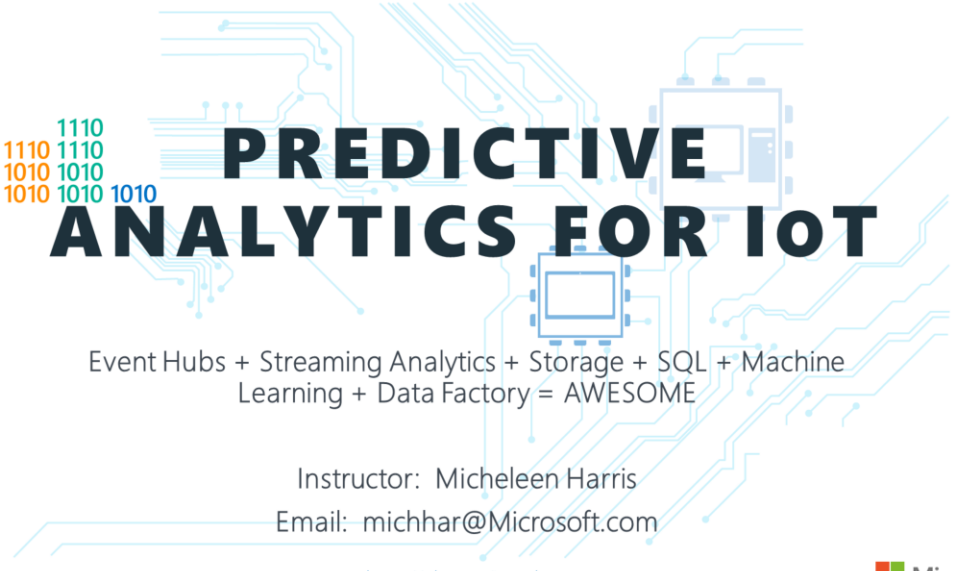
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PREDICTIVE
ANALYTICS FOR IoT
Event Hubs + Streaming Analytics + Storage + SQL + Machine Learning + Data Factory = AWESOME
Instructor: Micheleen Harris
Email: michhar@Microsoft.com
http://aka.ms/iotedu
Microsoft

WHAT YOU WILL BE ABLE TO DO AFTER THIS TRAINING

Be able to **piece apart the components** of a deployed solution for predictive analytics in Azure for streaming data, including gaining familiarity with the **data science** aspects of the solution.

Be able to build back up and **deploy a simple predictive analytics solution** in Azure for streaming data including a shareable BI dashboard for **rapid synthesis** of information.

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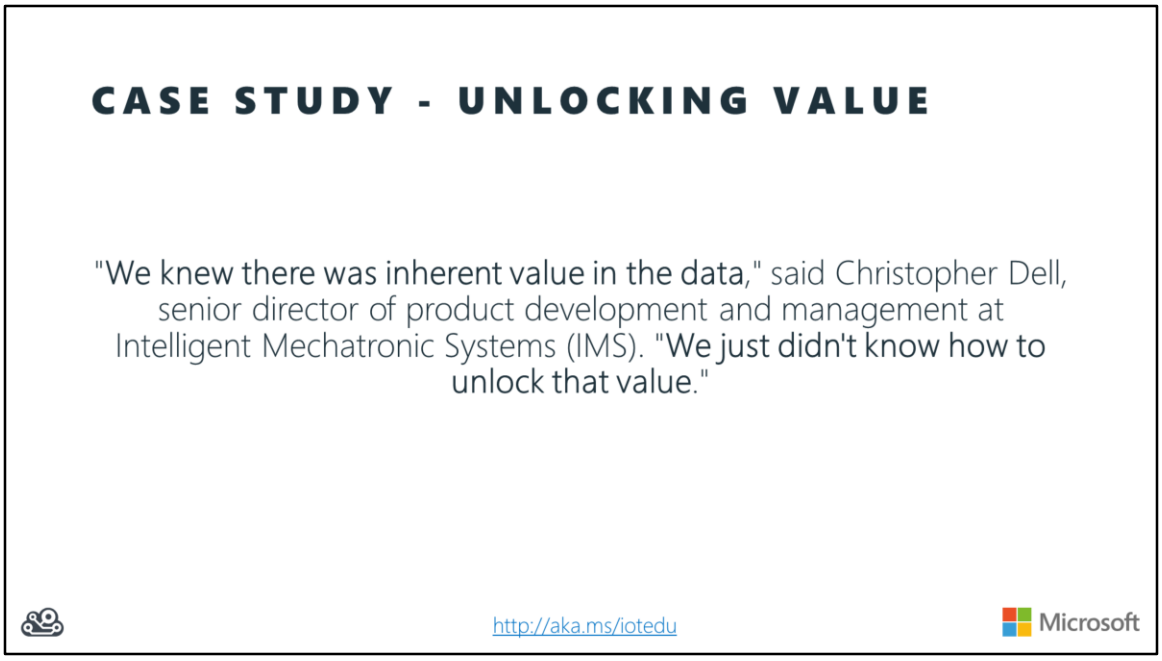
The BI Dashboard from a Power BI-integrated solution template will be shown now. We will be using the Energy Demand Forecasting solution template (not public yet) for our example solution throughout the course.



The story is about IoT-related struggles of a Canadian company called Intelligent Mechatronic Systems – a vehicle telemetry story (see “story.txt” under Misc folder on class site at https://aka.ms/iotedu)

In here they use Pentaho analytics BI suite. They do not use Azure, but note that we have integrated it into Azure (specifically, Active Directory – if you belong to one you should have free or affordable access to this offering)

Note, this suite integration is available on the very useful Azure associated integration site called the Azure Marketplace – a software integration and dev site where companies can submit integrations with other software, a valuable “market” to know about - https://azure.microsoft.com/en-us/marketplace/. You can even find many APIs and different types of virtual machines here already configured. There are over 4000 products.

However, in general solutions integrating Azure products with Machine Learning are very often surfaced on the Cortana Intelligence Gallery at: https://gallery.cortanaintelligence.com/ or the Cortana Intelligence Quick Starts at: https://start.cortanaanalytics.com/ (from where we are building out a pattern in

private preview status today)

DAY 1 SESSIONS

1) Logistics – 30 min
   - Go over Pre-Requisites and Any Questions
   - Using GitHub for the Class Site and User Accounts
2) Business Understanding (Goals and Use Cases) – 30 min
3) Break – 10 min
4) Architecture of a Cloud Solution and Naming Things – 60 min
   - More Time for Setup or Exploration
   - Deploy the Solution
5) Lunch – 1 hr
6) Data Understanding - Sources (Slow and Fast) and Road-Bumps – 90 min
7) Break – 20 min
8) Data in Motion - Handling the Fast-Moving Data and Dashboards – 90 min

(*note*: these are all approximate)

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This is the Day 1 Agenda

Course Description

This 4 day workshop entails 2 days of training and a 2-day build-a-thon that solidifies the training topics. The training will take an attendee through an end-to-end solution from the demand forecasting domain. Demand forecasting revolves around predictive analytics, so the emphasis will be on creating and deploying machine learning models, the ingestion of fast-moving-data, dashboarding and orchestrating data flow and storage. The makings of the predictive cloud solution will be drawn from the Cortana Intelligence Suite on Azure, Microsoft's cloud.

The Build-a-thon will give attendees a chance to bring their own ideas and data to expand and broaden the example of the cloud deployed predictive solution from within a proctored environment. In the end, attendees will be able to demonstrate and create their own predictive analytics workflows.

PREDICTIVE ANALYTICS FOR IoT

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PART 1 OF 5: LOGISTICS

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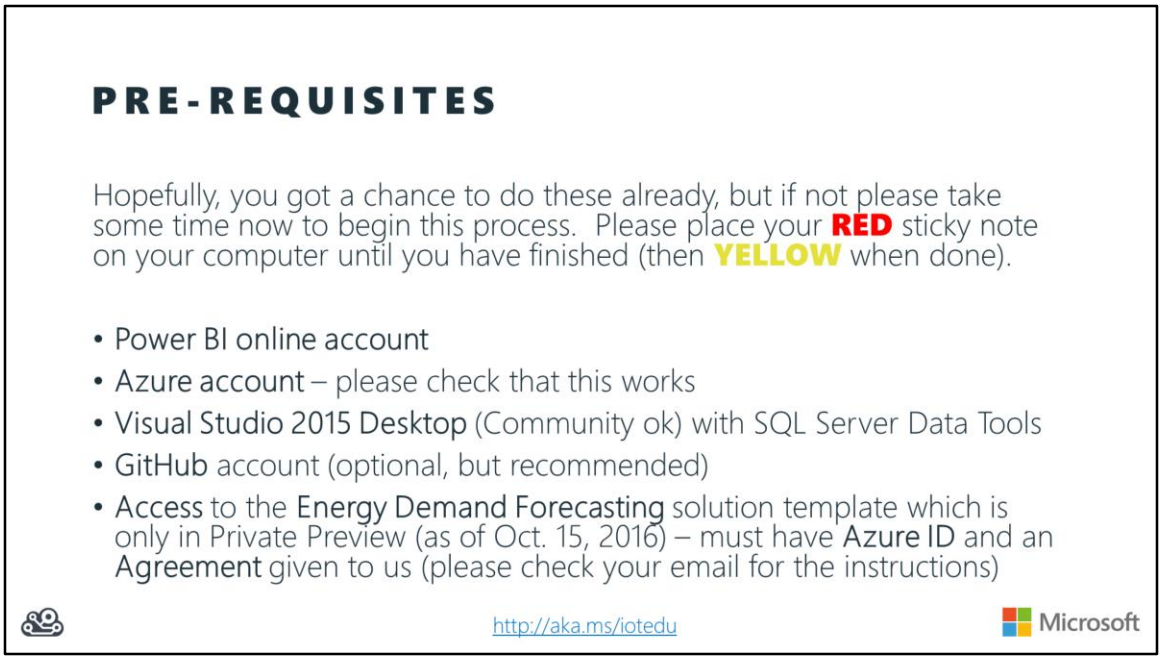
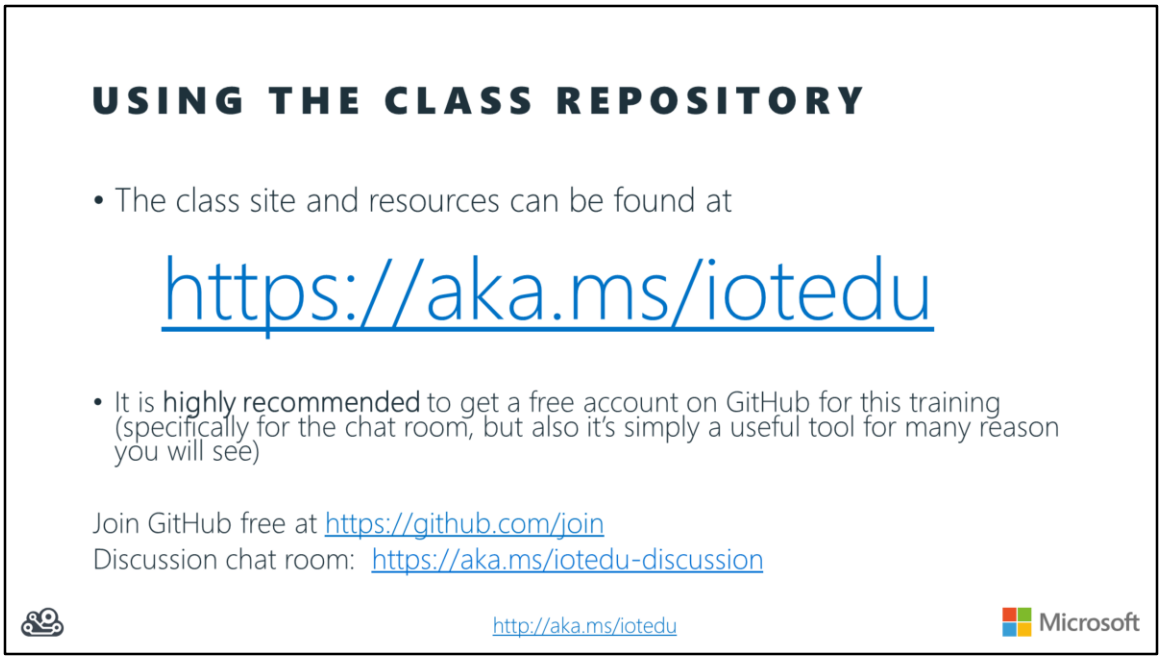


Pre-requisites site with more info: https://aka.ms/iotedu-prereqs

Visual Studio takes a long time to download and install.
The approval for the private solution template must have been completed beforehand to allow us time to whitelist you for access. If this has not been done, please pair up with someone who has completed this process.



GitHub is a free code hosting web service for developers and the trainers use it because it's easy to create documents and upload files. It's also free.

Join GitHub for free: https://github.com/join

Benefits:

- This will allow you to be able to programmatically "clone" repositories to your local machine or create your own to share and collaborate
- You will also be able to join the discussion forum for this class (https://aka.ms/iotedu-discussion)
- It can be useful even for just sharing text files
- Note, github uses Markdown as a text markup language, but you don't have to know it to create text files
- And as an fyi, GitHub has GitHub Pages – a free place to create and host a website (I use for my blog)
- Many more…

More details on signing up: https://help.github.com/articles/signing-up-for-a-new-

github-account/

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PART 2 OF 5: BUSINESS UNDERSTANDING

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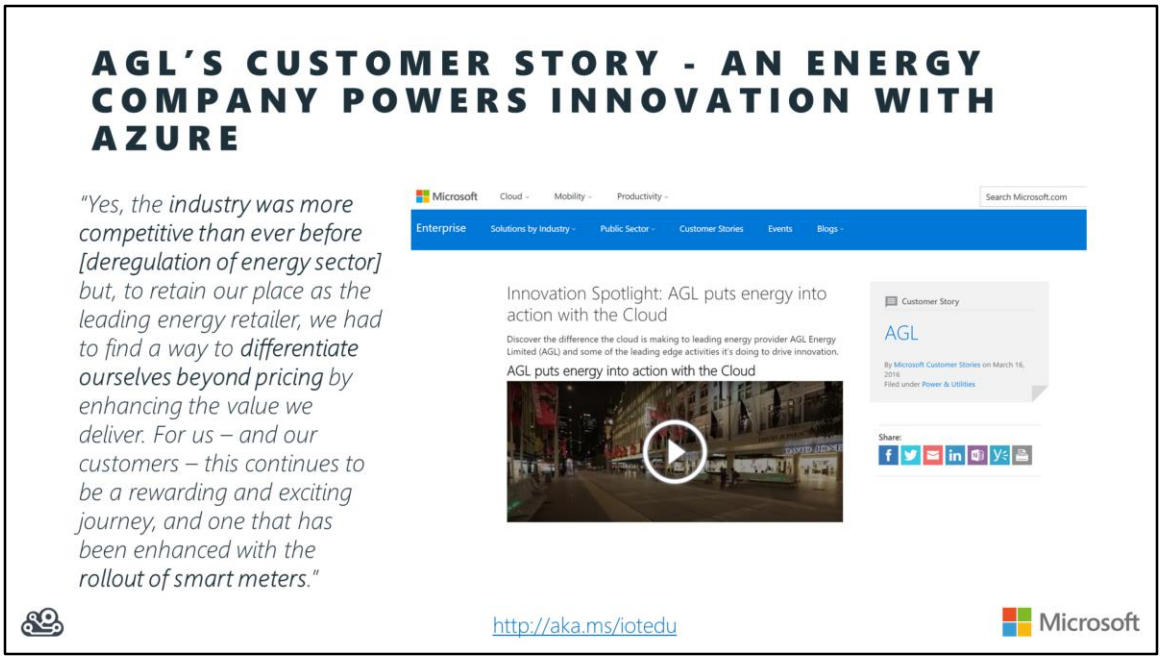
Customers can be also the businesses we enable
CRM is customer relationship management



Story here: https://enterprise.microsoft.com/en-us/industries/power-and-utilities/agl/
Company website: https://www.agl.com.au

About AGL: Australian Gas Light Company (AGL) is one of Australia's leading integrated energy companies and largest ASX listed owner, operator and developer of renewable energy generation in the country. They have 3.7 million customers across Queensland, New South Wales, Victoria and South Australia.

https://www.agl.com.au

"Empowering consumers to better understand their energy consumption, and subsequently lower costs and increase energy efficiency, smart meters are changing our industry, and allowing us to deliver data-rich and consider personalised experiences…."

