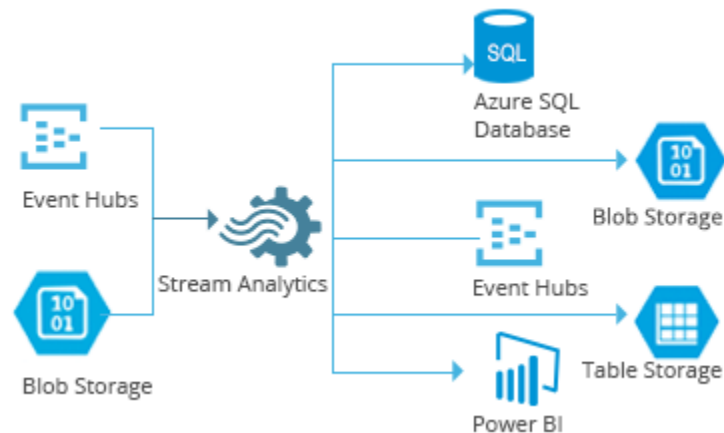




Modern Data Management & Business Intelligence

Assignment 3: Azure Streams Analytics



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- **Introduction**

Nowadays, there is the need to monitor / analyze data in near real time, as we live in a fast paced world (Social Media, Internet of Things etc.) and vast amounts of data are flowing at high velocity over the wire. Capturing and storing event data for later analysis is no longer enough. Organizations that can process and act on this streaming data in real time can dramatically improve efficiencies and differentiate themselves in the market.

Azure Stream Analytics is a fully managed, cost effective real-time event processing engine that helps to unlock deep insights from data. A user can author a Stream Analytics job by specifying the input source of the streaming data, the output sink for the results of your job, and a data transformation expressed in a SQL-like language.

- **Motivation**

We have access to a data stream of vehicle observations. The data stream is generated from sensors placed in some checkpoints (toll stations and speed cameras). Each time a car passes by one checkpoint, an event is generated. All cars are equipped with tags that provide the vehicleTypeID and colorID of each car. Tag readers are capable of reading this information. In addition, a camera reads the license plate and completed the event's data. We will create an Azure Analytics solution to answer some stream queries.

- **Setup a Stream Analytics Job**

In Figure 1, the stream input in the Event Hub along with the input reference data, saved as blob storage, are shown. Figure 2 depicts the corresponding reference json files uploaded.

