Analytics on Streaming Data with Azure Stream Analytics

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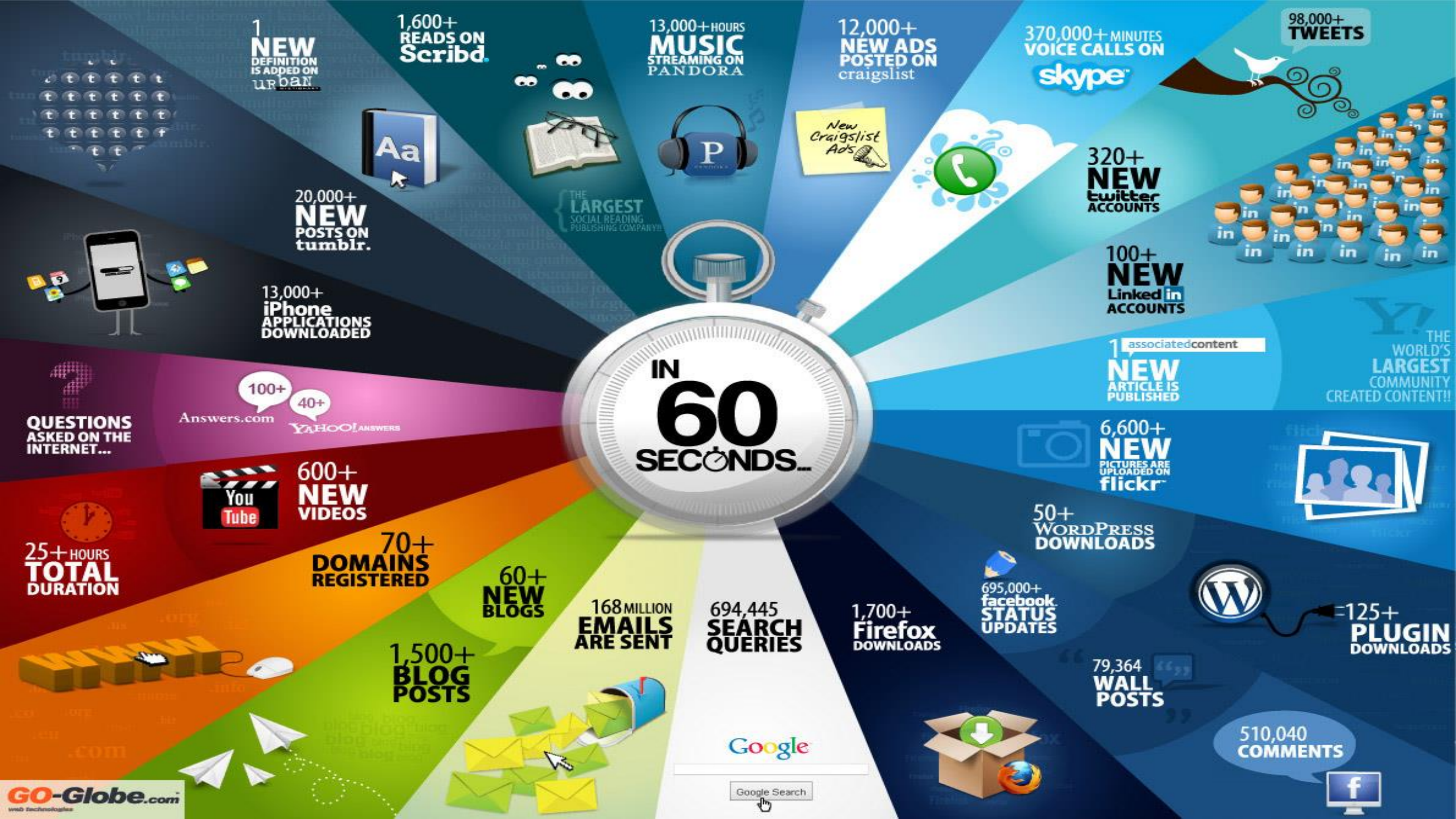


IN 60 SECONDS...

1 NEW DEFINITION IS ADDED ON urban DICTIONARY

1,600+ READS ON Scribd. THE LARGEST SOCIAL READING PUBLISHING COMPANY!!

13,000+ HOURS MUSIC STREAMING ON PANDORA

12,000+ NEW ADS POSTED ON craigslist

370,000+ MINUTES VOICE CALLS ON skype

98,000+ TWEETS

320+ NEW twitter ACCOUNTS

100+ NEW Linked in ACCOUNTS

1 NEW ARTICLE IS PUBLISHED associatedcontent

Y! THE WORLD'S LARGEST COMMUNITY CREATED CONTENT!!