More energy and utility customer stories: https://enterprise.microsoft.com/en-us/industries/power-and-utilities/

OUR BUSINESS GOAL

- Formulate predictive analytics in the context of the utility and energy domain

- Generalizing and modifying an end-to-end solution template to leverage for future predictive analytics solutions

We will leverage the Energy Demand Forecasting quick start as our learning tool over the next two days.

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MORE GENERAL BUSINESS GOALS

- Demonstrate a typical predictive analytics and machine learning solution
- Short deployment time or time-to-value of an ML-based solution
- Expand to other use cases or a broader scope based on business need
- Quickly gain Cortana Intelligence Suite (CIS) practical knowledge

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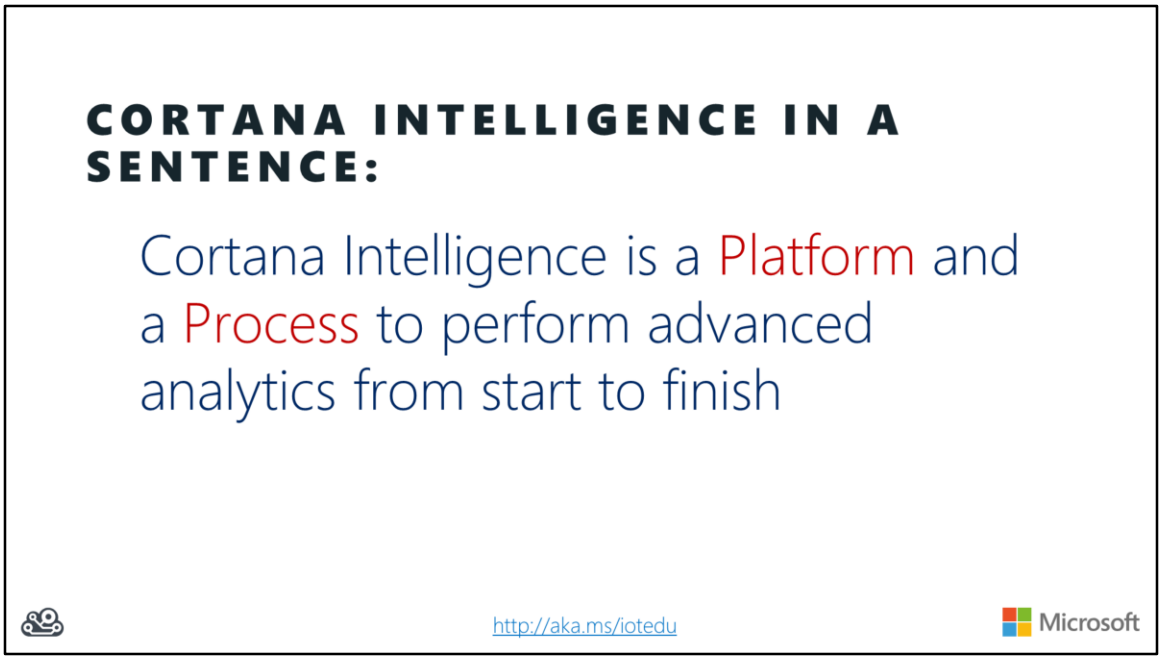

1. What you can do with CIS: https://www.microsoft.com/en-us/server-cloud/cortana-intelligence-suite/why-cortana-intelligence.aspx
2. More about the process: https://channel9.msdn.com/Blogs/Seth-Juarez/Understanding-Data-Science-for-building-Predictive-Analytics-Solutions-by-Francesca-Lazzeri

WHY ENERGY FORECASTING?

It's a great example of forecasting demand and gets us these results:

Cost reduction: Utility and energy companies that want to become more efficient need to forecast power consumption simply because that will give them greater ability to **balance supply and demand**, thus preventing energy wastage, **reduce greenhouse gas emission**, and control cost.

Cost forecasts: New abilities to trade power between utilities have brought in a great need to **forecast future demand and future price of electricity**.

Overload avoidance: By remotely regulating consumption (with the help of smart meters – our IoT devices discussed here), localized **overload situations can be handled**.

IoT + live resources + big data = big opportunities

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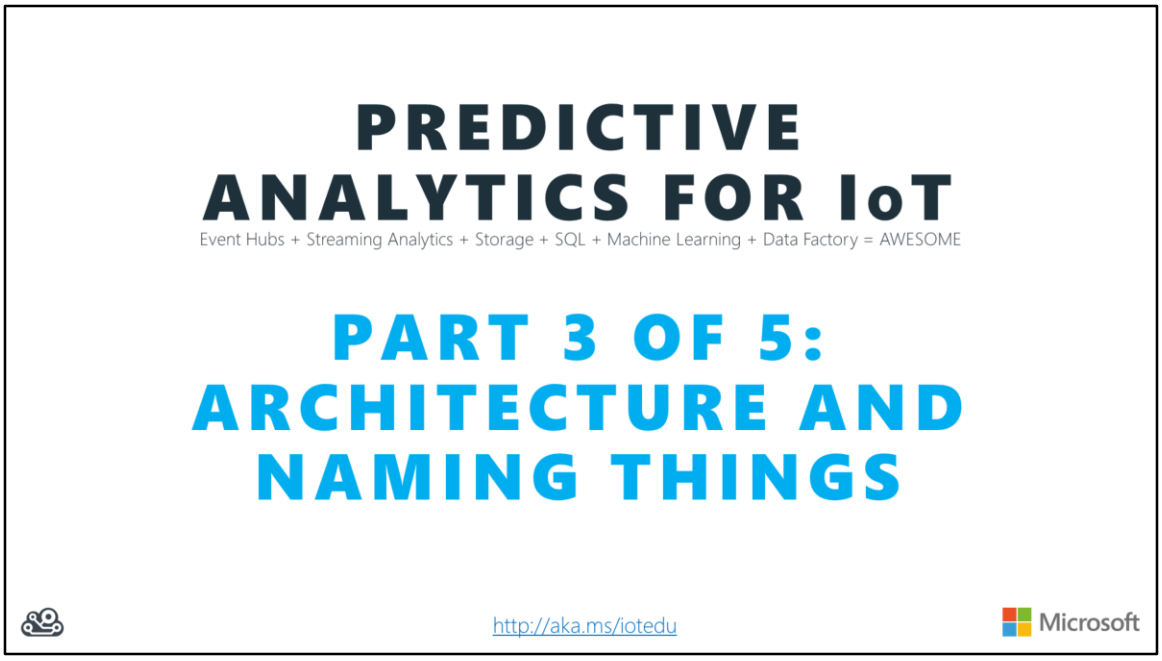
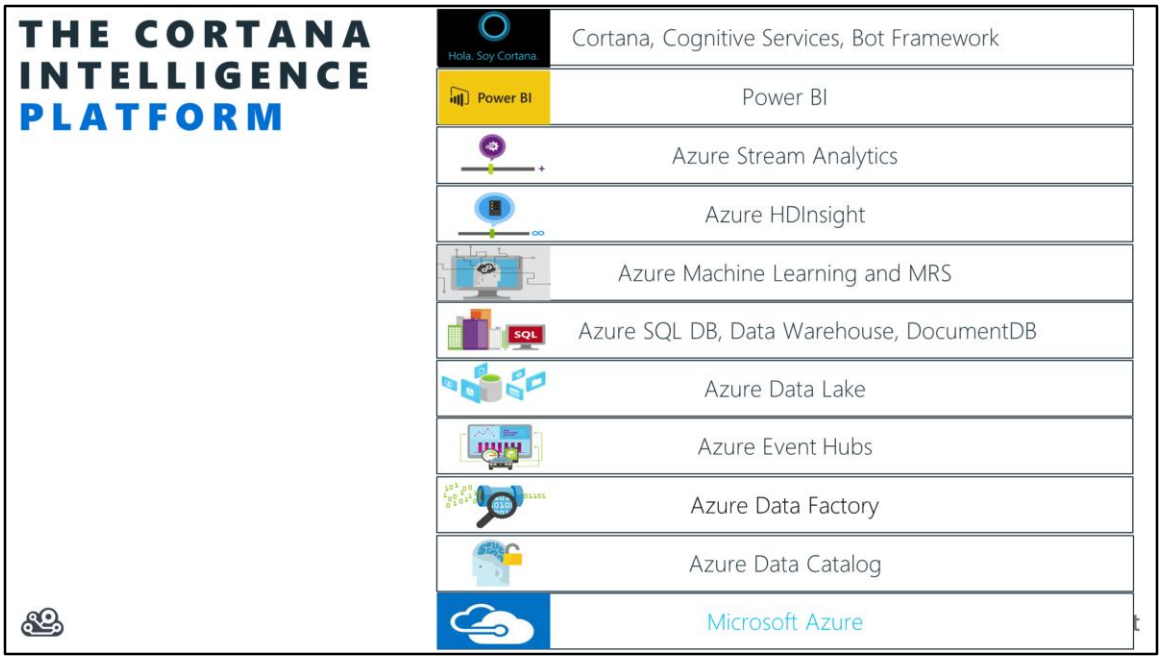
We will be thinking about the forecast horizon in a bit, but for now know that there are different time-range based forecasts that can be done. The forecast horizon is the time-range in the future in which the forecast will fall.

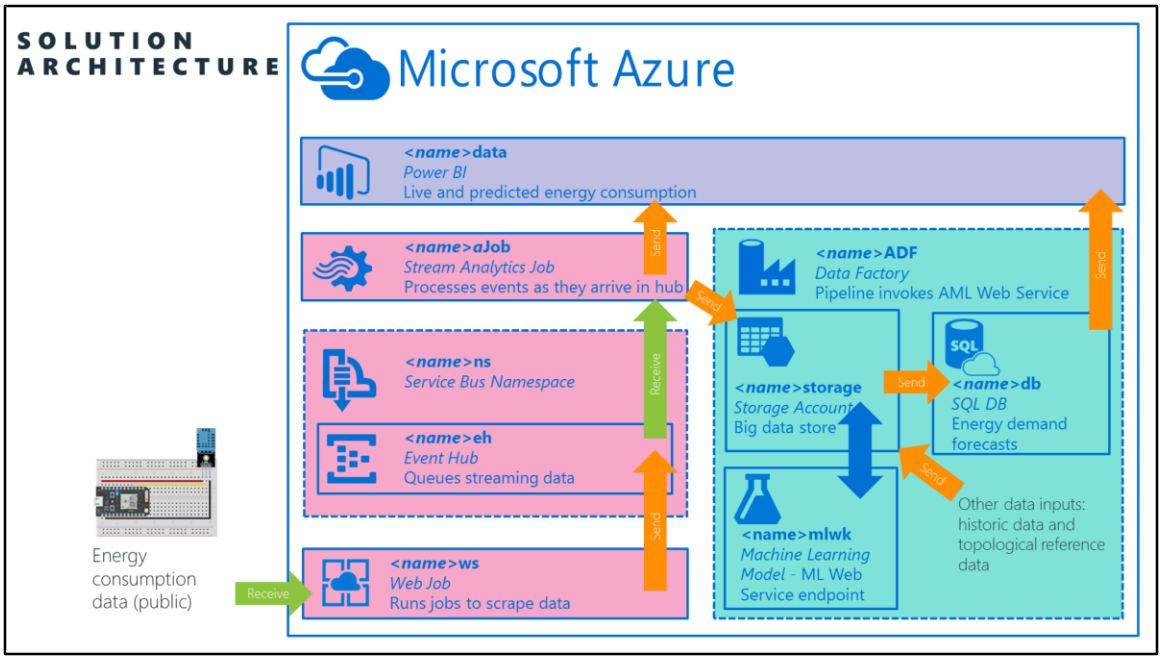


And in this session we will deploy the cloud solution to Azure so make sure you've satisfied your pre-requisites from the class site or registration information.



1. Platform and Storage: Microsoft Azure – http://microsoftazure.com Storage: https://azure.microsoft.com/en-us/documentation/services/storage/ **(Host It)**
2. Azure Data Catalog: http://azure.microsoft.com/en-us/services/data-catalog **(Doc It)**
3. Azure Data Factory: http://azure.microsoft.com/en-us/services/data-factory/ **(Move It)**
4. Azure Event Hubs: http://azure.microsoft.com/en-us/services/event-hubs/ **(Bring It)**
5. Azure Data Lake: http://azure.microsoft.com/en-us/campaigns/data-lake/ **(Store It)**
6. Azure DocumentDB: https://azure.microsoft.com/en-us/services/documentdb/ ,
7. Azure SQL Data Warehouse: http://azure.microsoft.com/en-us/services/sql-data-warehouse/ **(Relate It)**
8. Azure Machine Learning: http://azure.microsoft.com/en-us/services/machine-learning/ **(Learn It)**
9. Azure HDInsight: http://azure.microsoft.com/en-us/services/hdinsight/ **(Scale It)**
10. Azure Stream Analytics: http://azure.microsoft.com/en-us/services/stream-analytics/ **(Stream It)**
11. Power BI: https://powerbi.microsoft.com/ **(See It)**
12. Cortana: http://blogs.windows.com/buildingapps/2014/09/23/cortana-integration-and-speech-recognition-new-code-samples/ and https://blogs.windows.com/buildingapps/2015/08/25/using-cortana-to-interact-with-your-customers-10-by-10/ and https://developer.microsoft.com/en-us/Cortana **(Say It)**
13. Cognitive Services: https://www.microsoft.com/cognitive-services

14. Bot Framework: https://dev.botframework.com/



We'll spend a moment and get an overview of the architecture of the solution template.