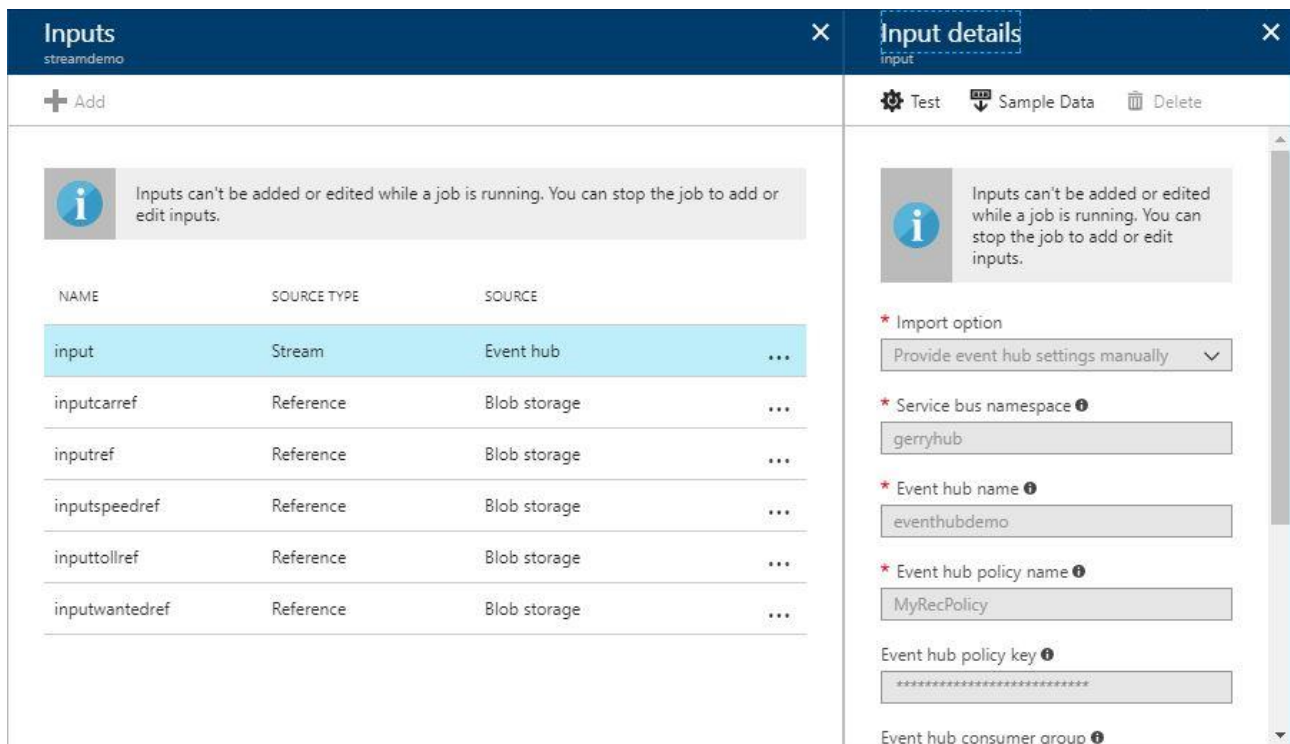


Figure 1

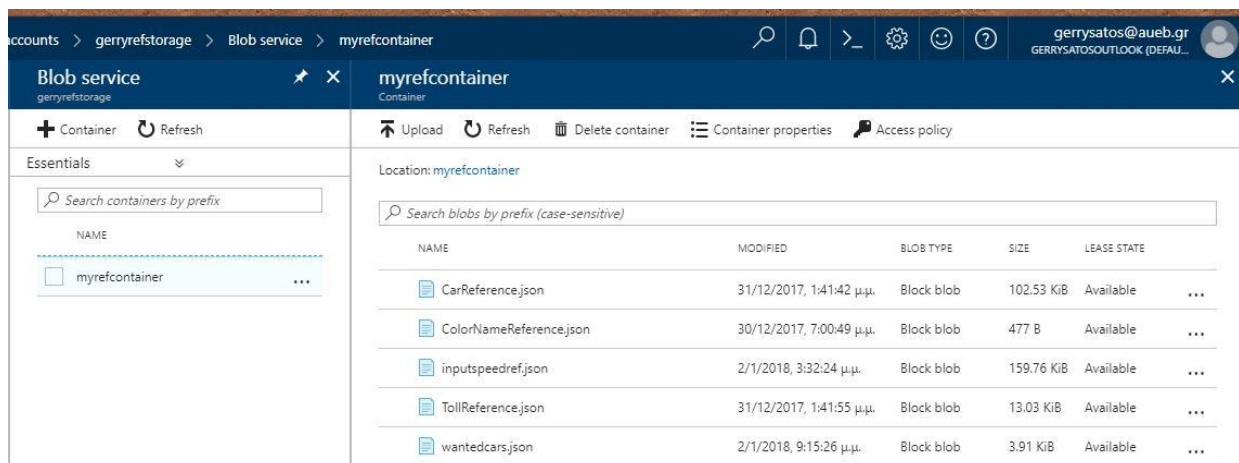


Figure 2

Next in Figure 3, we see on the left all the necessary components for a Stream Analytics Job: the storage account, the event hub, the reference storage, and the stream demo. In the same figure, we also notice an actual Job running. The same job is shown in Figure 4, as well, along with all the inputs (stream input and reference) and the outputs (stream output, Power BI output and some test outputs).