6,600+ NEW PICTURES ARE UPLOADED ON flickr

50+ WORDPRESS DOWNLOADS

=125+ PLUGIN DOWNLOADS

695,000+ facebook STATUS UPDATES

79,364 WALL POSTS

510,040 COMMENTS

1,700+ Firefox DOWNLOADS

694,445 SEARCH QUERIES

168 MILLION EMAILS ARE SENT

60+ NEW BLOGS

1,500+ BLOG POSTS

70+ DOMAINS REGISTERED

600+ NEW VIDEOS

25+ HOURS TOTAL DURATION

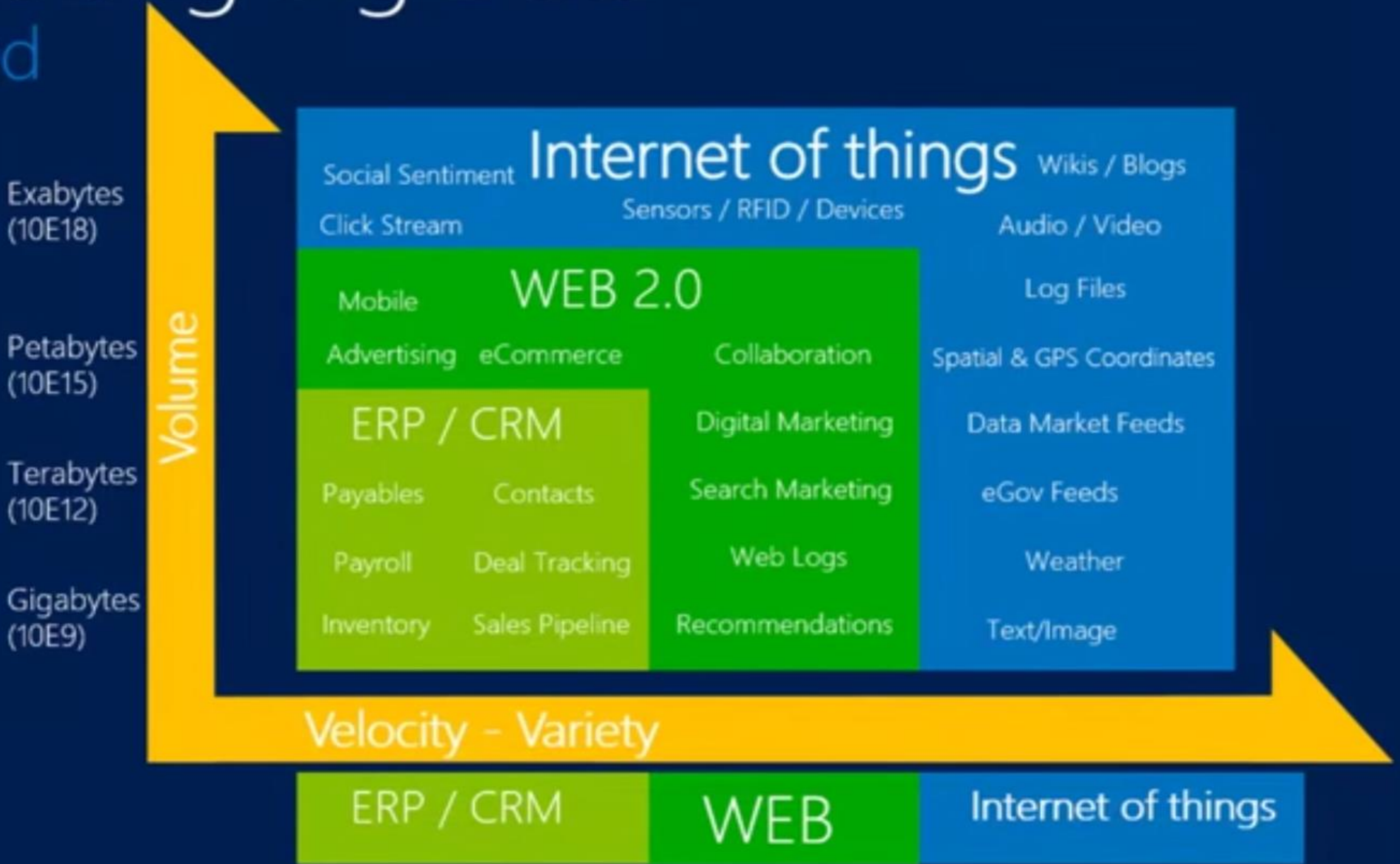
QUESTIONS ASKED ON THE INTERNET... 100+ Answers.com 40+ YAHOO! ANSWERS

13,000+ iPhone APPLICATIONS DOWNLOADED

20,000+ NEW POSTS ON tumblr.

Introducing Big Data

Continued



Exabytes (10E18)

Petabytes (10E15)

Terabytes (10E12)

Gigabytes (10E9)

Volume

Internet of things

Social Sentiment

Wikis / Blogs

Click Stream

Sensors / RFID / Devices

Audio / Video

Log Files

Spatial & GPS Coordinates

Data Market Feeds

eGov Feeds

Weather

Text/Image

WEB 2.0

Mobile

Advertising

eCommerce

Collaboration

Digital Marketing

Search Marketing

Web Logs

Recommendations

ERP / CRM

Payables

Contacts

Payroll

Deal Tracking

Inventory

Sales Pipeline

Velocity - Variety

ERP / CRM

WEB

Internet of things

Defining Real-time

Within seconds…

or…

Within minutes…

of an event occurring.

Up to 2 hours.

Timeliness of Information

What was trending in the past 5 minutes?

Your high school friend is also in Vegas RIGHT NOW.

A tornado will form in the next 30 minutes.

Timeliness of Information

A stock is going to crash in 20 minutes.

A fire is about to start in your house.

The power grid will overload in 2 minutes.

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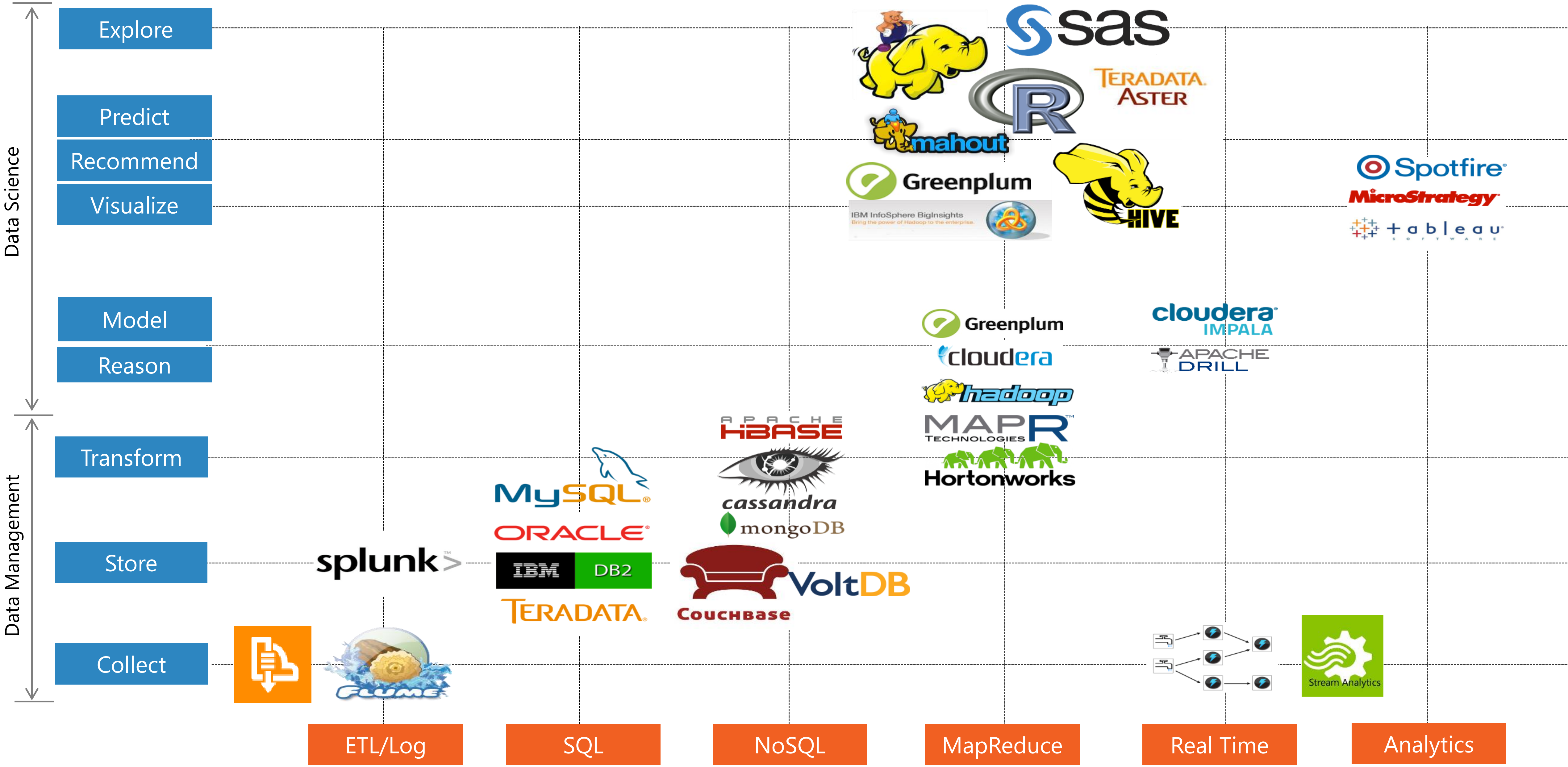