Pink background: Data in motion or fast-moving data
Green/blue background: Data at rest or slow-moving data

Data Source and Ingestion
Azure Web Jobs - scrapes data from a streaming data source and shuttles it to the Event Hub
Azure Event Hub - receives the raw data from the Web Job
Data Preparation and Analysis
Azure Stream Analytics - provides near real-time analytics and publishes results to Power BI dashboard, as well as, shuttles raw data to Azure Storage for archiving
Azure Storage - stores the archived, raw streaming data for future processing
Azure Data Factory - orchestrates data flow, running scripts, calling out to the Azure Machine Learning service, and managing the Azure SQL Database service
Azure Machine Learning - returns predictions (here, future power consumption forecasts) based on inputs received using a trained model
Data Publishing and Consumption

Azure SQL Database - stores the results of the Azure Machine Learning service
Power BI - dashboarding service used to show aggregations provided by Azure Stream Analytics (data in motion) and Azure Machine Learning service results stored in Azure SQL Database (data at rest)

COMING UP WITH A GOOD <name>

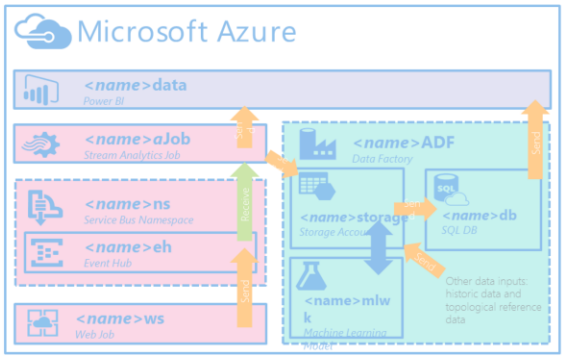
It's recommended that you use a **consistent prefix** when you name your objects in Azure

Many names need to be globally unique. Plus, a good prefix makes it easier to identify them, determine their role, and delete them later when you need to clean up.

The prefix is identified by the "<name>" placeholders in the architecture diagram.

I recommend using something informative and short, containing a marker of who you are such as initials or alias. Such as:

"octenergymh"



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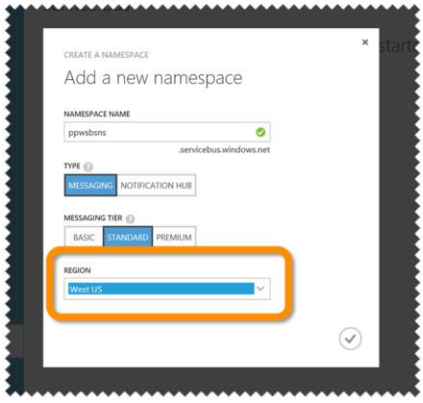
Note: we are using a solution template that when deployed provisions all of these components for us and even starts the ingress of data.

This name will prefix your resources and will also be the name of your resource group (making it easy to tear down when done)

USING THE SAME REGION

As you provision your resources in Azure you should use the same region for all of them.

This will decrease latency between them as well as reduce costs by eliminating data leaving one region as it travels to another.



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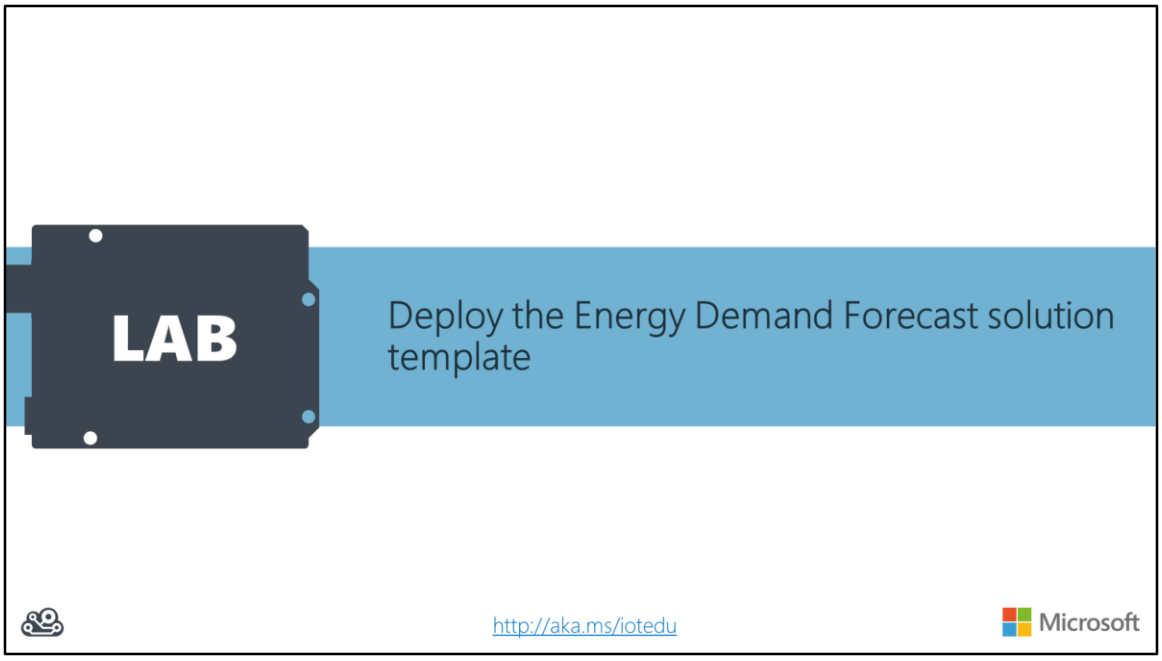
This is done automatically for us when we choose a region for the solution template, but when you create a custom solution this is something to consider.



Follow along with the instructor and instructions under “Labs” on the class site and the file called “LabProvision.md”

PREDICTIVE ANALYTICS FOR IoT

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PART 4 OF 5: DATA UNDERSTANDING

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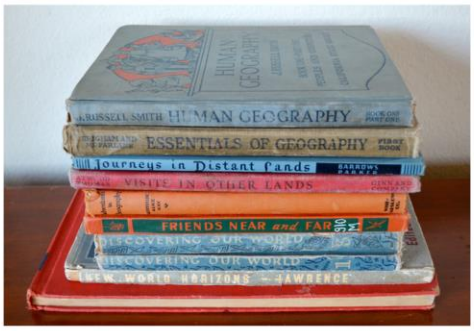
DATA TYPES

Streaming vs. Historic



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What are some examples of streaming data and the use cases around them?

What about historic data?

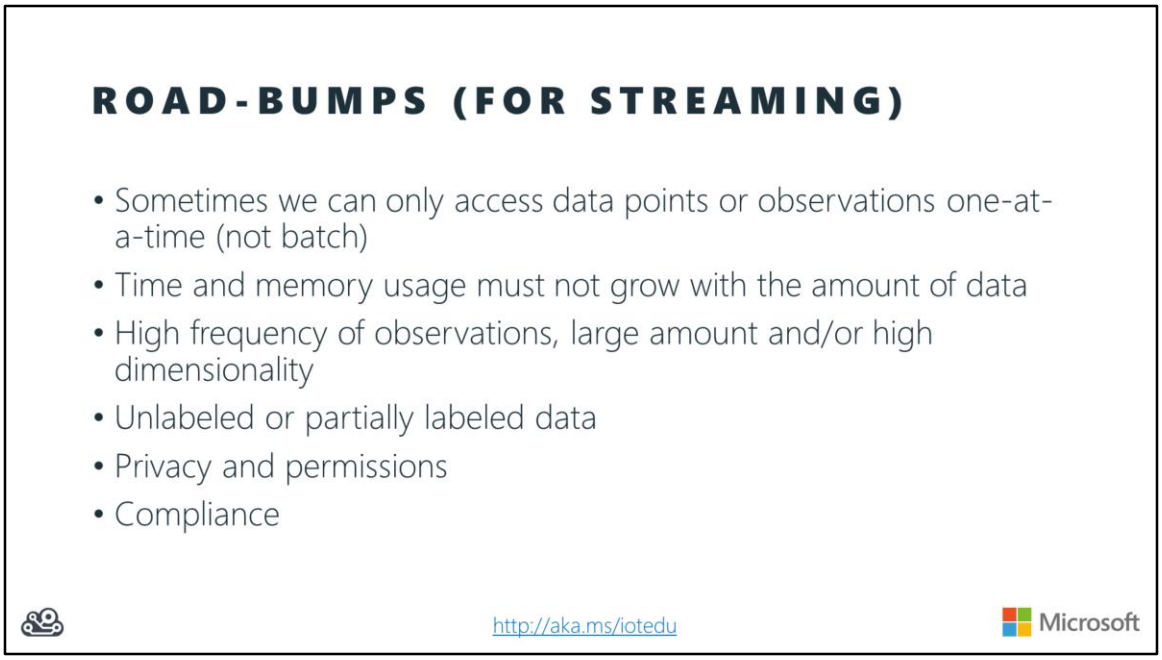
STREAMING - TYPES AND EXAMPLES

- Sensor (humidity, temperature, altitude) – multidimensional
- Resource-constrained or limited by processing, storage and often battery life (many hand-held devices are this way)
- Text-based (email – you may detect spam as email comes in)
- Video
- Sounds
- ...almost anything with a timestamp

REFERENCE – TYPES AND EXAMPLES

- Regional, historical (temperature and humidity aggregated by day for a city)
- Flight data (airports, delays, air speed, departure and arrival times)
- Harvest data (crop yields from previous seasons)
- Load data (energy consumption for a suburb within a city grouped by day of the week for the past 5 years)

- Often when we use the words *past*, *grouped-by*, *aggregated*...



How to perform stats or train/retrain machine learning models
In resource-constrained might be limited by the amount of storage on a device
Labels are needed for many machine learning algorithms (those of the supervised learning type)
Maintain privacy while being able to extract patterns from the data
Complying with laws and regulations while performing useful tasks on data

PREDICTIVE ANALYTICS FOR IoT

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PART 5 OF 5: DATA IN MOTION

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STREAMING DATA CASE STUDIES

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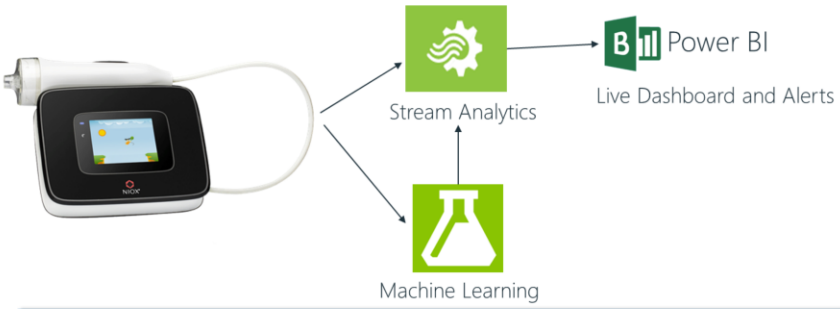
Aerocrine

NIOX® | CHANGING THE FACE OF ASTHMA CONTROL

Millions of asthma sufferers worldwide depend on Aerocrine monitoring devices to diagnose and treat their disease effectively. But those devices are sensitive to small changes in ambient environment. Aerocrine is using Stream Analytics to detect anomalies in Humidity which could potentially lead to device malfunction.

How real time analytics changes the business dynamics in the healthcare industry



"The ability to collect vital telemetry data from deployed devices has been a key objective of ours. A cloud-based solution allowing us to collect data on device performance in real-time helps us to be more proactive in our customer support and ensure that our NIOX devices help the physicians deliver the best possible outcome for the patient."

- Scott Myers, CEO of Aerocrine.

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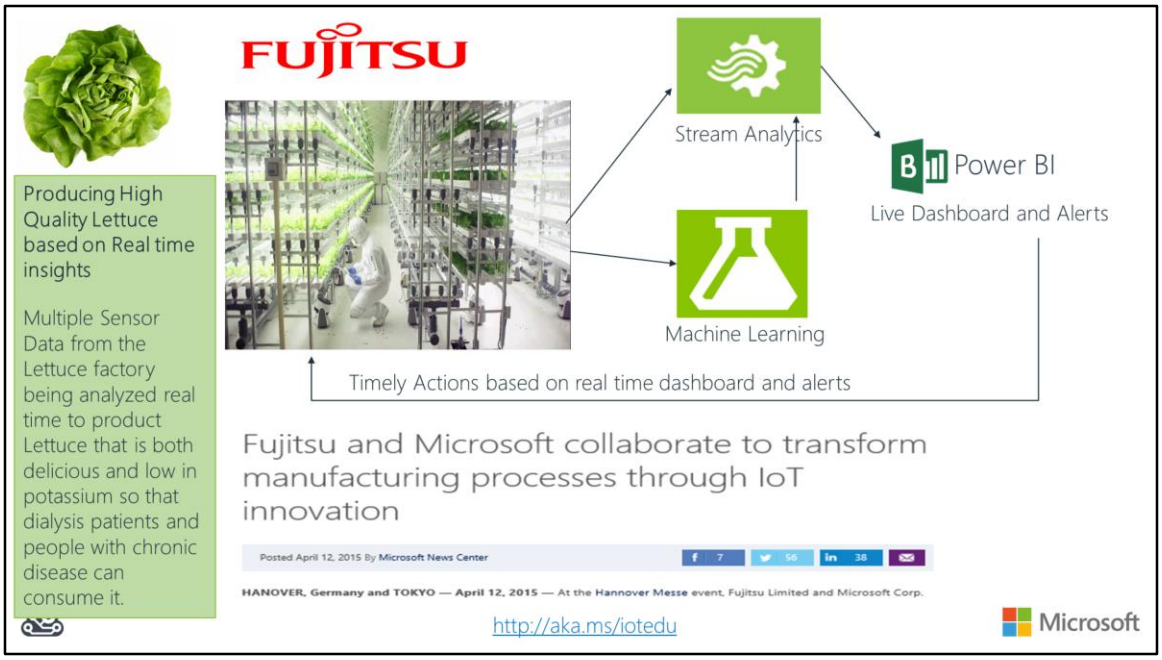
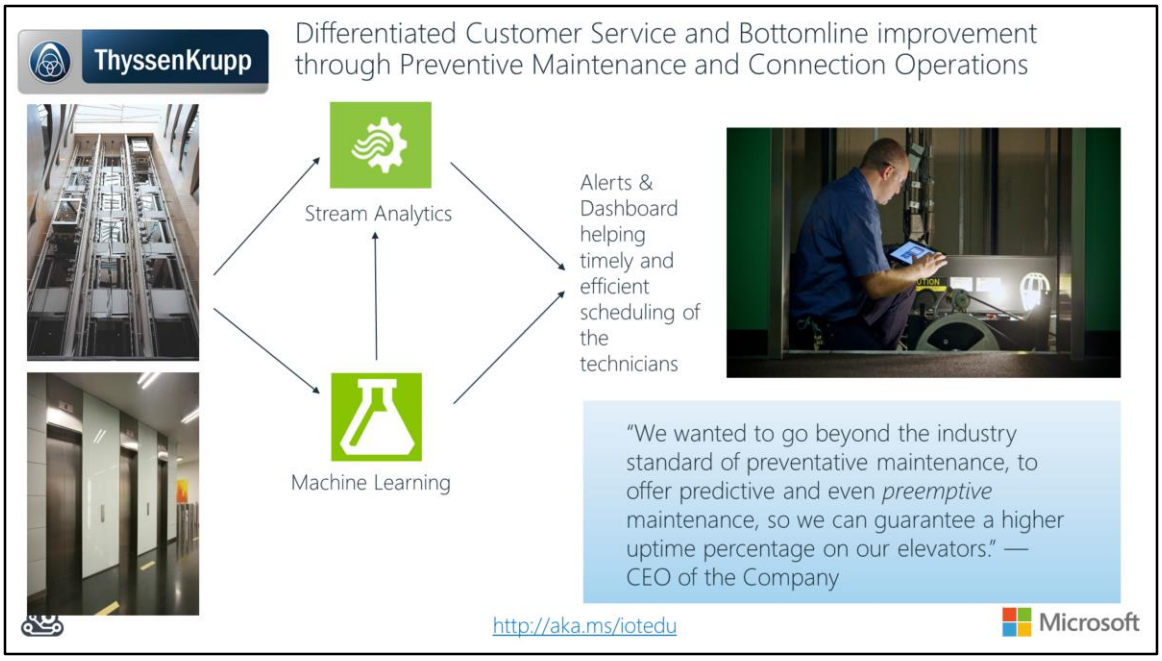
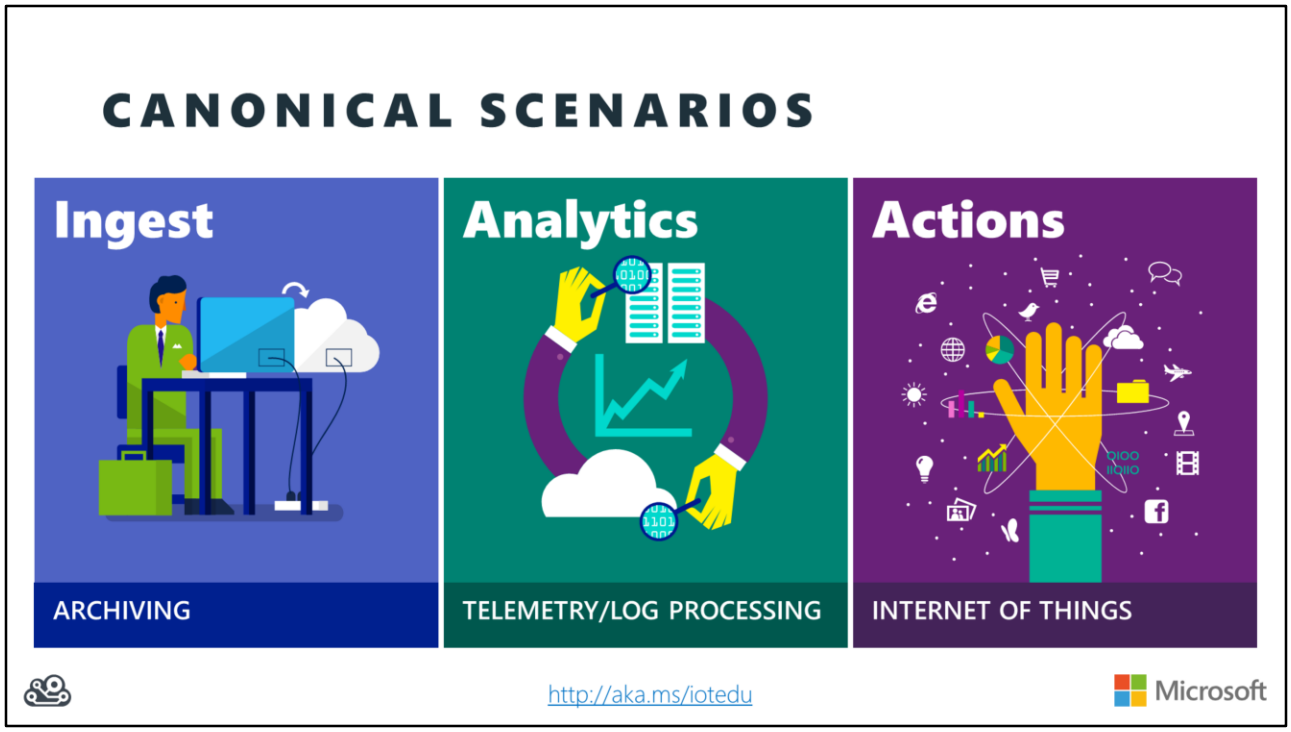
Press Release:
Case Study:



Press Release:
Case Study:



Press Release:
Case Study:



Ingest Use Case: Blob Historian

The expectations for fast and agile execution in businesses continue to grow. Businesses and developers are now opting for easy-to-use, cloud-based platforms to cope with the demand for more agility, and are looking for platforms that enable them to ingest and process a continuous stream of data generated by their systems in near real-time. The canonical Blob Historian scenario can be described as follows: Data from various devices and platforms which are geo-distributed across the world are pushed to a centralized data collector. Once the data is at the central location, some stateless transformation is performed on them such as scrubbing PII information, adding geo-tagging, IP lookup etc. The transformed data is then archived into Blob storage in a fashion which can be **readily consumed by HDInsight** for offline processing. Also **Replay for RCA** etc.

Analytics Use Case: Telemetry/Log Processing

Monitoring to reduce TTD, TTM

As the volume of devices, machines and applications grow, the most common enterprise use case to run businesses is the need to monitor and respond to changing business needs by creating rich analytics near real-time.

The canonical Telemetry/Log Processing scenario can be described using the Online

Service or Application example, however the pattern is commonly seen across businesses that collect and report on application or device telemetry. The application or service regularly collects health data (data representing the current status of the application or infrastructure at a point in time) in addition to user request logs and other data representing actions or activities performed within the application. The data is historically saved to a blob or other type of data store for further processing. With the recent trend towards real-time dashboarding, in addition to saving the data to a blob or other type of store for historical analysis, customers are looking to process and transform the stream of incoming data directly such that it can be immediately provided to end users in the form of Dashboards and/or Notifications when action needs to be taken, for example if the site goes down operations personnel can be notified to begin investigation and resolve the issue quickly.
As more data is gathered and processed Machine Learning can also be used to develop and learn from patterns seen in the system such that it is possible to better predict when machines may need to be serviced or when things are about to go wrong.

Operations Use Case: IoT Scenario
Command and Control, Maintenance
As devices become smarter and more devices are built with communication capabilities, the expectation of what can be done with the data generated and collected from these devices continues to evolve both in the commercial and consumer spaces. It is expected that with so much data available, we can quickly combine and process the data, gaining more insight into the environment around us, and the devices we use regularly.
The canonical IoT Scenario is often described using the **Vending Machine** example, however the pattern is commonly seen across IoT use cases. The Devices, the Vending machines, regularly send information (product stock, status, temperature, etc. data) to either a field gateway (if the device is Non-IP capable) or to a cloud gateway (IP Capable) for ingestion into the system. The incoming data stream is processed and transformed such that it can be immediately provided to end users in the form of Dashboards and Notifications when action needs to be taken, for example when product in a specific vending machine gets low, the relevant representative can be notified to restock the machine, or if the machine is in need of repair a technician can be scheduled. In some cases, the action that needs to be taken may be as simple as rebooting the machine or pushing down a firmware upgrade which can be done without the need for human interaction.
As more data is gathered and processed Machine Learning can also be used to develop and learn from patterns seen in the system such that it is possible to better predict when machines may need to be serviced or when things are about to go wrong.

PATTERN AND ARCHITECTURE

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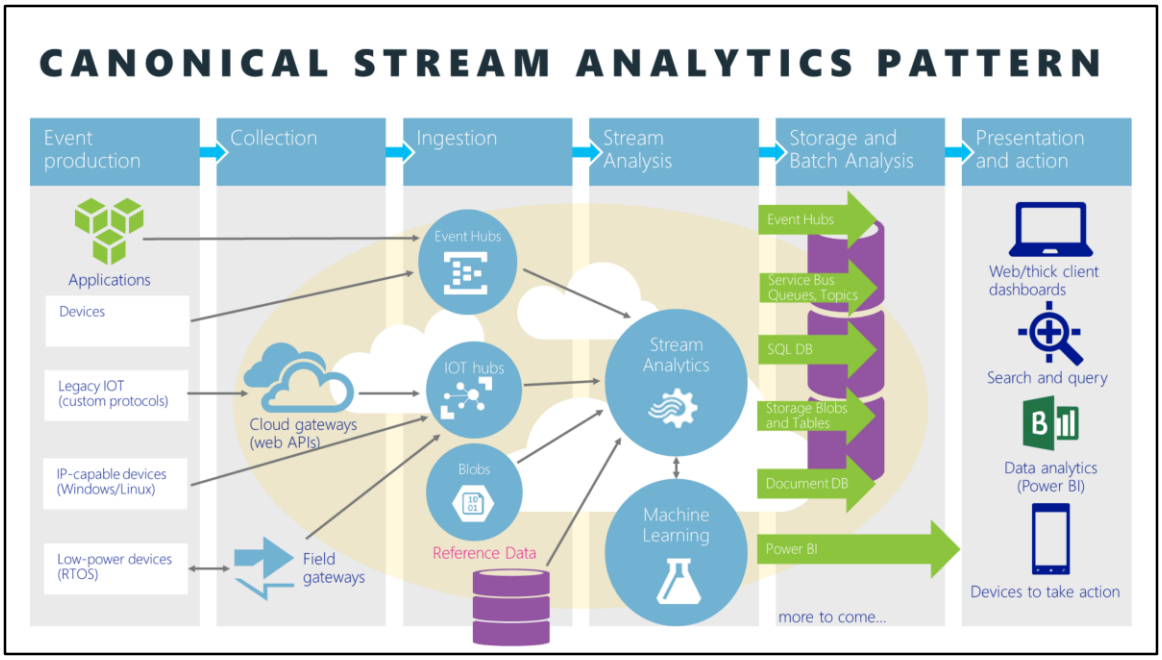
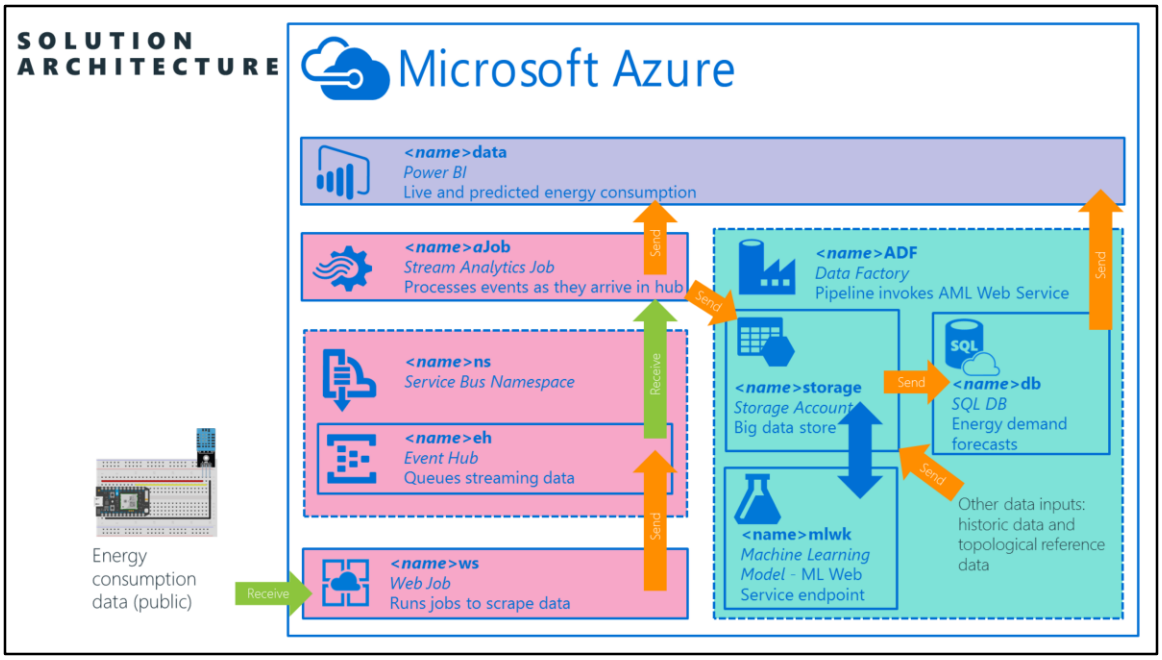


- **Stream Analytics is a building block** in a world of larger compositions of platform services
- Prominent integrations with **Event Hubs**, **Machine Learning** (new!), various output stores, and **Power BI**



Back to our architecture diagram

Pink background: Data in motion or fast-moving data
Green/blue background: Data at rest or slow-moving data