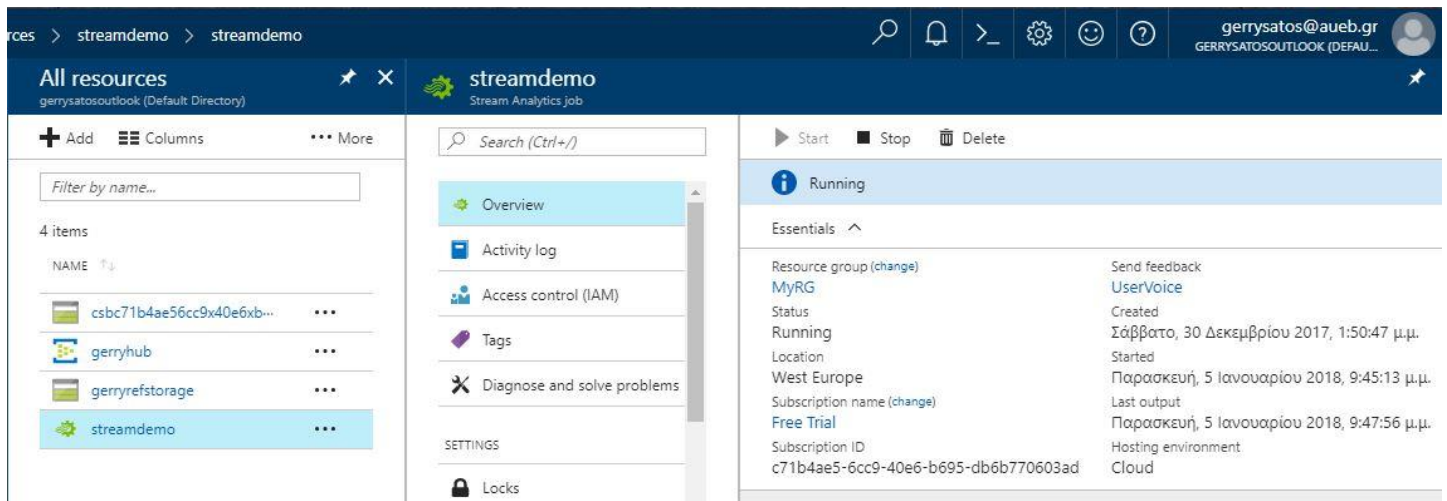


Figure 3

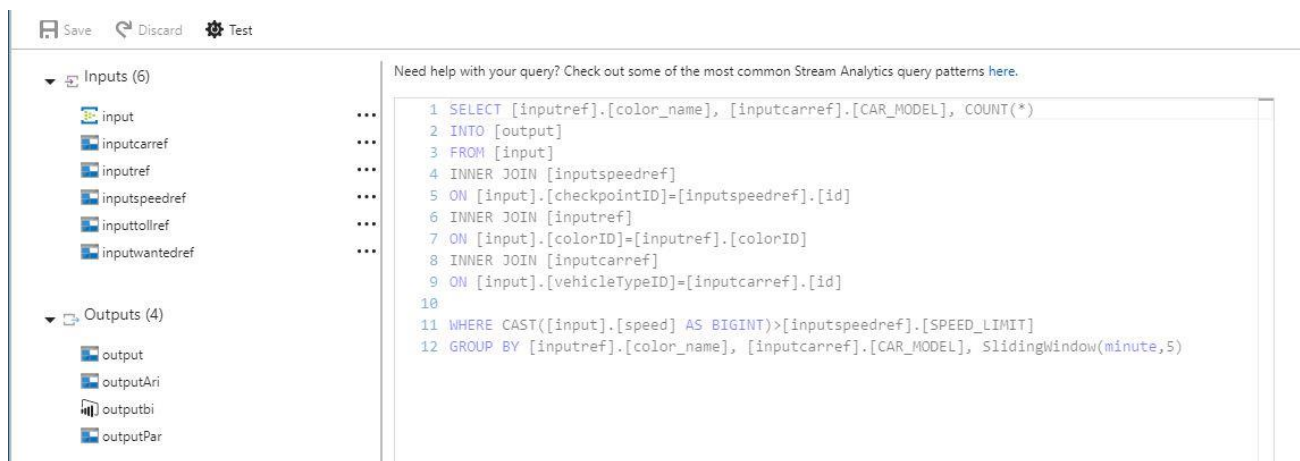


Figure 4

Finally, Figure 5 shows the data generator.