Data Science

Explore

Predict

Recommend

Visualize

Model

Reason

Data Management

Transform

Store

Collect

ETL/Log

SQL

NoSQL

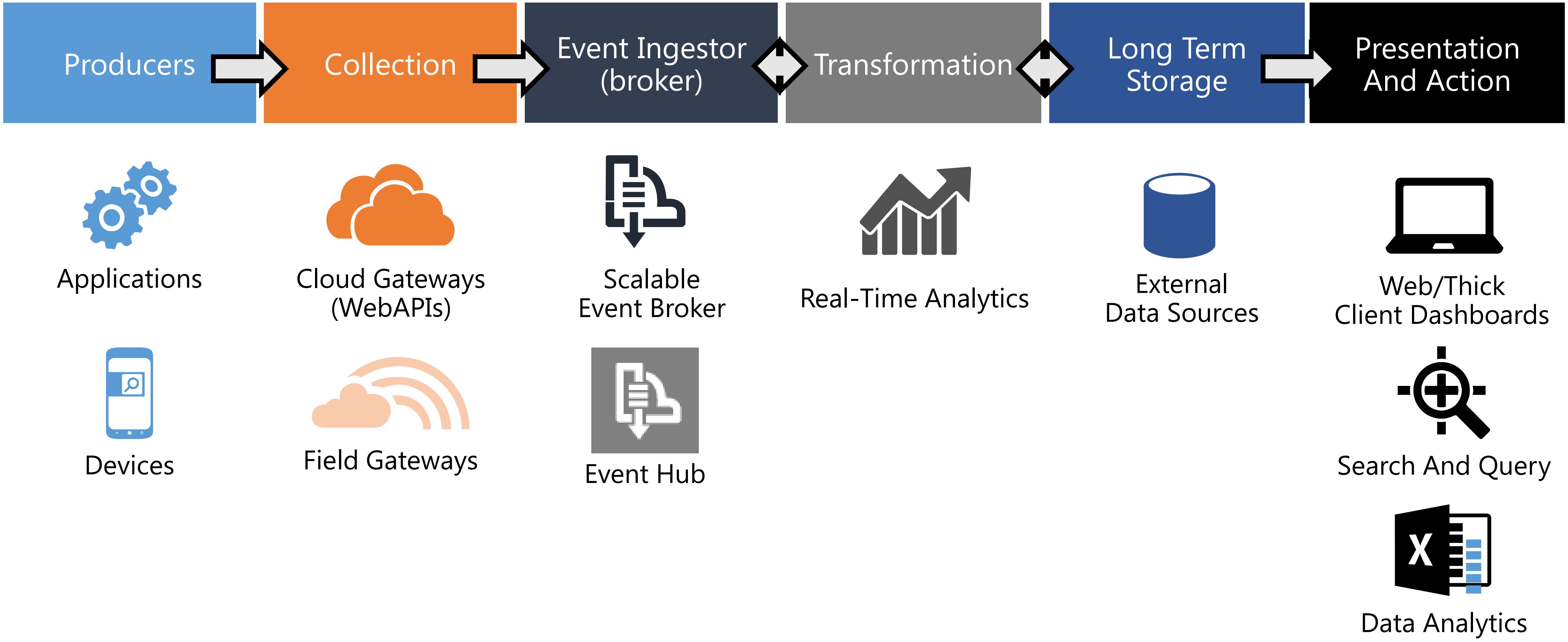
MapReduce

Real Time

Analytics

Big Data – Technology, Platforms & Products

Typical Event Processing



Producers

Collection

Event Ingestor (broker)

Transformation

Long Term Storage

Presentation And Action

Applications

Devices

Cloud Gateways (WebAPIs)

