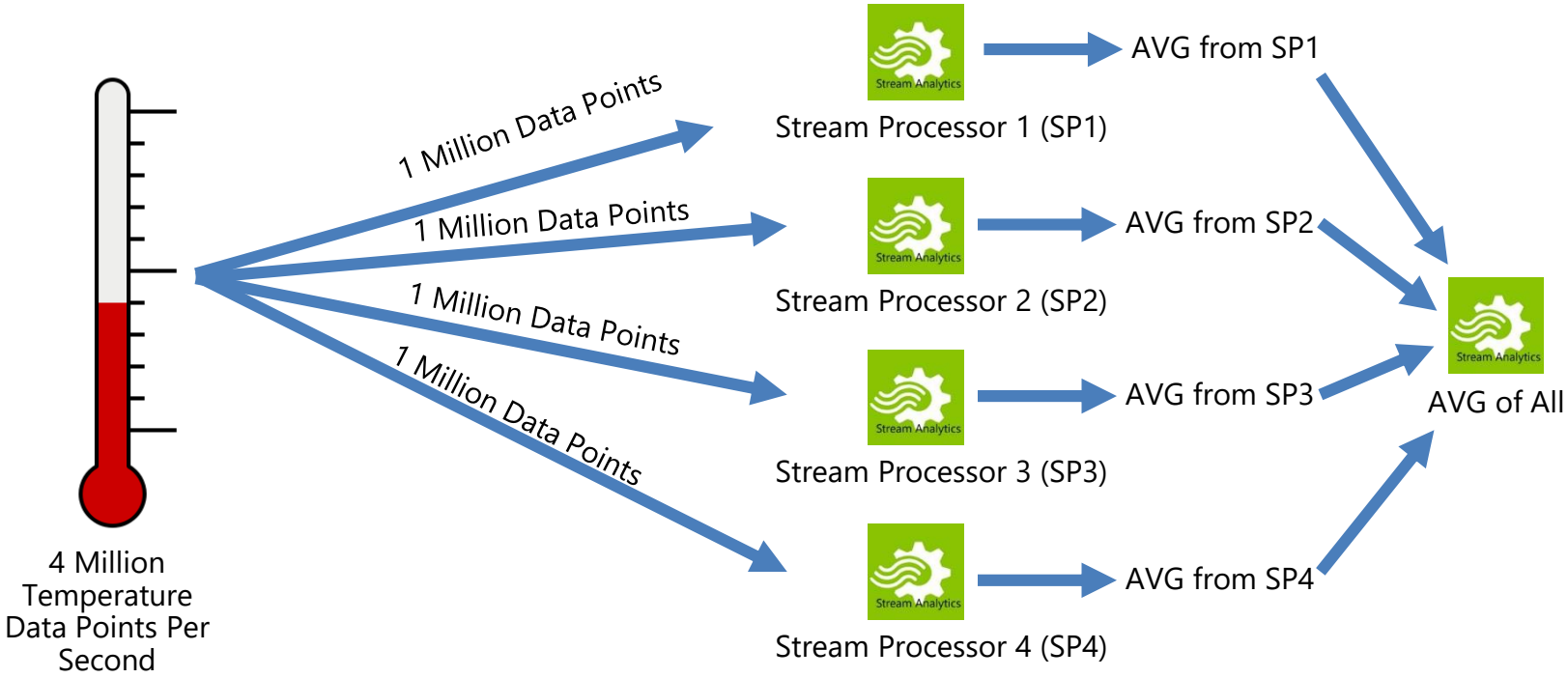
```
SELECT
    swipe.transaction_id
    swipe.swipe_date,
    bank.approval_time,
    DATEDIFF ( second, swipe.swipe_date, bank. approval_time) AS DurationInSeconds
FROM SwipeStream AS swipe TIMESTAMP BY swipe_date
JOIN BankStream AS bank TIMESTAMP BY approval_time
ON (swipe.transaction_id = bank.transaction_id)
    AND DATEDIFF ( minute, swipe, bank ) BETWEEN 0 AND 15
```

Joining Streams, by Window

- What was the average time that it took for transactions to get approved every 3 minutes?

```
SELECT
   System.Timestamp AS WindowEnd,
   avg( DATEDIFF ( second, swipe.swipe_date, bank.approval_time )) AS ApprovalTime
FROM SwipeStream AS swipe TIMESTAMP BY swipe_date
JOIN BankStream AS bank TIMESTAMP BY approval_time
ON (swipe.transaction_id = bank.transaction_id)
   AND DATEDIFF ( minute, swipe, bank ) BETWEEN 0 AND 15
Group by TumblingWindow( minute, 3)
```

Average of Average Approximations



Built-In Functions And Supported Types

Aggregate functions

Count, Min, Max, Avg, Sum

Scalar functions

Cast

Date and time

Datename, Datepart, Day, Month, Year, Datediff, Dateadd

String

Len, Concat, Charindex, Substring, Patindex

QUESTIONS