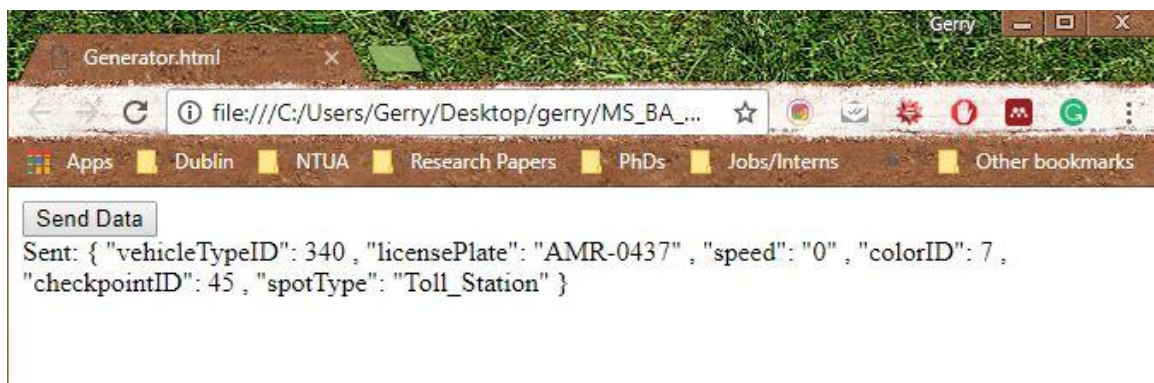


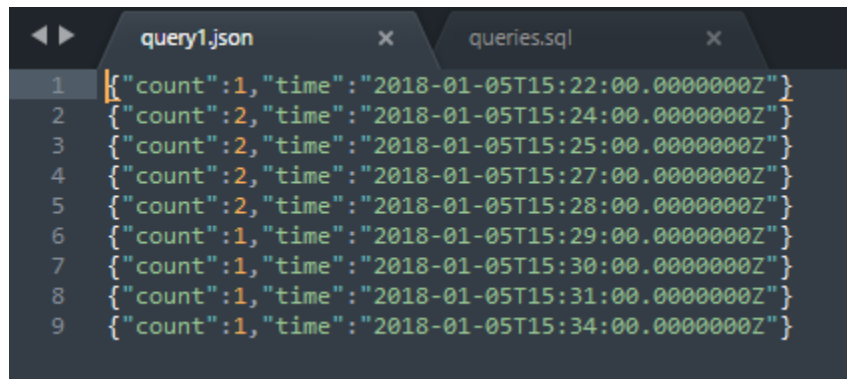
Figure 5

- Query 1

In a tumbling window of 1 minute count the number of Audis that passed through a toll station.

```
SELECT COUNT(*)
INTO [output]
FROM [input]
INNER JOIN [inputcarref] -- CAR_DATA.csv
ON [input].[vehicleTypeID]=[inputcarref].[id]
WHERE [input].[spotType]='Toll_Station' AND
[inputcarref].[CAR_MAKE]='Audi'
GROUP BY [inputcarref].[CAR_MAKE], TumblingWindow(second,60)
```

Some results from the stream analytics job are following:



Line	Result
1	{"count":1,"time":"2018-01-05T15:22:00.0000000Z"}
2	{"count":2,"time":"2018-01-05T15:24:00.0000000Z"}
3	{"count":2,"time":"2018-01-05T15:25:00.0000000Z"}
4	{"count":2,"time":"2018-01-05T15:27:00.0000000Z"}
5	{"count":2,"time":"2018-01-05T15:28:00.0000000Z"}
6	{"count":1,"time":"2018-01-05T15:29:00.0000000Z"}
7	{"count":1,"time":"2018-01-05T15:30:00.0000000Z"}
8	{"count":1,"time":"2018-01-05T15:31:00.0000000Z"}
9	{"count":1,"time":"2018-01-05T15:34:00.0000000Z"}

- Query 2

In a hopping window of 3 minutes, for each color, calculate the total number of cars that passed through a police speed limit camera. Repeat every 90 seconds.

```
SELECT [inputref].[color_name],COUNT(*), System.Timestamp as Time
into [output]

FROM [input]
INNER JOIN [inputref] -- COLORS.json
ON [input].[colorID]=[inputref].[colorID]

WHERE [input].[spotType]='Speed_Limit_Camera'
GROUP BY [inputref].[color_name], HoppingWindow(second,180,90)
```

Some results are following:

	query2.json	query6.json	query4.json	que
1	{ "color_name": "Blue", "count": 3, "time": "2018-01-05T16:42:00.000000Z" }			
2	{ "color_name": "Yellow", "count": 3, "time": "2018-01-05T16:42:00.000000Z" }			
3	{ "color_name": "Brown", "count": 4, "time": "2018-01-05T16:42:00.000000Z" }			
4	{ "color_name": "Pink", "count": 4, "time": "2018-01-05T16:42:00.000000Z" }			
5	{ "color_name": "Black", "count": 1, "time": "2018-01-05T16:42:00.000000Z" }			
6	{ "color_name": "Green", "count": 3, "time": "2018-01-05T16:42:00.000000Z" }			
7	{ "color_name": "Silver", "count": 6, "time": "2018-01-05T16:42:00.000000Z" }			
8	{ "color_name": "White", "count": 3, "time": "2018-01-05T16:42:00.000000Z" }			
9	{ "color_name": "Red", "count": 1, "time": "2018-01-05T16:42:00.000000Z" }			
10	{ "color_name": "Blue", "count": 8, "time": "2018-01-05T16:43:30.000000Z" }			
11	{ "color_name": "Yellow", "count": 6, "time": "2018-01-05T16:43:30.000000Z" }			
12	{ "color_name": "Brown", "count": 8, "time": "2018-01-05T16:43:30.000000Z" }			
13	{ "color_name": "Pink", "count": 8, "time": "2018-01-05T16:43:30.000000Z" }			