Field Gateways

Scalable Event Broker

Event Hub

Real-Time Analytics

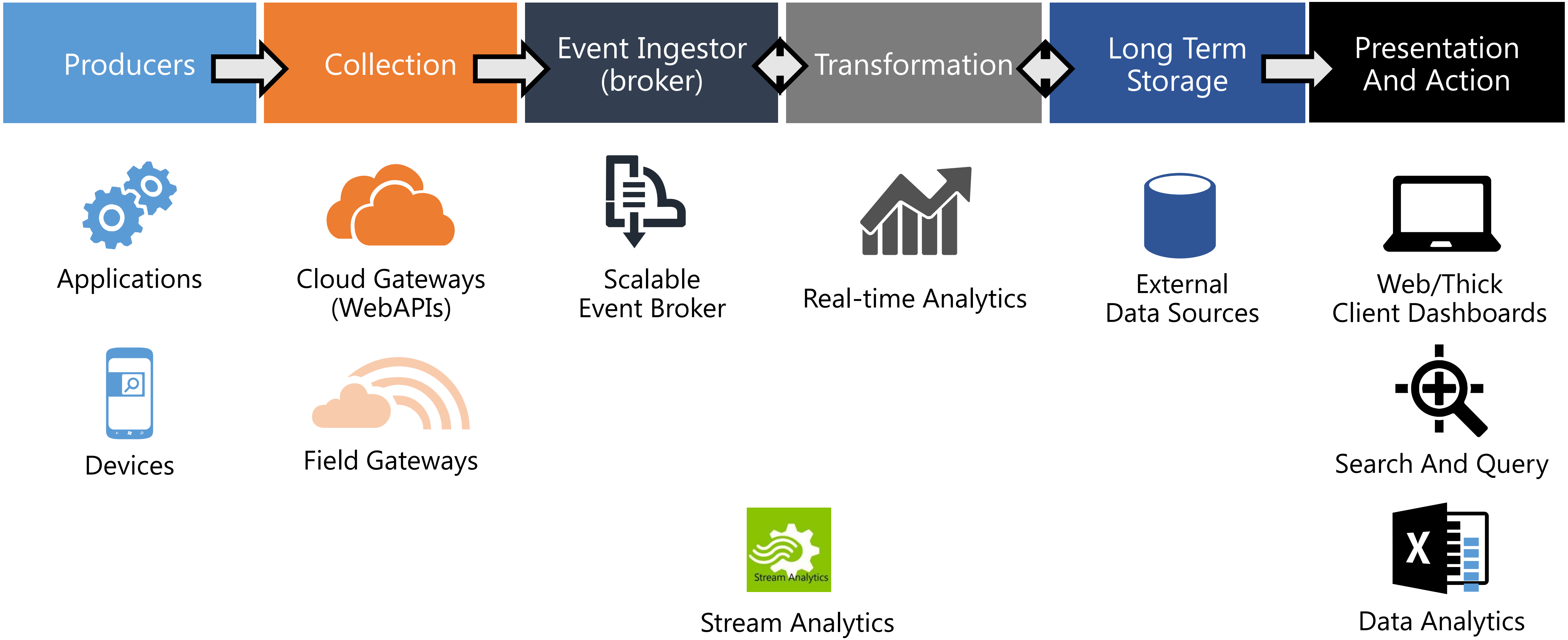
External Data Sources

Web/Thick Client Dashboards

Search And Query

Data Analytics

Typical Event Processing



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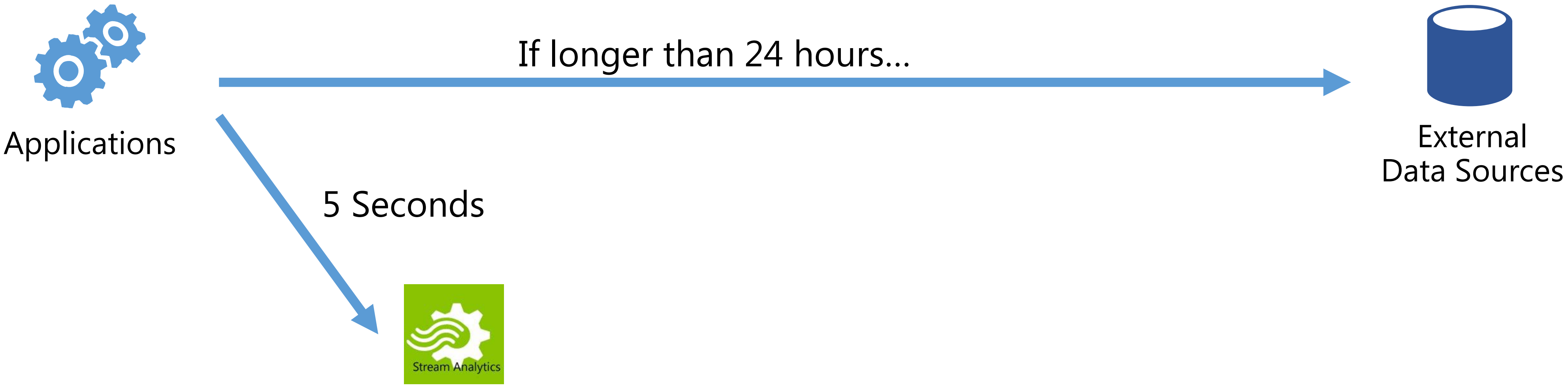
ETL Time Frame



Applications

If longer than 24 hours…

External
Data Sources

5 Seconds

Popular Up and Coming Event Processors

Azure Stream Analytics

Amazon Kinesis

Demo

Tolls on I-405

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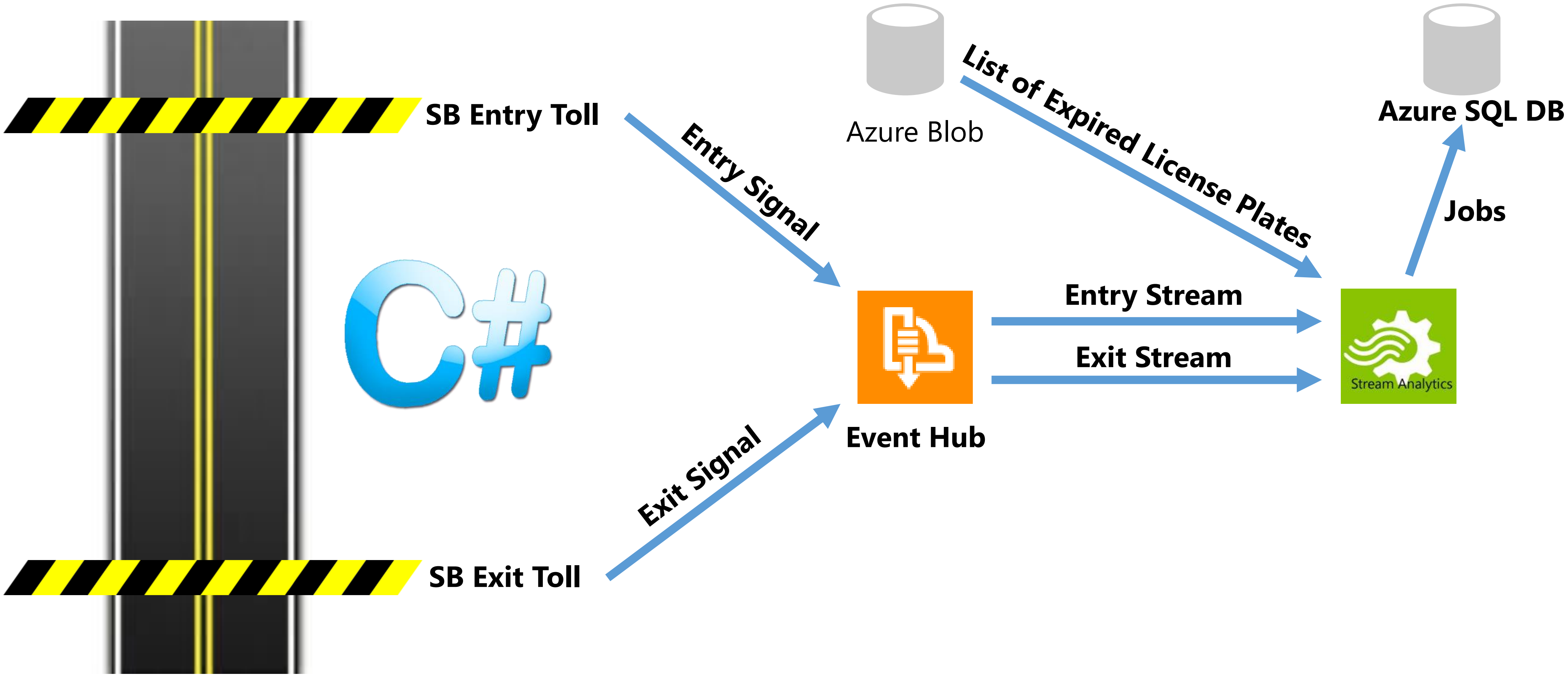
Automated Tolls