WEB JOBS

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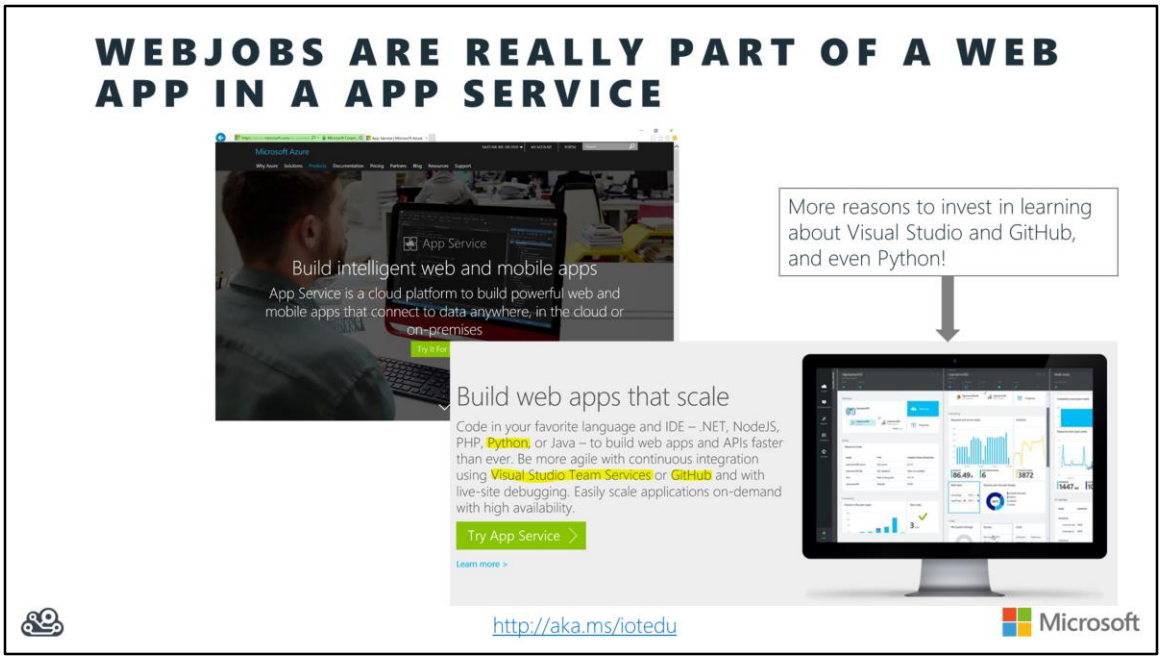
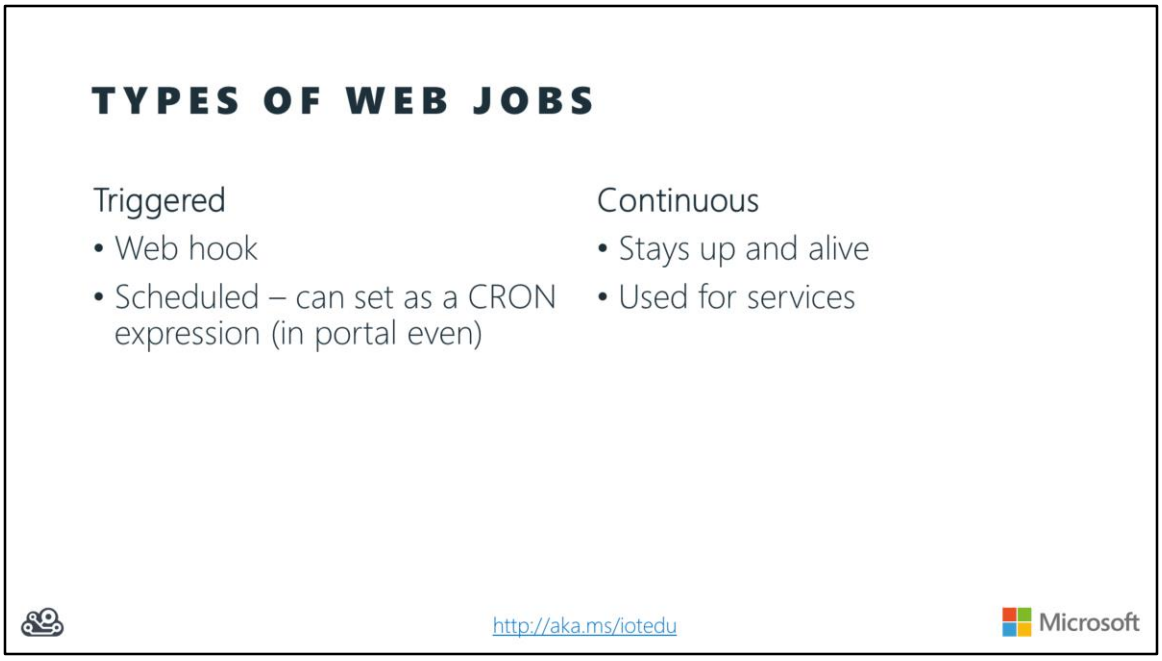
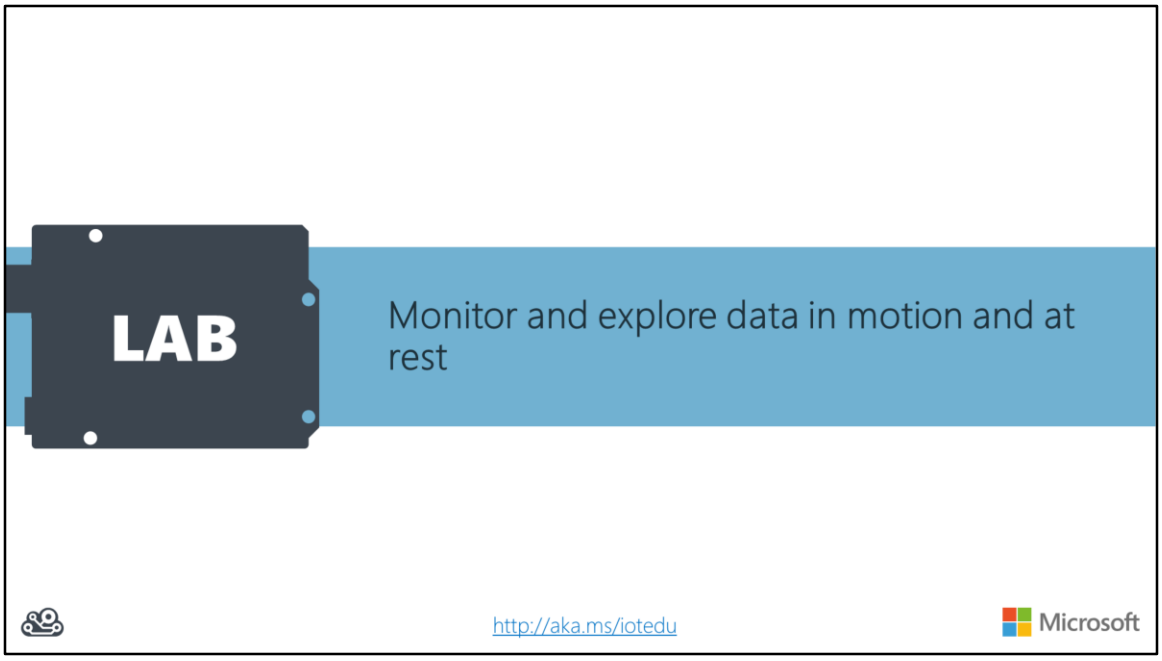


What are they? How can you create them? What types of scripting languages can you use? Answers here: https://azure.microsoft.com/en-us/documentation/articles/web-sites-create-web-jobs/

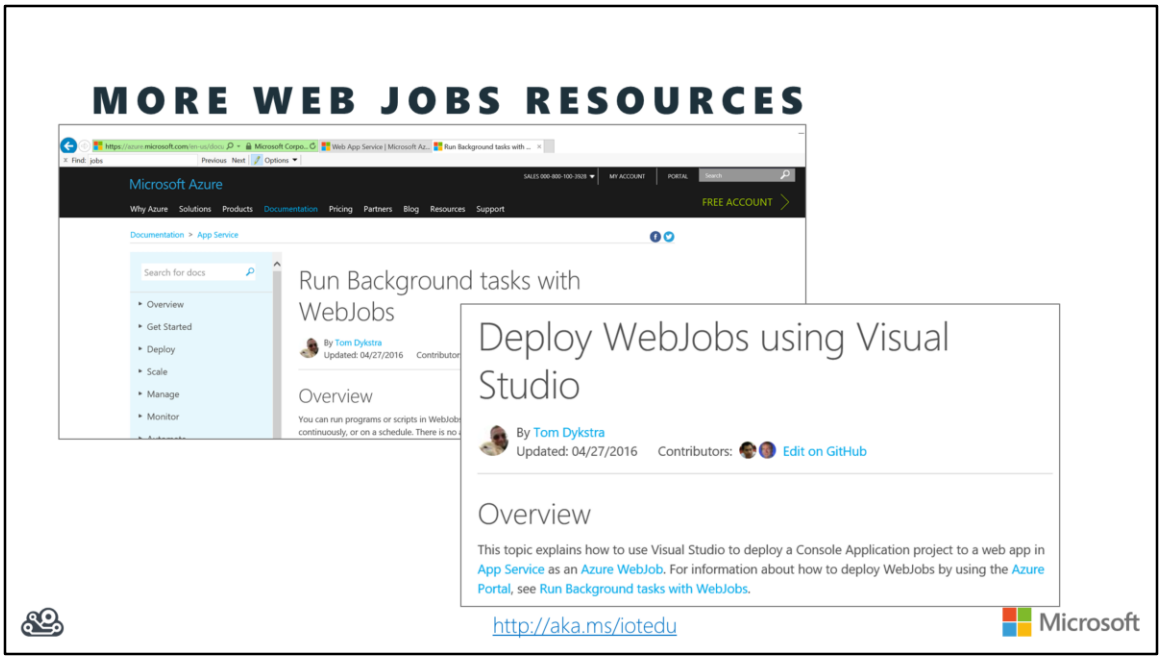
How to programmatically leverage them with SDKs (note: samples on github): https://azure.microsoft.com/en-us/documentation/articles/websites-dotnet-webjobs-sdk/



Video on the new UX for Web Jobs in the Azure portal and good description of Web Jobs in general: https://channel9.msdn.com/Shows/Azure-Friday/Azure-web-jobs-and-new-UX



Follow the instructions under “Labs” -> LabWebJobs.md or here: https://github.com/michhar/data-pipeline-education/blob/master/Labs/LABWebJobs.md

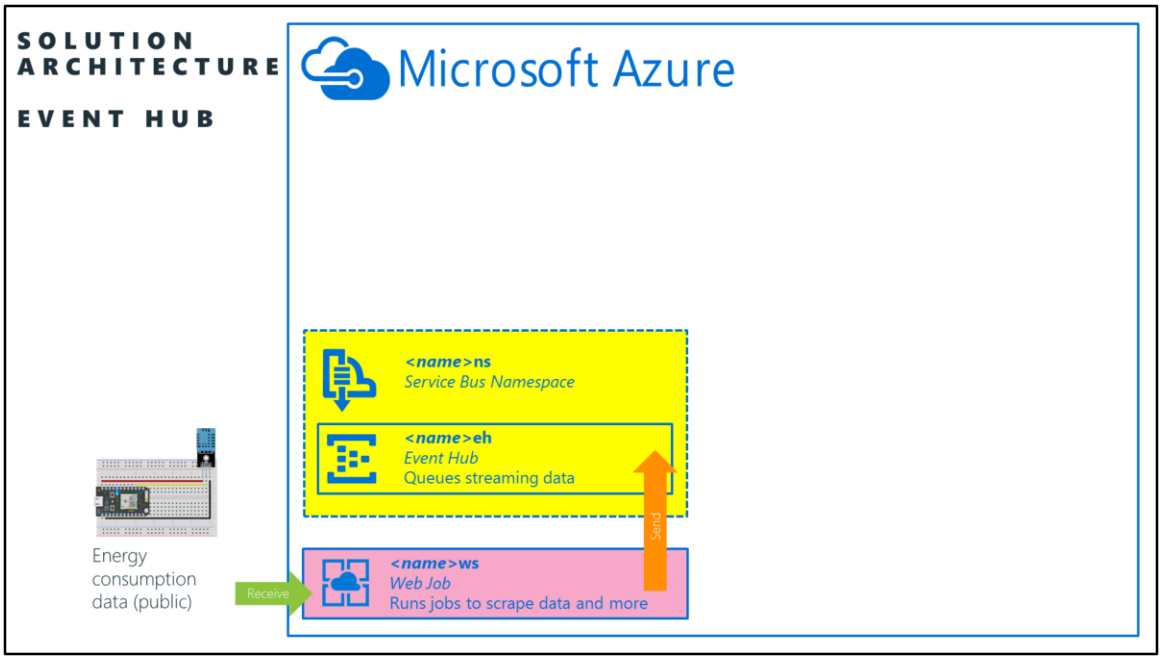


Deploy from VS in various languages, but here's .NET sdk exaple: https://azure.microsoft.com/en-us/documentation/articles/websites-dotnet-deploy-webjobs/

EVENT HUBS

http://aka.ms/iotedu

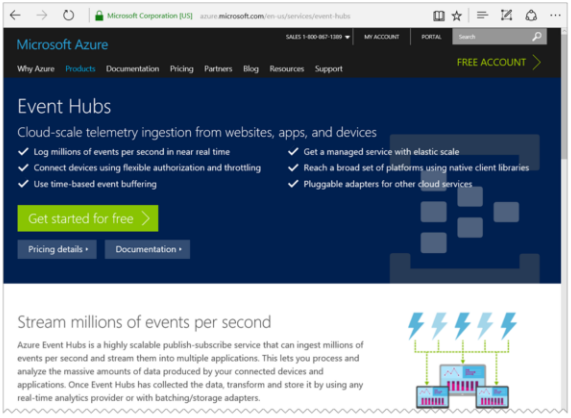
Microsoft



Pink background: Data in motion or fast-moving data
Green/blue background: Data at rest or slow-moving data

AZURE EVENT HUBS

"Azure Event Hubs is a highly scalable publish-subscribe service that can ingest millions of events per second and stream them into multiple applications."



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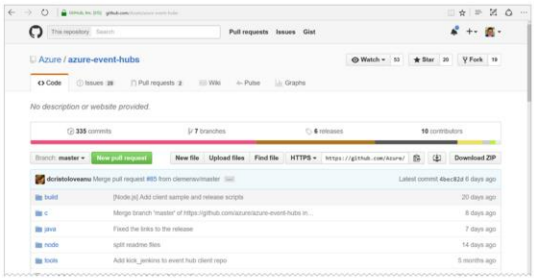
Microsoft

Learn more here: https://azure.microsoft.com/services/event-hubs/

AZURE-EVENT-HUBS REPOSITORY

Azure Event Hub clients for

- C
- Java
- Node.js



https://github.com/Azure/Azure-event-hubs

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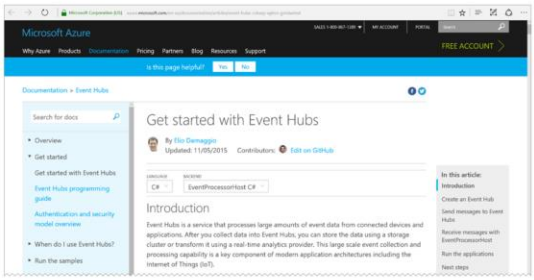
Microsoft

.NET EVENT HUB CLIENT TUTORIAL

The .NET client library is available as a NuGet package.

Get started using Event Hubs from C#. This tutorial helps you create both a sender and a receiver using the "Microsoft Azure Service Bus" and "Microsoft Azure Service Bus Event Hub - EventProcessorHost" NuGet packages.



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Microsoft

STREAM ANALYTICS

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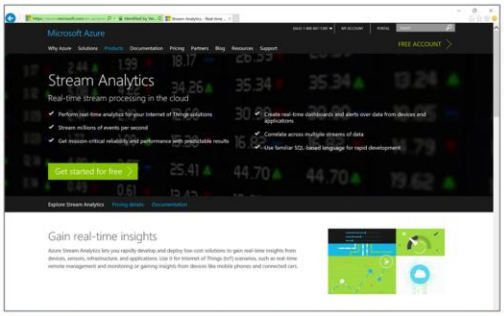
STREAM ANALYTICS

*Azure Stream Analytics is an **event processing engine** in the cloud that uncovers insights from devices, sensors, cloud infrastructure, and applications in real-time. With **out-of-the-box integration to Event Hubs**, the combined solution can ingest millions of events and do analytics to better understand patterns, **power a dashboard**, or kick off an action while data is being **streamed in real-time**.*



https://azure.microsoft.com/services/stream-analytics/

http://aka.ms/iotedu

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Landing page: https://azure.microsoft.com/en-us/services/stream-analytics/

REAL-TIME ANALYTICS

Fully managed real-time analytics

Real-time Analytics

- Intake **millions of events per second** (up to 1 GB/s)
- **Low processing latency**, auto adaptive (sub-second to seconds)
- **Correlate** between different streams, or with reference data
- Find **patterns** or lack of patterns in data in real-time

Fully Managed Cloud Service

- No hardware acquisition and maintenance
- No platform/infrastructure deployment and maintenance
- Easily **expand your business globally** leveraging Azure regions

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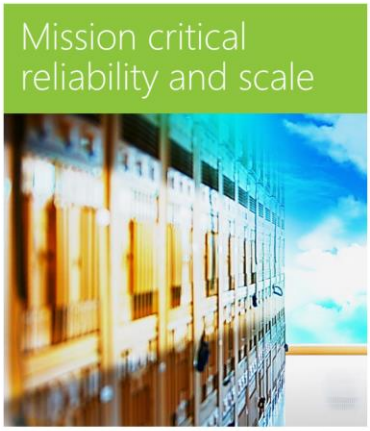
MISSION CRITICAL



Mission Critical Reliability

- **Guaranteed event delivery**
- **Guaranteed business continuity**: Automatic and fast recovery

Effective Audits

- **Privacy and security** properties of solutions are evident
- Azure integration for **monitoring and ops alerting**

Easy To Scale

- **Scale** from small to large on demand

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Microsoft

31:00

RAPID DEVELOPMENT

Enables rapid development

Rapid Development with SQL like language

- **High-level**: focus on stream analytics solution
- **Concise**: less code to maintain
- **Fast test**: Rapid development and debugging
- First-class support for **event streams and reference data**