- Query 3

In a tumbling window of 20 seconds, for each color, find the oldest car that passed through a toll station.

```
WITH View1 AS(
SELECT [inputref].[color_name] AS Color,
MIN([inputcarref].[CAR_MODEL_YEAR]) AS Min_Year, System.Timestamp as Time
FROM [input]
INNER JOIN [inputref]
ON [input].[colorID]=[inputref].[colorID]
INNER JOIN [inputcarref]
ON [input].[vehicleTypeID]=[inputcarref].[id]
WHERE [input].[spotType]='Toll_Station'
GROUP BY [inputref].[color_name], TumblingWindow(second,20)
)

SELECT [inputref].[color_name],[input].[vehicleTypeID]
,[inputcarref].[CAR_MODEL_YEAR], System.Timestamp as Time
INTO [output]
FROM [input]
INNER JOIN View1
ON DATEDIFF(second,input,View1) BETWEEN 0 AND 20
INNER JOIN [inputcarref]
ON [input].[vehicleTypeID]=[inputcarref].[id]
INNER JOIN [inputref]
ON [input].[colorID]=[inputref].[colorID]

WHERE [inputcarref].[CAR_MODEL_YEAR]=[View1].[Min_Year]
AND [inputref].[color_name]=[View1].[Color]
```

Some results are following:

	query3.json	query1.json	query8ajson	queries.sql
1	{ "color_name": "Yellow", "vehicletypeid": 429, "car_model_year": 1972, "time": "2018-01-05T15:50:00.0000000Z" }			
2	{ "color_name": "White", "vehicletypeid": 419, "car_model_year": 1987, "time": "2018-01-05T15:50:00.0000000Z" }			
3	{ "color_name": "Black", "vehicletypeid": 723, "car_model_year": 1991, "time": "2018-01-05T15:50:00.0000000Z" }			
4	{ "color_name": "Blue", "vehicletypeid": 90, "car_model_year": 1998, "time": "2018-01-05T15:50:00.0000000Z" }			
5	{ "color_name": "Red", "vehicletypeid": 268, "car_model_year": 2011, "time": "2018-01-05T15:50:00.0000000Z" }			
6	{ "color_name": "Pink", "vehicletypeid": 565, "car_model_year": 1997, "time": "2018-01-05T15:50:00.0000000Z" }			
7	{ "color_name": "Brown", "vehicletypeid": 45, "car_model_year": 1966, "time": "2018-01-05T15:50:00.0000000Z" }			
8	{ "color_name": "Green", "vehicletypeid": 639, "car_model_year": 1981, "time": "2018-01-05T15:50:20.0000000Z" }			
9	{ "color_name": "Silver", "vehicletypeid": 817, "car_model_year": 2012, "time": "2018-01-05T15:50:20.0000000Z" }			
10	{ "color_name": "Yellow", "vehicletypeid": 365, "car_model_year": 1993, "time": "2018-01-05T15:50:20.0000000Z" }			
11	{ "color_name": "Black", "vehicletypeid": 160, "car_model_year": 2002, "time": "2018-01-05T15:50:20.0000000Z" }			
12	{ "color_name": "White", "vehicletypeid": 381, "car_model_year": 2004, "time": "2018-01-05T15:50:20.0000000Z" }			
13	{ "color_name": "Brown", "vehicletypeid": 51, "car_model_year": 1994, "time": "2018-01-05T15:50:20.0000000Z" }			
14	{ "color_name": "Green", "vehicletypeid": 173, "car_model_year": 2008, "time": "2018-01-05T15:50:40.0000000Z" }			
15	{ "color_name": "Silver", "vehicletypeid": 896, "car_model_year": 1999, "time": "2018-01-05T15:50:40.0000000Z" }			
16	{ "color_name": "Yellow", "vehicletypeid": 10, "car_model_year": 2003, "time": "2018-01-05T15:50:40.0000000Z" }			

- Query 4

In a sliding window of 60 seconds, calculate the speed limit camera spots where the most violations happened.

```
WITH View1 AS (
    SELECT [inputspeedref].[id] AS violationID ,COUNT(*) AS
ViolationsPerSpot
    FROM [input]
    INNER JOIN [inputspeedref]
    ON [input].[checkpointID]=[inputspeedref].[id]
    WHERE [input].[spotType]='Speed_Limit_Camera' AND CAST([input].[speed]
AS BIGINT)>[inputspeedref].[SPEED_LIMIT]
    GROUP BY [inputspeedref].[id],SlidingWindow(second,60)
)

SELECT [inputspeedref].[CITY], MAX([View1].[ViolationsPerSpot]) As
Max_Number_Violations, System.Timestamp AS Time
INTO [output]
FROM [View1]
INNER JOIN [inputspeedref]
ON [View1].[violationID]=[inputspeedref].[id]
GROUP BY [inputspeedref].[CITY], SlidingWindow(second,60)
```