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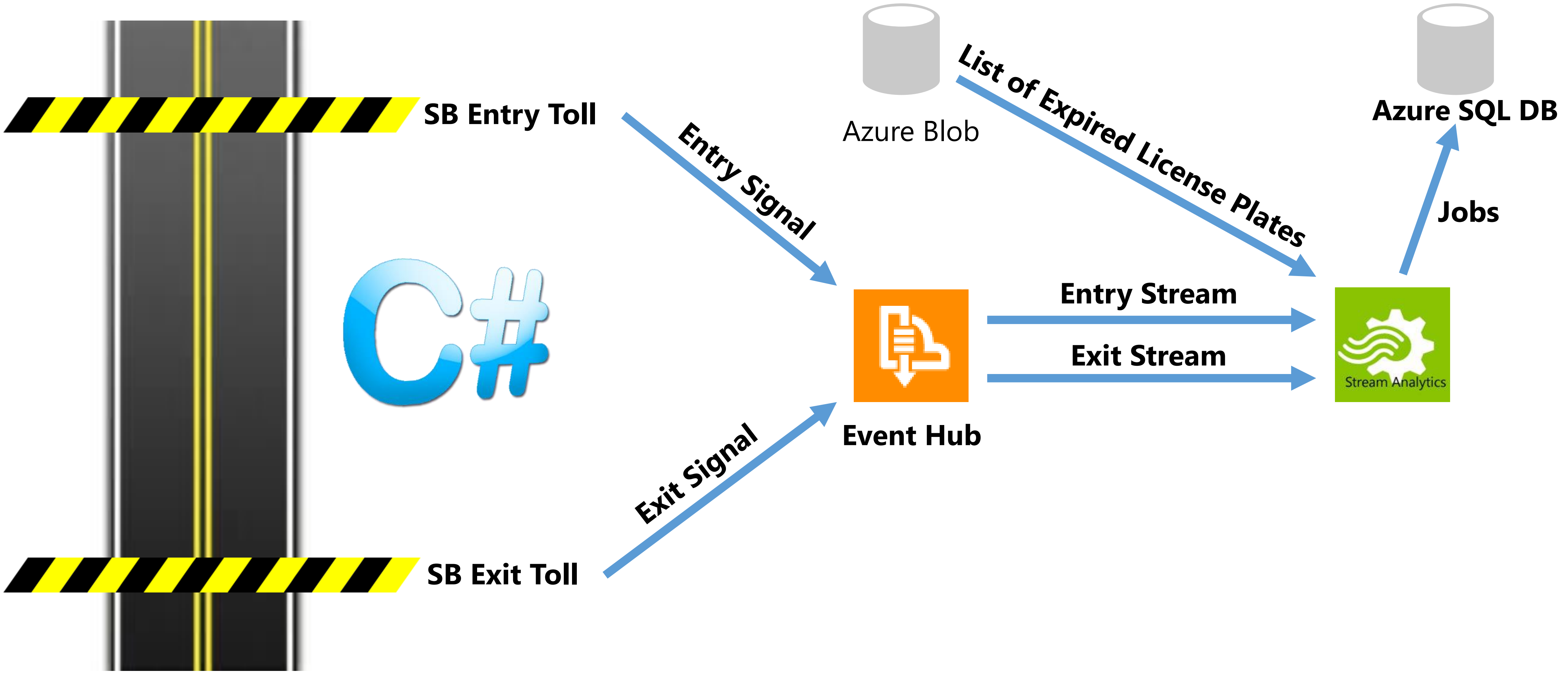
Automated Tolls



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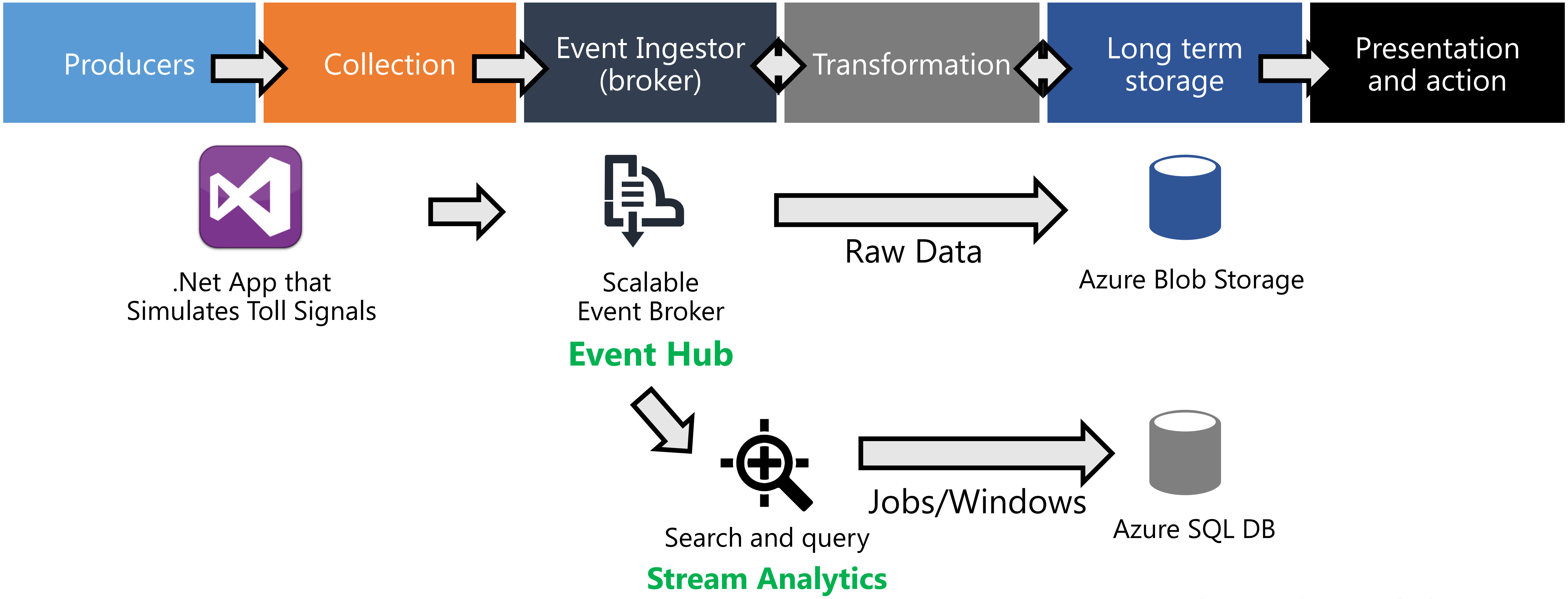
Tolls Work Process



Producers → Collection → Event Ingestor (broker) ⟷ Transformation ⟷ Long term storage → Presentation and action

.Net App that Simulates Toll Signals

Scalable Event Broker

Event Hub

Raw Data

Azure Blob Storage

Search and query

Stream Analytics

Jobs/Windows

Azure SQL DB

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Data at Rest

- **Question** “How many red cars are in the parking lot?”
- **Answering with a relational database**
  Walk out to the parking lot
  Count vehicles that are: Red, Car
- **SELECT COUNT**(*) **FROM** ParkingLot
  WHERE type **=** 'Auto'
  AND color **=** 'Red'

Data in Motion

- **Different Question** “How many red cars have passed exit 18A on A-10 in the last hour?”
- **Answering with a relational database**
  Pull over, park all vehicles in a lot, keep them there for an hour
  Count vehicles in the lot
- **Not a great solution…**

Temporal Questions

Count the number of cars….

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

Azure Stream Query Language

- Queries through time
- Simple SQL dialect
  - Familiar – learning curve reduction
  - High-Level – expression of intent, not implementation
  - Maintainable – focus on the essentials of the problem

- Extended in natural ways to express temporal concepts
  - WINDOW – multiple kinds
    - Tumbling, hopping, sliding
  - TIMESTAMP BY, BETWEEN
  - DATEDIFF in joins
  - PARTITION BY for scale-out

```
WITH agg AS
(
    SELECT Avg(reading), Building
    FROM Temperature
    GROUP BY TumblingWindow(minute, 1), building
)
SELECT A1.Avg AS Old, A2.Avg AS New, A1.Building
FROM Agg A1 JOIN Agg A2
ON A1.Building = A2.Building
AND DATEDIFF(minute,A1,A2) BETWEEN 4.5 AND 5.5
WHERE
   (a1.avg < a2.avg - 10) OR (a1.avg > a2.avg+10)
```

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.
- Stream Analytics can append your events with a timestamp (bad practice if standalone)
  - Can be skewed by network and hardware latency
- Users can define application time stamps with the TIMESTAMP BY clause
- Aggregations have timestamps at the end of the window

Which Timestamp?