Built in temporal semantics

- Built-in **temporal windowing and joining**
- Simple **policy configuration** to manage out-of-order events and late arrivals

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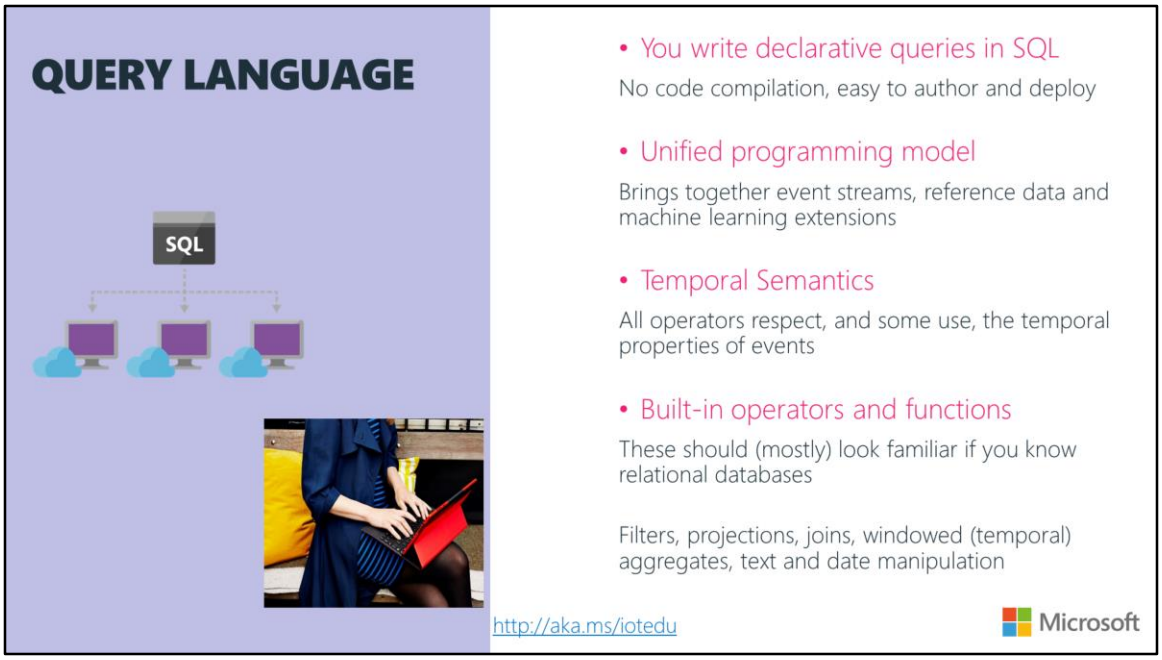
Microsoft

33:00



Data-first, queries-first

Focus on what matters most

No need to spend most of your time on *plumbing* code

Democratize Event Processing

Language and constructs familiar to most developers

Simplify, empower, extend

Built-in operators, powerful but easy to use

Temporal semantics (no PhD required)

Machine learning ready

Unify

Live streams, historical and reference data, all together, same query language, same runtime, same results

QUERY LANGUAGE

A Subset of T-SQL

Can take data in from either streams (Event Hubs) or static data (Blobs) or relational data (SQL Database)

Can join multiple streams. For example you could join event hub message data with relational data from a database

Can output data to a streams, static data, databases, or Power BI.

Has powerful windowing functions for creating aggregations over Tumbling, Hopping or Sliding time windows

https://msdn.microsoft.com/library/azure/dn834998.aspx

http://aka.ms/iotedu

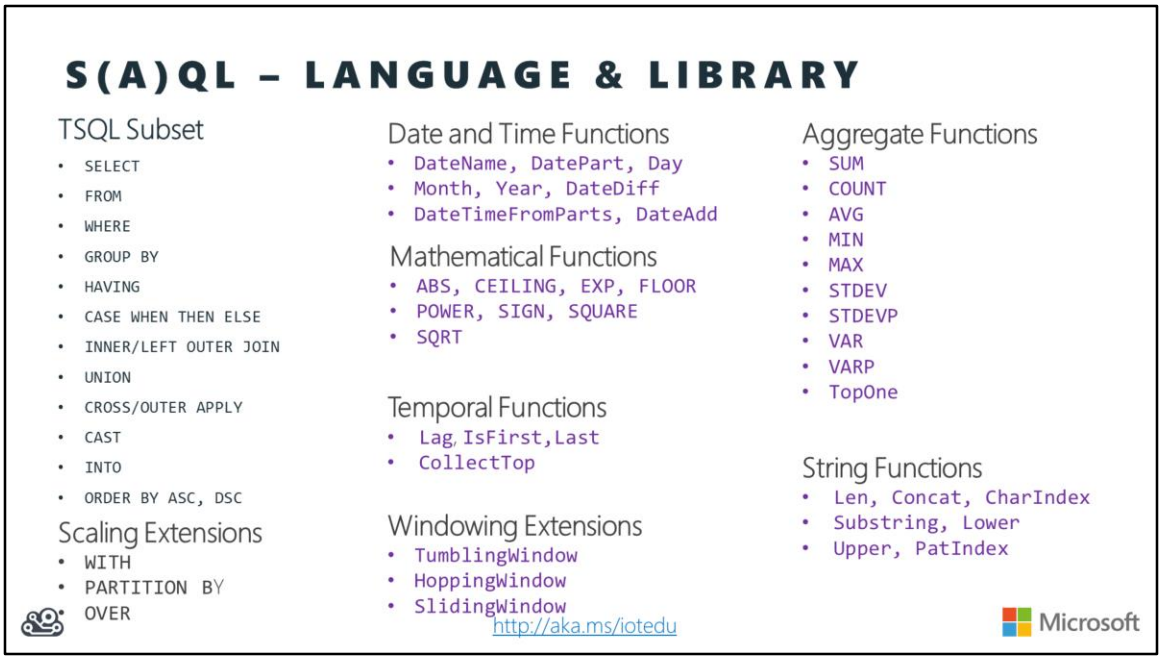
Microsoft

Link from slide: https://msdn.microsoft.com/library/azure/dn834998.aspx – query language reference

It is essential to understand the progress of time. Every event that flows through the system comes with a timestamp that can be accessed via System.Timestamp.

Toll Booth scenario
A tolling station is a common phenomenon – we encounter them in many expressways, bridges, and tunnels across the world. Each toll station has multiple toll booths, which may be manual – meaning that you stop to pay the toll to an attendant, or automated – where a sensor placed on top of the booth scans an RFID card affixed to the windshield of your vehicle as you pass the toll booth. It is easy to visualize the passage of vehicles through these toll stations as an event stream over which interesting operations can be performed.

What are two different ways a timestamp could be made in this scenario?

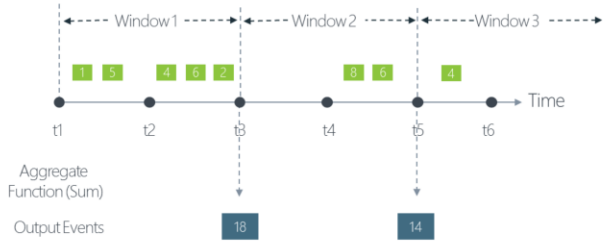


- Let's take a quick look at the ASA language – Stream Analytics Query Language
- A subset of T-SQL, extended with temporal concept, aggregation and dynamic schema

- Built-In Functions (purple) https://msdn.microsoft.com/en-us/library/azure/dn835030.aspx
- T-SQL-based functions (black) https://msdn.microsoft.com/en-us/library/azure/mt582049.aspx

WINDOWING CONCEPTS

- Windows can be – Hopping, Sliding or Tumbling
- Windows are **fixed** length
- Output event will have the timestamp of the **end** of the window
- Must be used in a **GROUP BY** clause



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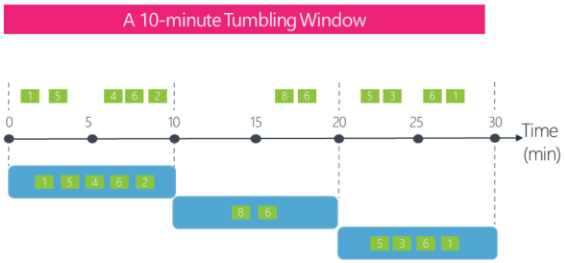
Microsoft

- Windowing is a core requirement for streaming analytic applications
- Common requirement to perform some set-based operation (count, aggregation etc.) over events that arrive within a specified period of time
- Azure Stream Analytics supports three types of windows: Hopping, Sliding and Tumbling
- Every window operation outputs events at the end of the window
- The output of the window will be single event based on the aggregate function used. The event will have the time stamp of the end of the window
- All windows have a fixed length
- All windows should be used in a GROUP BY clause

TUMBLING WINDOWS

Tell me the sum of the energy load over 10 minute intervals

```
SELECT
  System.Timestamp as T,
  PTID,
  SUM(Load) as Load
FROM
  InputEventHub
  TIMESTAMP BY utcTimeStamp
  GROUP BY PTID, TumblingWindow(minute, 10)
```



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Microsoft

Tumbling windows:

- Repeat
- Are non-overlapping

An event can belong to only one tumbling window

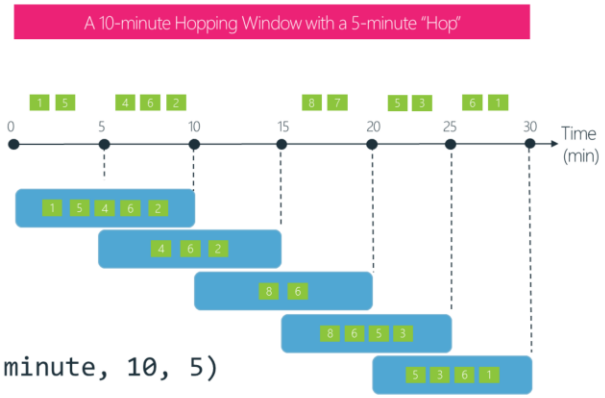
Note on timestamps in stream analytics

In Azure Stream Analytics, all events have a well-defined timestamp.
You may use the TIMESTAMP BY keyword to specify the column in the payload
Example query with TIMESTAMP BY:

HOPPING WINDOWS

Every 5 minutes give me the sum of the energy load over the last 10 minutes

```
SELECT
  System.Timestamp as T,
  PTID,
  SUM(Load) as Load
FROM
  InputEventHub
  TIMESTAMP BY utcTimeStamp
  GROUP BY PTID, HoppingWindow(minute, 10, 5)
```



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Microsoft

Hopping windows:

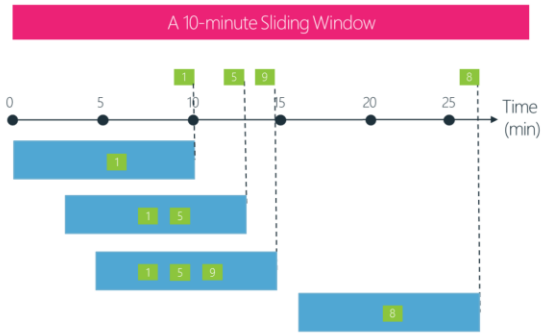
- Hop forward in time by a fixed period
- Repeat
- Can overlap

Same as tumbling window if hop size = window size

Events can belong to more than one hopping window

SLIDING WINDOWS

Give me the summed energy load when it is more than 3 energy units in the last 10 minutes




```
SELECT
  System.Timestamp as T,
  PTID,
  SUM(Load) as Load
FROM
  InputEventHub
  TIMESTAMP BY utcTimeStamp
  GROUP BY PTID, SlidingWindow(minute, 10)
  HAVING SUM(Load) > 3
```

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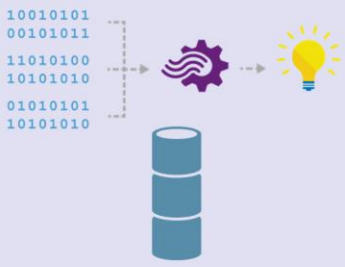
Microsoft

Sliding window:

- Continuously moves forward by an € (epsilon)
- Produces an output *only during the occurrence of an event*
- Every window will have at least one event

Events can belong to more than one sliding window

REFERENCE DATA



Seamless correlation of event streams with reference data

Static or slowly-changing data stored in blobs

CSV and JSON files in Azure Blobs;
scanned for new snapshots on a settable cadence

JOIN (INNER or LEFT OUTER) between streams and reference data sources

Reference data appears like another input:

```
SELECT myRefData.Name, myStream.Value
FROM myStream
JOIN myRefData
       ON myStream.myKey = myRefData.myKey
```

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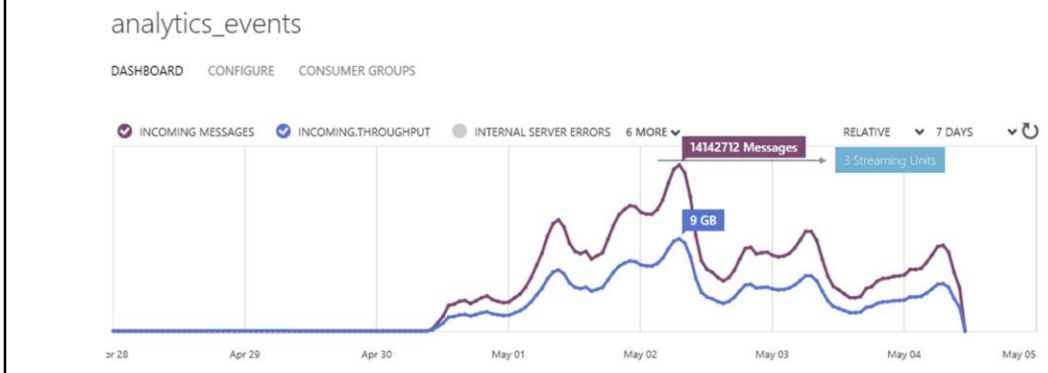
Microsoft

This has been done also for us in the ASA job query so you may wish to take a look.

ADVANTAGE OF CLOUD – SCALE AND COSTS



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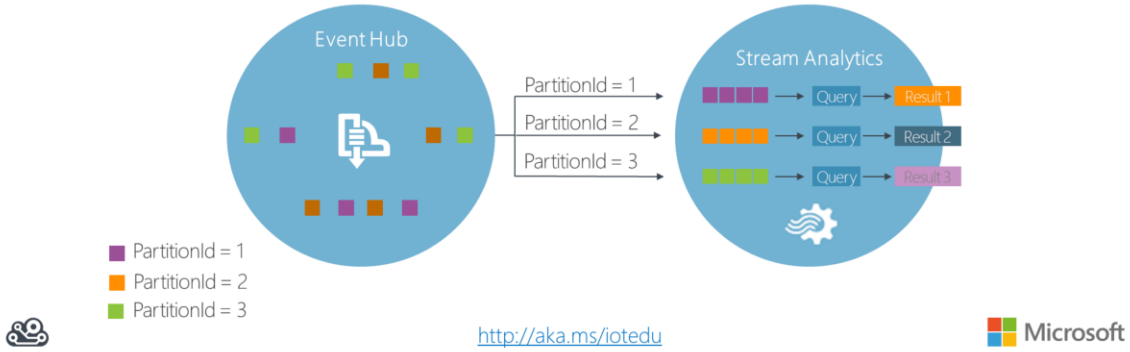
Microsoft

Pay only for what you use and per hour billing
Pricing details: https://azure.microsoft.com/en-us/pricing/details/stream-analytics/

SCALING USING PARTITIONS

Partitioning allows for parallel execution over scaled-out resources

```
SELECT SUM(*) AS Sum, PTID
FROM InputEventHub PARTITION BY PartitionId
GROUP BY TumblingWindow(minute, 10), PTID, PartitionId
```



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Microsoft

More Advanced, but here for reference.