Some results:


```

query4.json x query3.json x query1.json x query8ajson x
1 [{"city": "Xiong@erzhai", "max_number_violations": 1, "time": "2018-01-05T15:57:32.3950000Z"}]
2 [{"city": "Mau@", "max_number_violations": 1, "time": "2018-01-05T15:57:33.4570000Z"}]
3 [{"city": "Pasirlaja", "max_number_violations": 1, "time": "2018-01-05T15:57:54.7870000Z"}]
4 [{"city": "Bergamo", "max_number_violations": 1, "time": "2018-01-05T15:58:00.4000000Z"}]
5 [{"city": "Mosoc Llacta", "max_number_violations": 1, "time": "2018-01-05T15:58:03.4010000Z"}]
6 [{"city": "Cangyou", "max_number_violations": 1, "time": "2018-01-05T15:58:04.4320000Z"}]
7 [{"city": "Almaguer North", "max_number_violations": 1, "time": "2018-01-05T15:58:05.4020000Z"}]
8 [{"city": "Vysok@ nad Jizerou", "max_number_violations": 1, "time": "2018-01-05T15:58:06.4330000Z"}]
9 [{"city": "Yuto", "max_number_violations": 1, "time": "2018-01-05T15:58:16.3900000Z"}]
10 [{"city": "Buruju", "max_number_violations": 1, "time": "2018-01-05T15:58:18.3900000Z"}]
11 [{"city": "Shagang", "max_number_violations": 1, "time": "2018-01-05T15:58:20.4050000Z"}]
12 [{"city": "Xunjian", "max_number_violations": 1, "time": "2018-01-05T15:58:30.3930000Z"}]
13 [{"city": "Barretos", "max_number_violations": 1, "time": "2018-01-05T15:58:34.3930000Z"}]
14 [{"city": "Gamut", "max_number_violations": 1, "time": "2018-01-05T15:58:38.3960000Z"}]
15 [{"city": "Wyszogr@d", "max_number_violations": 1, "time": "2018-01-05T15:58:42.3830000Z"}]
16 [{"city": "Damietta", "max_number_violations": 1, "time": "2018-01-05T15:59:05.4240000Z"}]
17 [{"city": "Hanyu", "max_number_violations": 1, "time": "2018-01-05T15:59:43.4160000Z"}]

```

• Query 5

In a sliding window of five minutes, for each color and car model, display the total number of cars that break the speed limit.

```

SELECT [inputref].[color_name], [inputcarref].[CAR_MODEL], COUNT(*)
INTO [output]
FROM [input]
INNER JOIN [inputspeedref]
ON [input].[checkpointID]=[inputspeedref].[id]
INNER JOIN [inputref]
ON [input].[colorID]=[inputref].[colorID]
INNER JOIN [inputcarref]
ON [input].[vehicleTypeID]=[inputcarref].[id]

WHERE CAST([input].[speed] AS BIGINT)>[inputspeedref].[SPEED_LIMIT]
GROUP BY [inputref].[color_name], [inputcarref].[CAR_MODEL],
SlidingWindow(minute,5)

```

Some results:

```

50 {"color_name": "Pink", "car_model": "Eos", "count": 1}
51 {"color_name": "Silver", "car_model": "G35", "count": 2}
52 {"color_name": "Yellow", "car_model": "Navigator", "count": 1}
53 {"color_name": "Blue", "car_model": "Talon", "count": 1}
54 {"color_name": "Blue", "car_model": "Bonneville", "count": 1}
55 {"color_name": "Red", "car_model": "Passport", "count": 1}
56 {"color_name": "Black", "car_model": "S5", "count": 1}
57 {"color_name": "Yellow", "car_model": "Caravan", "count": 1}
58 {"color_name": "Black", "car_model": "LTD", "count": 1}
59 {"color_name": "Blue", "car_model": "B-Series", "count": 1}
60 {"color_name": "Green", "car_model": "Sonic", "count": 1}
61 {"color_name": "Blue", "car_model": "Millenia", "count": 1}
62 {"color_name": "Silver", "car_model": "CT", "count": 1}
63 {"color_name": "Silver", "car_model": "Electra", "count": 1}
64 {"color_name": "Red", "car_model": "G-Series G20", "count": 1}

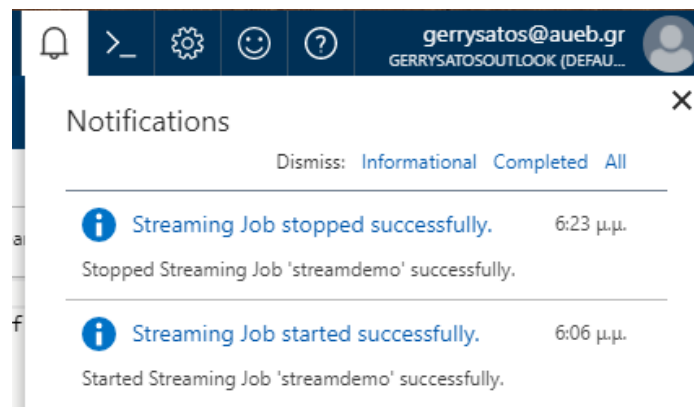
```