- When the event occurs
- When the event is measured
- When the event is transmitted to a broker
- When the event is received by a broker
- When the broker transmits to an event processor
- When the event is received by the event processor
- When the event broker begins processing the event
- When the processor stops processing the event
- When the processor submits the processed event

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

Traditional SQL

How many vehicles passed through each toll booth yesterday?

- Why can’t we ask how many cars have gone through so far today?

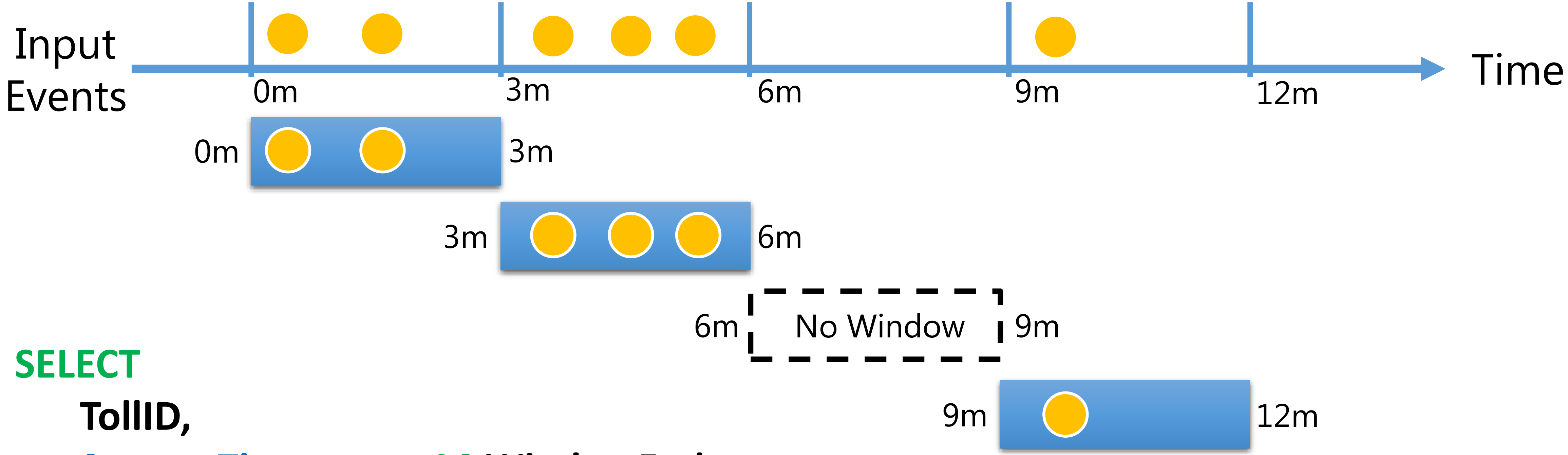
```
SELECT TollID, Count(*) AS Count
FROM EntryStream
WHERE date = ‘yesterday’
GROUP BY TollID
```

Azure Stream Query Language

How many vehicles pass through each toll booth every 3 minutes?

```
SELECT TollID, System.Timestamp AS WindowEnd, Count(*) AS Count
FROM EntryStream TIMESTAMP BY EntryTime
GROUP BY TUMBLINGWINDOW(minute, 3), TollID
```

Tumbling Window



```
SELECT
    TollID,
    System.Timestamp AS WindowEnd,
    Count(*) AS Count
FROM EntryStream TIMESTAMP BY EntryTime
GROUP BY TUMBLINGWINDOW(minute, 3), TollID
```

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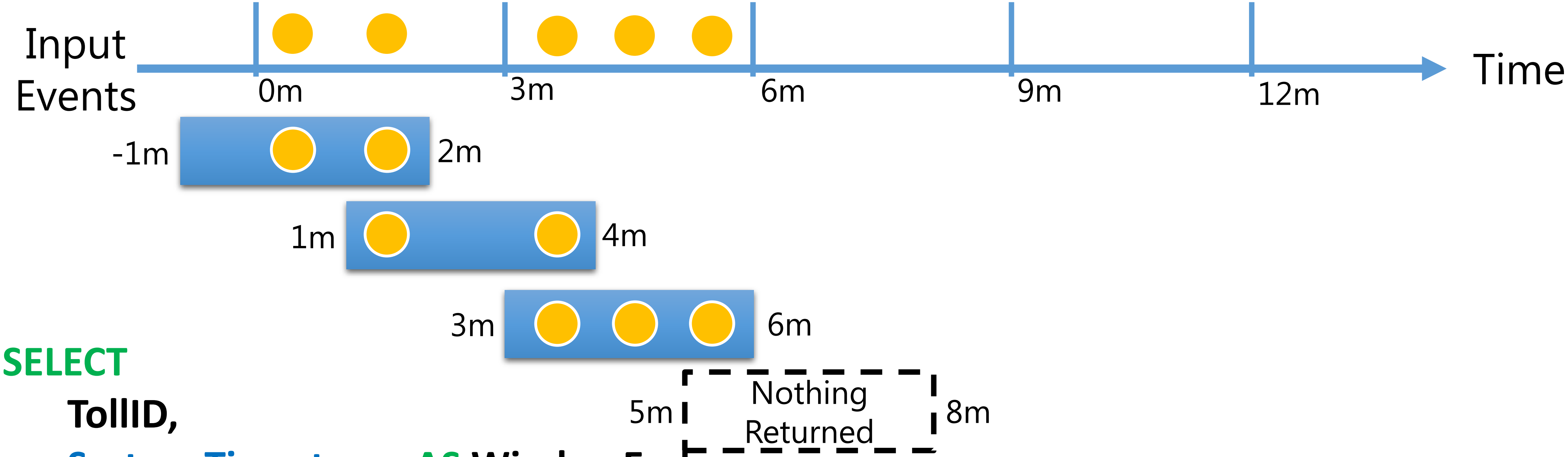
Hopping Window



```
SELECT
     TollID,
     System.Timestamp AS WindowEnd,
     Count(*) AS Count
FROM EntryStream TIMESTAMP BY EntryTime
GROUP BY HOPPINGWINDOW(minute, 3, 2), TollID
```