When a query is partitioned, input events will be processed and aggregated in separate partition groups
Output events are produced for each partition group

Partitioning a step enables more streaming units to be allocated to a job as there is a limit on the number of units that can be assigned to an un-partitioned step.

Partitioning requires that all three conditions listed in the slide be satisfied.

When a query is partitioned, the input events will be processed and aggregated in separate partition groups, and outputs events are generated for each of the groups. If a combined aggregate is desirable, you must create a second non-partitioned step to aggregate.

You can always partition by the PartitionId field, which is a built-in field in your query. The PartitionId field indicates from which partition of source data stream the event is from. Since Event Hubs supports partitioning, you can easily develop partitioned queries that read data from Event Hubs.

MULTIPLE STEPS, MULTIPLE OUTPUTS

```
WITH Step1 AS (
    SELECT Count(*) AS CountTweets, Topic
    FROM TwitterStream PARTITION BY PartitionId
    GROUP BY TumblingWindow(second, 3), Topic, PartitionId
),
Step2 AS (
    SELECT Avg(CountTweets)
    FROM Step1
    GROUP BY TumblingWindow(minute, 3)
)
SELECT * INTO Output1 FROM Step1
SELECT * INTO Output2 FROM Step2
SELECT * INTO Output3 FROM Step2
```

- A query can have **multiple steps** to enable pipeline execution
- A step is a sub-query defined using **WITH** ("common table expression")
- Can be used to develop complex queries more elegantly by creating a **intermediary named result**
- Creates unit of execution for scaling out when **PARTITION BY** is used
- Each step's output can be sent to multiple output targets using **INTO**

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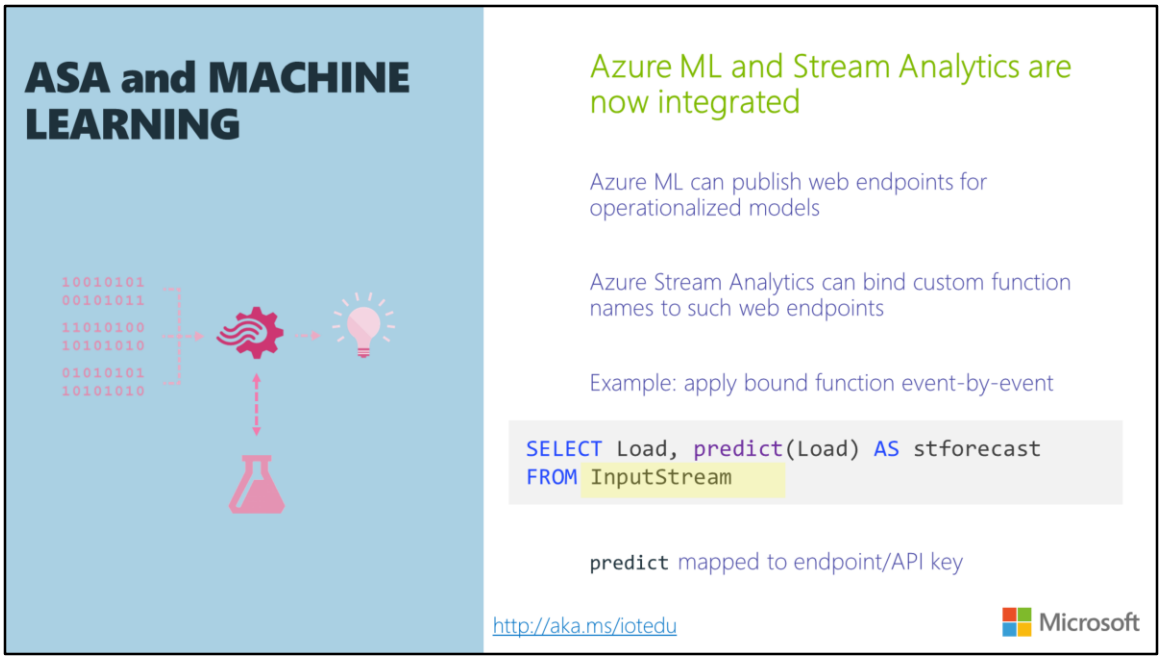
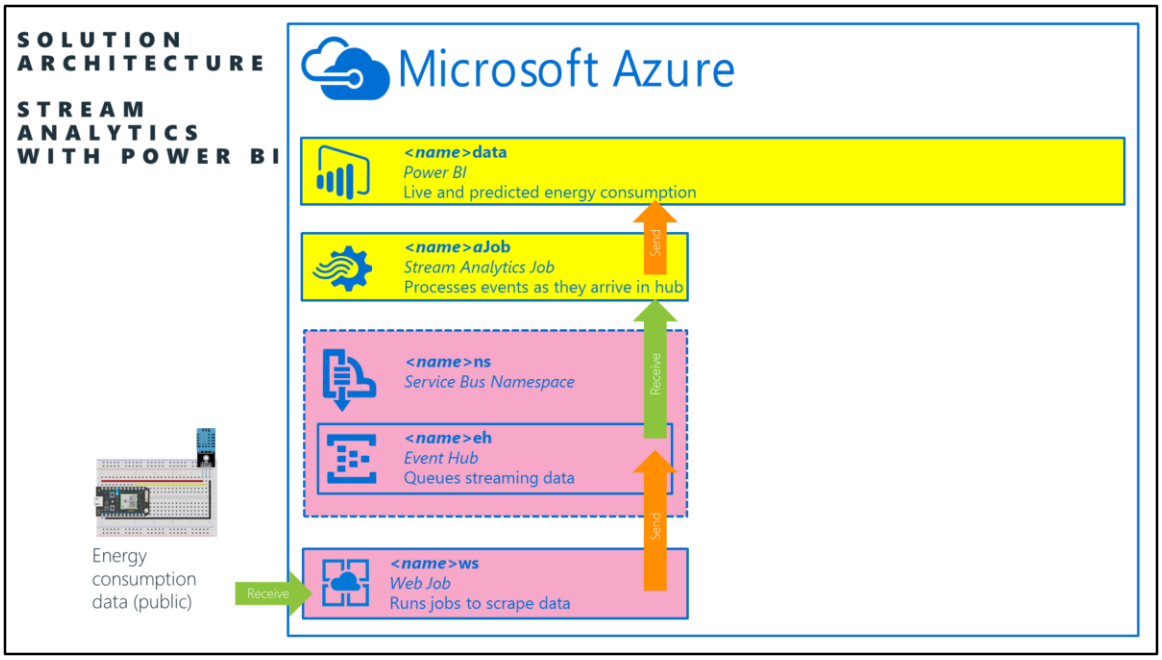
Microsoft

More advanced, but here for reference.



- ASA-AML integration
- **REST endpoint created by operationalizing ML model** can be **bound to a function (UDF)**


SOLUTION ARCHITECTURE
STREAM ANALYTICS WITH POWER BI
Microsoft Azure
<name>data
Power BI
Live and predicted energy consumption
<name>aJob
Stream Analytics Job
Processes events as they arrive in hub
Send
<name>ns
Service Bus Namespace
Receive
<name>eh
Event Hub
Queues streaming data
Send
Energy consumption data (public)
Receive
<name>ws
Web Job
Runs jobs to scrape data

TIPS TO KEEP IN MIND FOR STREAM ANALYTICS

- It is critical to identify the "timestamp" in the incoming stream of data and one should ensure that the time captured also confirms the occurrence of an event.
- We recommend using TIMESTAMP BY over arrival time as a best practice.
- All field names referenced in the query are case *insensitive* – so be careful with the schema key names in the payload (from event hub)

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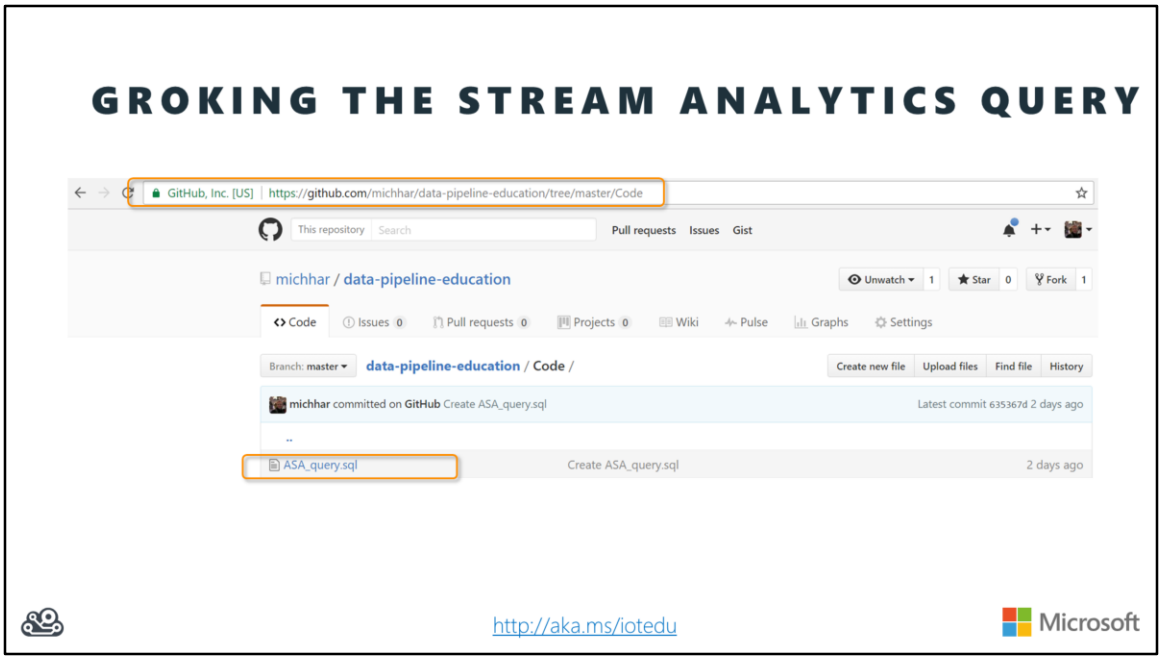
Microsoft



Get to this query file at https://github.com/michhar/data-pipeline-education/blob/master/Code/ASA_query.sql

GROKING THE STREAM ANALYTICS QUERY

```
CREATE TABLE InputEventHub (
    utcTimeStamp datetime,
    PTID bigint,
    Load float
);
```

Issuing the "CREATE TABLE" statement before the query allows us to define the schema of the data. Any incoming messages that don't meet this schema will be rejected. This helps prevent the Stream Analytics job from failing on invalid messages.

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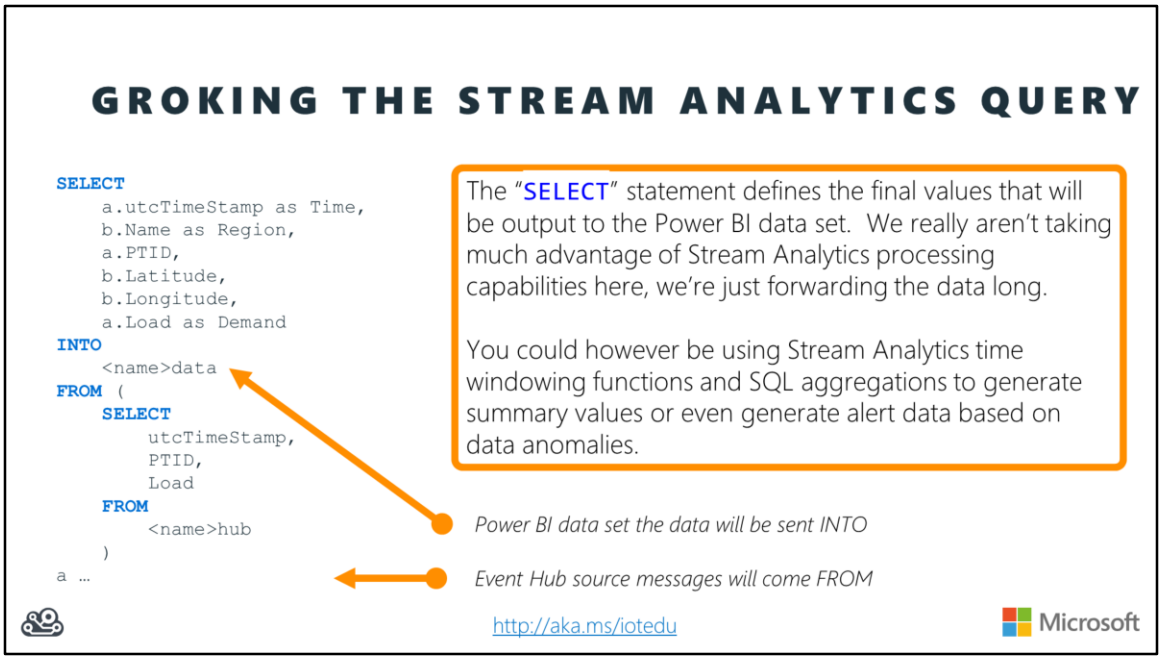
Subset of this file: https://github.com/michhar/data-pipeline-education/blob/master/Code/ASA_query.sql



This is a subset of the statement found in the SQL code on the class site. Subset of this file: https://github.com/michhar/data-pipeline-education/blob/master/Code/ASA_query.sql

This portion represents the "hot path" to PBI (the other portion after the join will be discussed with the SQL database session later on). The rest of the query can be seen on the site.