- Query 6

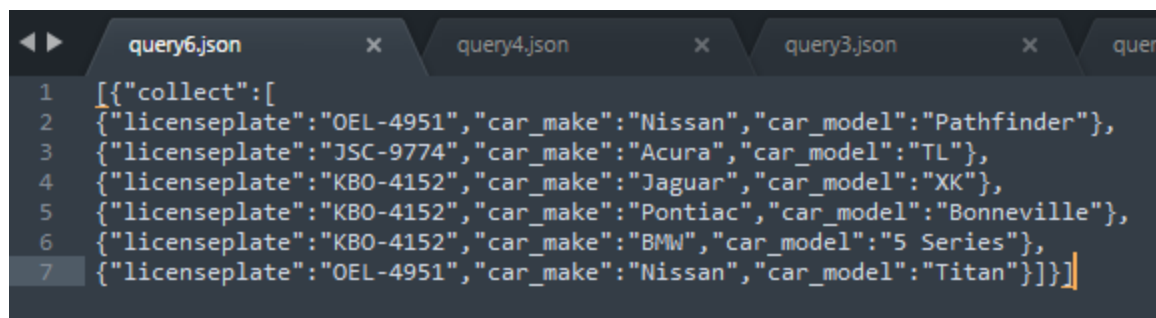
You have been given a list of the license plates of police's most wanted criminals. In a sliding window of 1 minute, display a list of all the cars that you spotted at any checkpoint.

```
WITH V1 AS(
SELECT [input].[licensePlate], [inputcarref].[CAR_MAKE],
[inputcarref].[CAR_MODEL]
FROM [input]
INNER JOIN [inputwantedref]
ON [input].[licensePlate] = [inputwantedref].[licensePlate]
INNER JOIN [inputcarref]
ON [input].[vehicleTypeID] = [inputcarref].[id]
WHERE [input].[licensePlate] = [inputwantedref].[licensePlate]
)
SELECT Collect()
INTO [output]
FROM [V1]
GROUP BY SlidingWindow(second,60)
```

Letting the stream to run for a while, no output was produced. That happens probably because all the combinations of licenses plates are extremely a lot and it didn't manage to spot a wanted license plate.



Testing our query with sample data from file 'stream-demo-input' we see that it works.



- Query 7

In a **sliding window of 1 minute**, display a list of fake license plates. Check if the same license plate has passed through any type of checkpoint twice in the same time window.

```
SELECT [input].[licensePlate] AS 'Fake License Plates',  
COUNT([input].[licensePlate]) AS 'How many times'  
INTO [output]  
FROM [input]  
GROUP BY [input].[licensePlate], SlidingWindow(second,60)  
HAVING COUNT([input].[licensePlate])>1
```

Testing our query with sample data from file 'stream-demo-input' we see that it works.

Save Discard Test

Inputs (6)

input inputcarref inputref inputspeedref inputtollref inputwantedref

Outputs (4)

output outputAri outputbi outputPar

Need help with your query? Check out some of the most common Stream Analytics query patterns here.

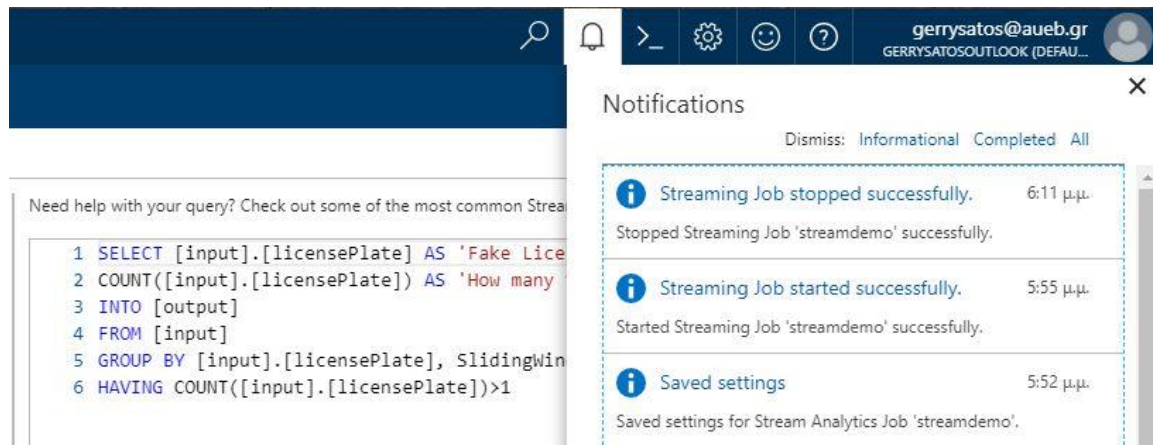
```
1 SELECT [input].[licensePlate] AS 'Fake License Plates',  
2 COUNT([input].[licensePlate]) AS 'How many times'  
3 INTO [output]  
4 FROM [input]  
5 GROUP BY [input].[licensePlate], SlidingWindow(second,60)  
6 HAVING COUNT([input].[licensePlate])>1
```