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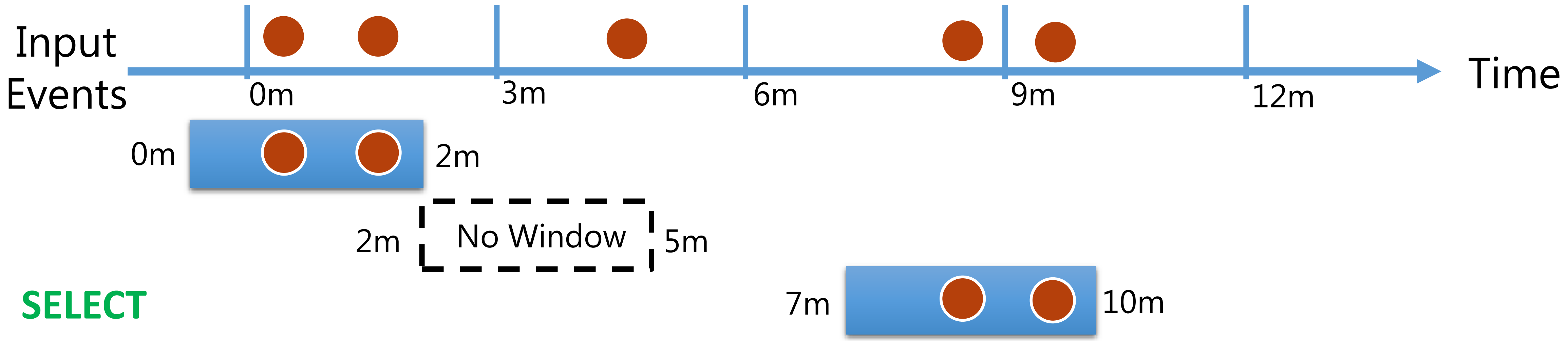
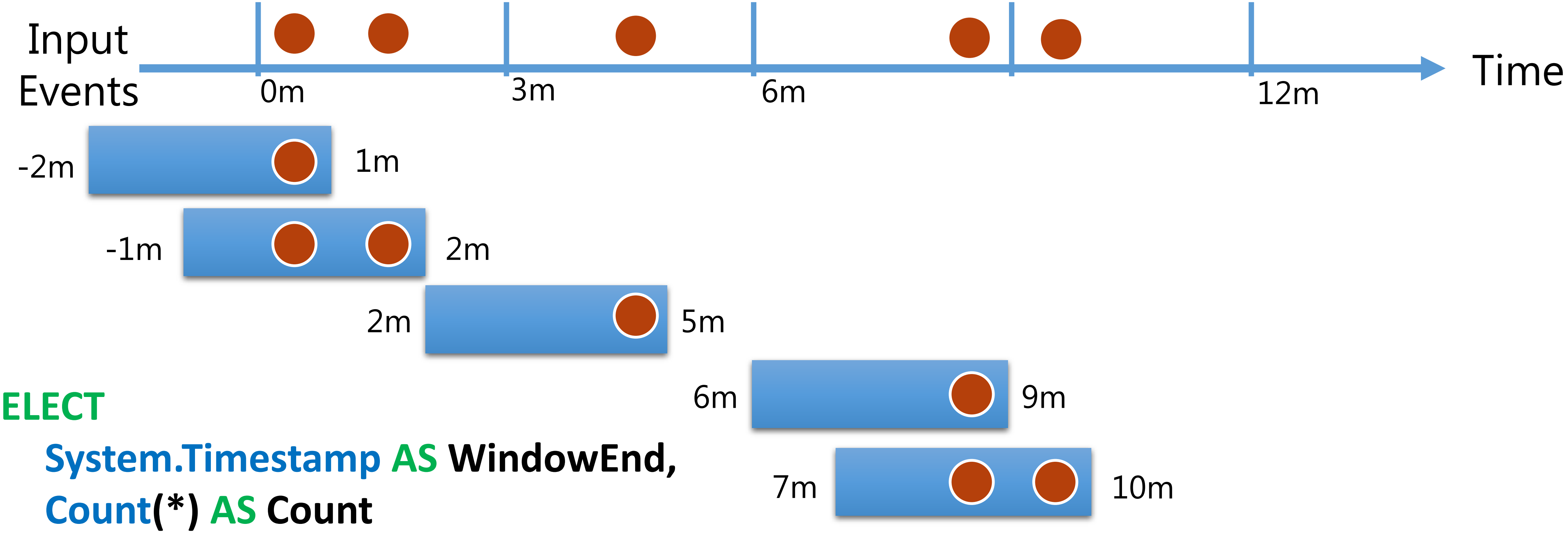
Sliding Window



```
SELECT
      System.Timestamp AS WindowEnd,
      Count(*) AS Count
FROM EntryStream TIMESTAMP BY EntryTime
GROUP BY SLIDINGWINDOW(minute, 3)
HAVING CarCount > 2
```

Sliding Window: Without 'Having' Clause



```
SELECT
    System.Timestamp AS WindowEnd,
    Count(*) AS Count
FROM EntryStream TIMESTAMP BY EntryTime
GROUP BY SLIDINGWINDOW(minute, 3)
```

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Sum Aggregation

How much toll revenue is being accumulated every 3 minutes?

```
SELECT
    System.Timestamp AS WindowEnd,
    Sum(TollAmount) AS IntervalRevenue
FROM EntryStream TIMESTAMP BY EntryTime
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(TollAmount) AS IntervalRevenue
FROM EntryStream TIMESTAMP BY EntryTime
GROUP BY TUMBLINGWINDOW(minute, 3), WindowEnd
Having IntervalRevenue > 10
```

Descriptive Statistics

Generate descriptive statistics for toll booth 2 every 3 minutes (car count, min, max, average, standard deviation, and total revenue).

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

DateDiff and Time

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

```
SELECT
    System.Timestamp AS WindowEnd,
    count(*) AS CarCount,
    datediff(second, min(EntryTime), max(EntryTime)) AS FirstLastDuration,
    datediff(second, min(EntryTime), System.Timestamp) AS FirstEndDuration
FROM EntryStream TIMESTAMP BY EntryTime
WHERE TollId = 2
GROUP BY TUMBLINGWINDOW(minute, 3), WindowEnd
HAVING count(*) >= 2
```

Join

How long did it take for each car to pass through the toll zone?

- JOIN operator requires specifying a temporal wiggle room describing an acceptable time difference between the joined events
- Use DATEDIFF function to specify that events should be no more than 15 minutes from each other

Joining Stream with Reference Data

Who has expired license plates? Let’s issue them a citation.

```
SELECT
   EntryStream.EntryTime,
   EntryStream.LicensePlate,
   EntryStream.TollId,
   Registration.RegistrationId
FROM EntryStream TIMESTAMP BY EntryTime
JOIN Registration
ON EntryStream.LicensePlate = Registration.LicensePlate
WHERE Registration.Expired = ‘1’
```

Joining Streams

How long did it take for each car to pass through the toll zone? (in seconds)

```
SELECT
   en.TollId,
   en.LicensePlate,
   en.EntryTime, ex.ExitTime,
   DATEDIFF ( second, en.EntryTime, ex.ExitTime ) AS DurationInMinutes
FROM EntryStream AS en TIMESTAMP BY EntryTime
JOIN ExitStream AS ex TIMESTAMP BY ExitTime
ON (en.LicensePlate = ex.LicensePlate)
     AND DATEDIFF ( minute, en, ex ) BETWEEN 0 AND 15
```

Joining Streams, by Window

What was the average time that it took for cars to go through the toll zone, every 3 minutes? (in seconds)

```
SELECT
    en.TollId,
    en.LicensePlate,
    avg( DATEDIFF ( second, en.EntryTime, ex.ExitTime )) AS DurationInMinutes
FROM EntryStream AS en TIMESTAMP BY EntryTime
JOIN ExitStream AS ex TIMESTAMP BY ExitTime
ON (en.LicensePlate = ex.LicensePlate)
      AND DATEDIFF ( minute, en, ex ) BETWEEN 0 AND 15
Group by TumblingWindow( minute, 3), en.TollId, en.LicensePlate
```

DATEDIFF, integer only

How long (in HOURS) does it take for each car to pass through the toll zone?

- Known bug right now: Decimal floats cut off, returns only 0

(Broken at the moment)

```
SELECT
   en.TollId, en.LicensePlate, en.EntryTime, ex.ExitTime,
   DATEDIFF ( hour, en.EntryTime, ex.ExitTime ) AS DurationHours
FROM EntryStream AS en TIMESTAMP BY EntryTime
JOIN ExitStream AS ex TIMESTAMP BY ExitTime
ON (en.LicensePlate = ex.LicensePlate)
AND DATEDIFF ( hour, en, ex ) BETWEEN 0 AND 1
```

Calculations

How fast (mph) was each car traveling through the toll zone?

Assume the toll zone was 1.5 miles long.

(Broken at the moment)

```
SELECT
    en.TollId, en.LicensePlate, en.EntryTime, ex.ExitTime,
    1.5 / DATEDIFF ( hour, en.EntryTime, ex.ExitTime ) AS MPH
FROM EntryStream AS en TIMESTAMP BY EntryTime
JOIN ExitStream AS ex TIMESTAMP BY ExitTime
ON (en.LicensePlate = ex.LicensePlate)
AND DATEDIFF ( hour, en, ex ) BETWEEN 0 AND 1
```

Caching On Having Only

Who was speeding through the toll zone?

- Simple question… but the query below will break.

```
SELECT
    en.TollId, en.LicensePlate, en.EntryTime, ex.ExitTime,
    1.5 / DATEDIFF ( hour, en.EntryTime, ex.ExitTime ) AS MPH
FROM EntryStream AS en TIMESTAMP BY EntryTime
JOIN ExitStream AS ex TIMESTAMP BY ExitTime
ON (en.LicensePlate = ex.LicensePlate)
AND DATEDIFF ( hour, en, ex ) BETWEEN 0 AND 1
~~WHERE MPH > 62~~
```

StreamQL Quirks

Who was speeding through the toll zone?

No caching -- must rewrite calculations…

```
SELECT
   en.TollId, en.LicensePlate, en.EntryTime, ex.ExitTime,
   1.5 / DATEDIFF ( hour, en.EntryTime, ex.ExitTime ) AS MPH
FROM EntryStream AS en TIMESTAMP BY EntryTime
JOIN ExitStream AS ex TIMESTAMP BY ExitTime
ON (en.LicensePlate = ex.LicensePlate)
AND DATEDIFF ( hour, en, ex ) BETWEEN 0 AND 1
WHERE 1.5 / DATEDIFF ( hour, en.EntryTime, ex.ExitTime ) > 62
```

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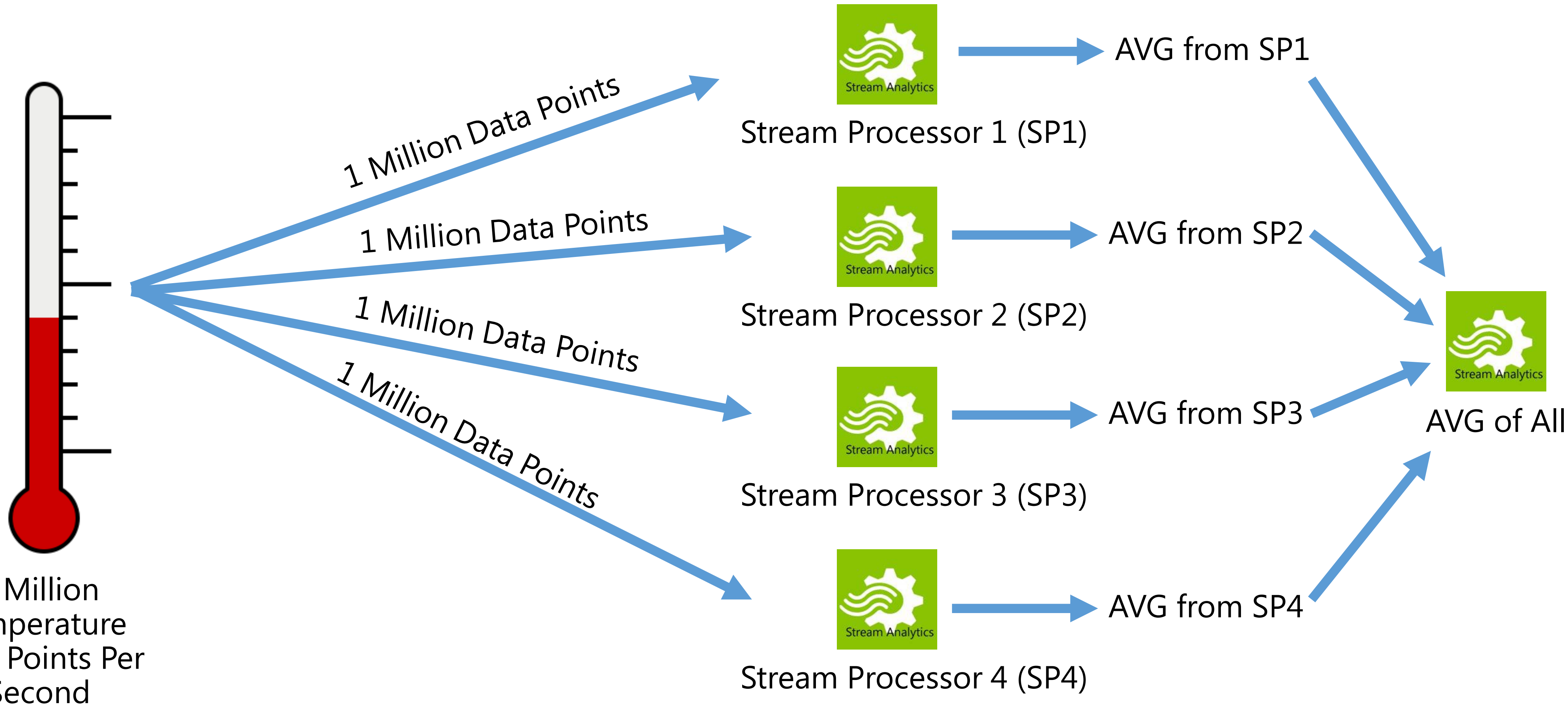
Average of Average Approximations



4 Million Temperature Data Points Per Second

1 Million Data Points

1 Million Data Points

1 Million Data Points

1 Million Data Points

Stream Processor 1 (SP1)

Stream Processor 2 (SP2)

Stream Processor 3 (SP3)

Stream Processor 4 (SP4)

AVG from SP1

AVG from SP2

AVG from SP3

AVG from SP4

AVG of All