Your query could be put in logs that are in a potentially different geography.
Missing some language constructs? [Let us know!](#) (Powered by UserVoice - [Privacy Policy](#))

Download results

FAKE LICENSE PLATES	HOW MANY TIMES
"KBO-4152"	3
"OEL-4951"	2

Letting now the stream to run for 16 minutes, no output was produced. That happens probably because all the combinations of licenses plates are extremely a lot and it didn't manage to find 2 or more identical plates.



The screenshot shows the Stream Analytics interface. On the left, a query is displayed:

```

1 SELECT [input].[licensePlate] AS 'Fake License Plate'
2 COUNT([input].[licensePlate]) AS 'How many'
3 INTO [output]
4 FROM [input]
5 GROUP BY [input].[licensePlate], SlidingWindow(16, 1)
6 HAVING COUNT([input].[licensePlate]) > 1

```

On the right, a 'Notifications' panel is open, showing three messages:

- Streaming Job stopped successfully. 6:11 μμ. Stopped Streaming Job 'streamdemo' successfully.
- Streaming Job started successfully. 5:55 μμ. Started Streaming Job 'streamdemo' successfully.
- Saved settings 5:52 μμ. Saved settings for Stream Analytics Job 'streamdemo'.

• Query 8

In a tumbling window of 2 minutes, calculate the percentage of BMW drivers that break the speed limit.

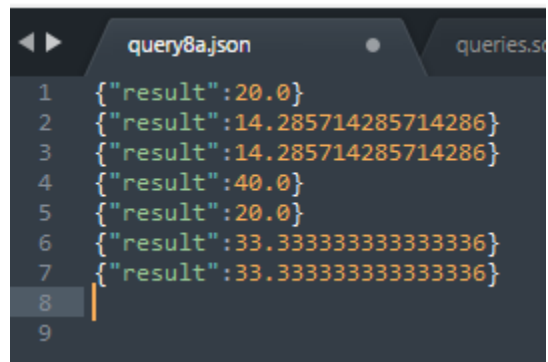
```

WITH V1 AS(
SELECT COUNT([input].[vehicleTypeID]) AS Arithmitis
FROM [input]
JOIN [inputcarref]
ON [input].[vehicleTypeID]=[inputcarref].[id]
JOIN [inputspeedref]
ON [input].[checkpointID]=[inputspeedref].[id]
WHERE [inputcarref].[CAR_MAKE]='BMW' AND
      CAST([input].[speed] AS BIGINT)>[inputspeedref].[SPEED_LIMIT]
GROUP BY TumblingWindow(second,120)
), V2 AS(
SELECT COUNT([input].[vehicleTypeID]) AS Paronomastis
FROM [input]
JOIN [inputcarref]
ON [input].[vehicleTypeID]=[inputcarref].[id]
WHERE [inputcarref].[CAR_MAKE]='BMW'
GROUP BY TumblingWindow(second,120)
)

SELECT 100* CAST ([V1].[Arithmitis] AS float)/CAST ([V2].[Paronomastis] AS float) AS Result
INTO [output]
FROM [V1]
INNER JOIN [V2]
ON DATEDIFF(second,[V1],[V2]) between 0 AND 120

```

Some results are following:



A screenshot of a code editor window with a dark theme. The active tab is labeled 'query8a.json'. The editor displays a list of JSON objects, each on a new line, numbered 1 through 9 on the left margin. The JSON objects are: 1: {"result": 20.0}, 2: {"result": 14.285714285714286}, 3: {"result": 14.285714285714286}, 4: {"result": 40.0}, 5: {"result": 20.0}, 6: {"result": 33.333333333333336}, 7: {"result": 33.333333333333336}, 8: (empty object), and 9: (empty object). A vertical orange cursor is positioned at the start of line 8.

```
1 {"result": 20.0}
2 {"result": 14.285714285714286}
3 {"result": 14.285714285714286}
4 {"result": 40.0}
5 {"result": 20.0}
6 {"result": 33.333333333333336}
7 {"result": 33.333333333333336}
8 {}
9 {}
```