"b" refers to some historical data coming in from blob storage (pulled in by the Web Job – same job that sends the streaming data to the Event Hub)

ASA RESOURCE LIBRARY

Business Overview	http://azure.microsoft.com/en-us/services/stream-analytics/
Documentation	http://azure.microsoft.com/en-us/documentation/services/stream-analytics/
Samples	https://github.com/streamanalytics/samples
ASA Blog	http://blogs.msdn.com/b/streamanalytics/rss.aspx
Follow us on Twitter	https://twitter.com/AzureStreaming (follow @AzureStreaming)
ASA Forum	https://social.msdn.microsoft.com/Forums/en-US/home?forum=AzureStreamAnalytics
Vote for ideas	http://feedback.azure.com/forums/270577-azure-stream-analytics
Email ASA Team	azstream@microsoft.com

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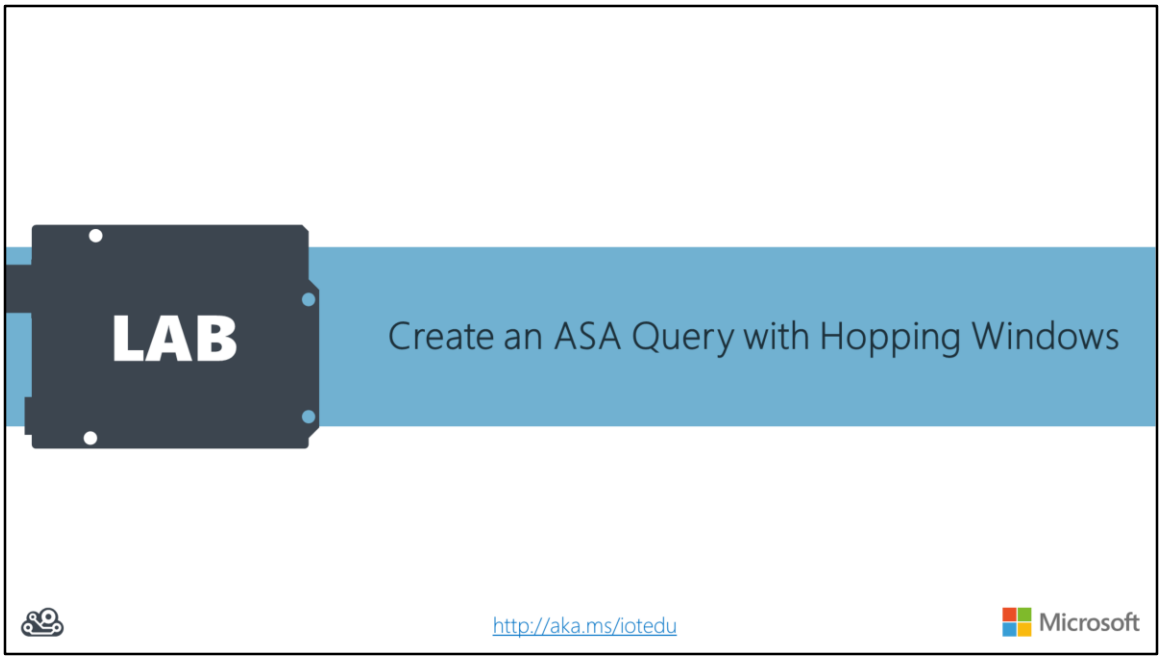

Instructions are simple:

- Follow along to get to the Query in the classic portal (manage.azure.com)
- Save the original query somewhere for later
- Modify the query to use a hopping window for the aggregation of Load which is the energy load (let's aggregate by the SUM). Then, check your answer in the "Code" folder within the ASA_Query_Hopping.sql file or at https://github.com/michhar/data-pipeline-education/blob/master/Code/ASA_Query_Hopping.sql. You may want to test here (which is why we are using the classic portal for the editing)

Later we will change this back to the original query.

In case you finish early, take a look at:
- Another sample of ASA (this one for fraud detection): https://azure.microsoft.com/en-us/documentation/articles/stream-analytics-real-time-fraud-detection/

POWER BI (AND THE STREAM ANALYTICS INTEGRATION)

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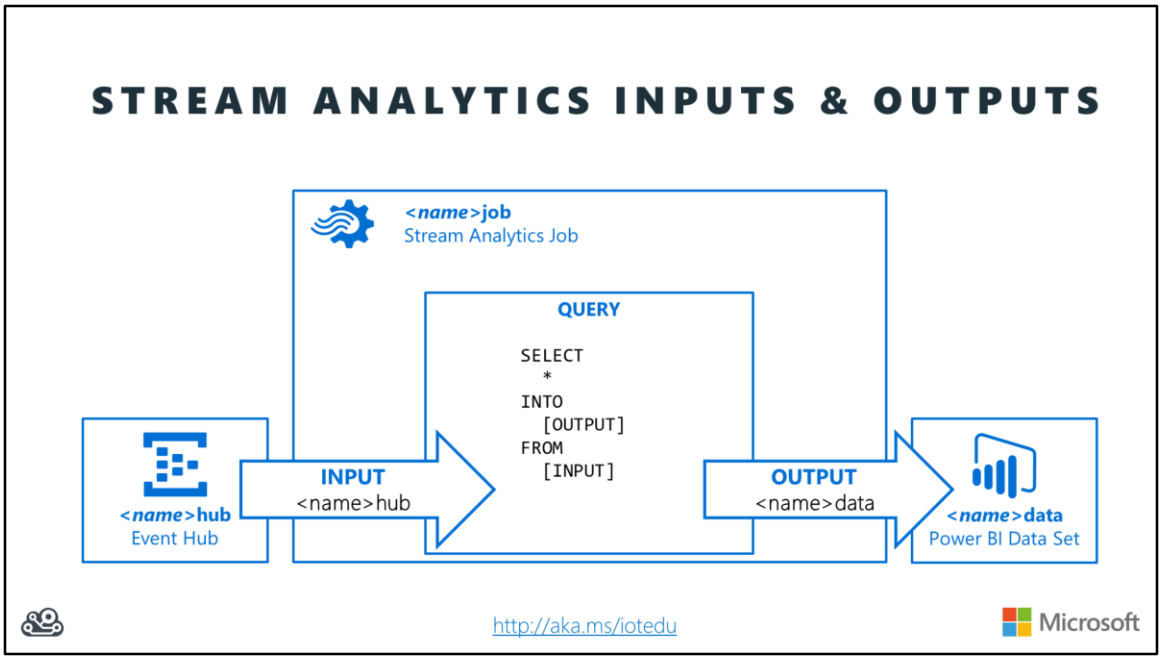
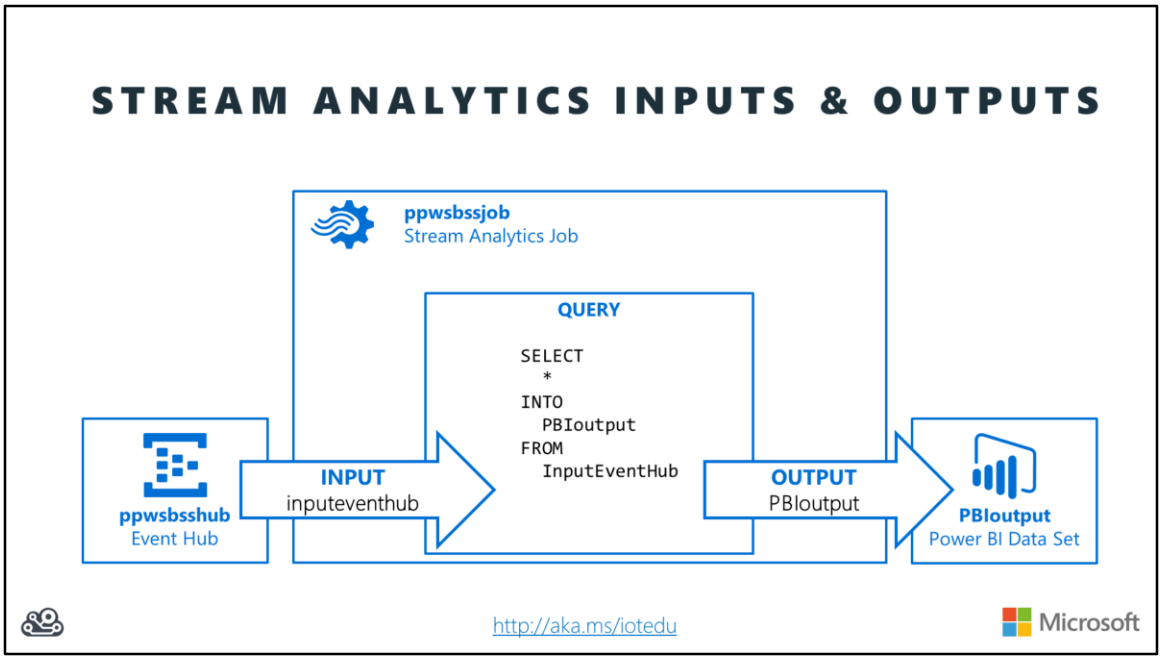


Use the “classic” portal to modify the query and hook up to PBI.
https://manage.windowsazure.com



Side Note for Later: the OUTPUT, called PBIoutput is the output according to ASA. When we hook it up to PBI (the "hot path") later you will see it gets renamed for the actual PBI online interface so the dataset, PBIoutput, will likely have a different name in PBI itself. This will become clearer later.

Query Code
Check out the more complete query on the class site at https://github.com/michhar/data-pipeline-education/blob/master/Code/ASA_query.sql

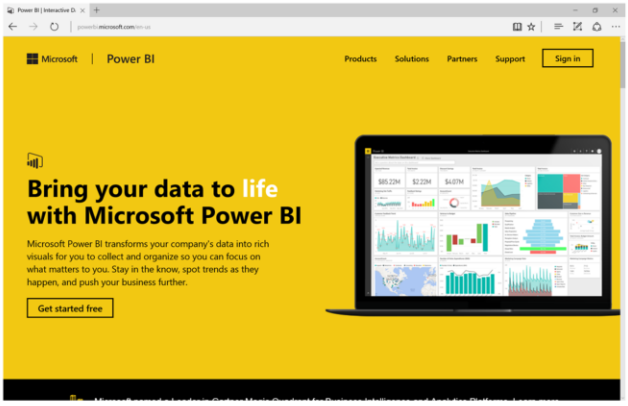
or on the "classic" portal at https://manage.windowsazure.com under the stream analytics job and its query

WHAT IS POWER BI ONLINE?

Create **custom** reports and dashboards using data from **many different sources** in an intuitive web interface.

Share datasets, reports and dashboards with your organization and others.

You need a **Work or School Account** (a.k.a. organizational email) to sign up for Power BI online (like Office 365).



http://aka.ms/iotedu

Microsoft

There is also a Power BI desktop app. They are both free to use, but there are limitations on creating dashboards to share in desktop. (e.g. can't pin tiles from a desktop report to a dashboard online)

Power BI originated as a part of Excel.

You can't use outlook.com, gmail.com, etc. personal accounts (even a personal Microsoft Account). Check out this blog post for more info on signing up: http://BretStateham.com/Using-power-bi-at-events

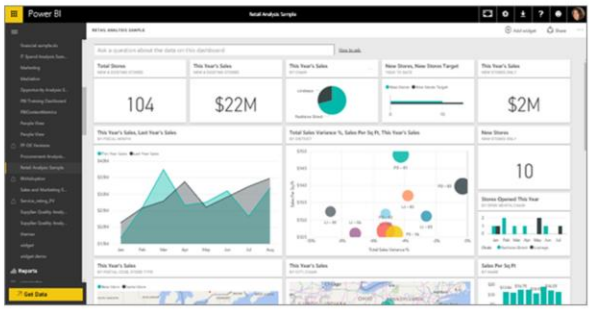
WHAT IS A POWER BI DASHBOARD

Dashboards consists of tiles which can be from PBI reports, other dashboards, PBI datasets, Excel reports, SSRS and more.

Pinning an entire report page creates *live* tiles one can interact with.

A tile is a snapshot of your data, pinned to the dashboard.

Quick Insights is a lightning fast way to create a dashboard from a dataset.



http://aka.ms/iotedu

Microsoft

Dashboard help: https://powerbi.microsoft.com/en-us/documentation/powerbi-service-dashboards/

Sharing – read-only, personal or collaborator
Content as tiles
Tiles can be created from sources such as: Excel, an online PBI report, dataset, other PBI dashboard, the Q&A box, SQL Server Reporting Services and more (can't pin, however, directly from PBI Desktop reports**) – can even link On-Prem data with available software called the On-Premises Gateway (https://powerbi.microsoft.com/en-us/documentation/powerbi-gateway-onprem/)
Standalone tiles can be created from: web content, images, videos, and text boxes

Can make hard copies to save or print

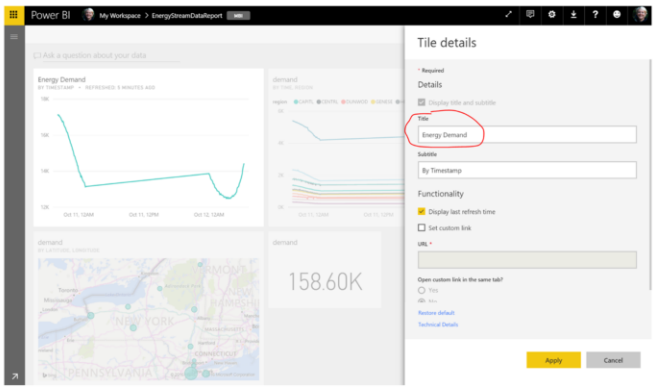
**Reports from PBI Desktop (as well as Excel and CSV) files may be used if they are store in OneDrive for Business.

Note:

If the original visualization used to create the tile changes, the tile doesn't change (unless it’s a live tile). The data refreshes, but the visualization type does not. For example, if you pinned a line chart from a report and then you change the line chart to a bar chart, the dashboard tile continues to show a line chart.

WORKING IN THE DASHBOARD

From within the dashboard you can change the title and other properties.



http://aka.ms/iotedu

Microsoft

WORKING IN THE DASHBOARD

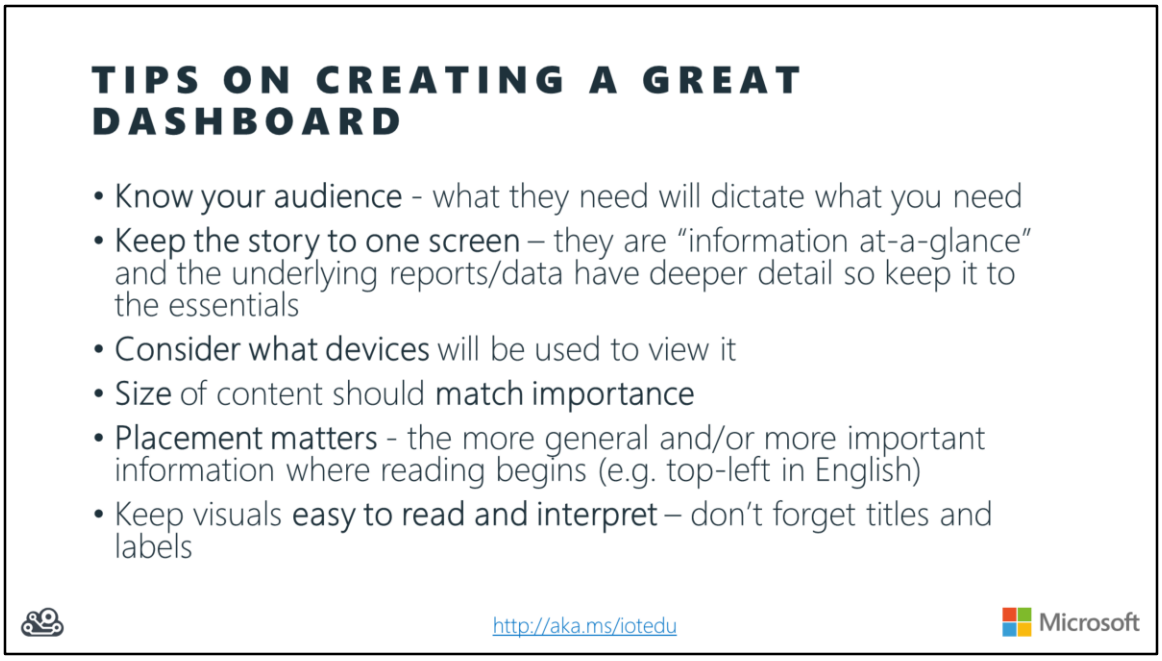
PBI Q&A – "search" the dataset in plain text and pin a visual representing that "query"

http://aka.ms/iotedu

Microsoft

Red arrow is my query
Red circle is the actual description translating to the query
Blue circle is how we pin this visual to the dashboard

Remember this is all from the dashboard itself.

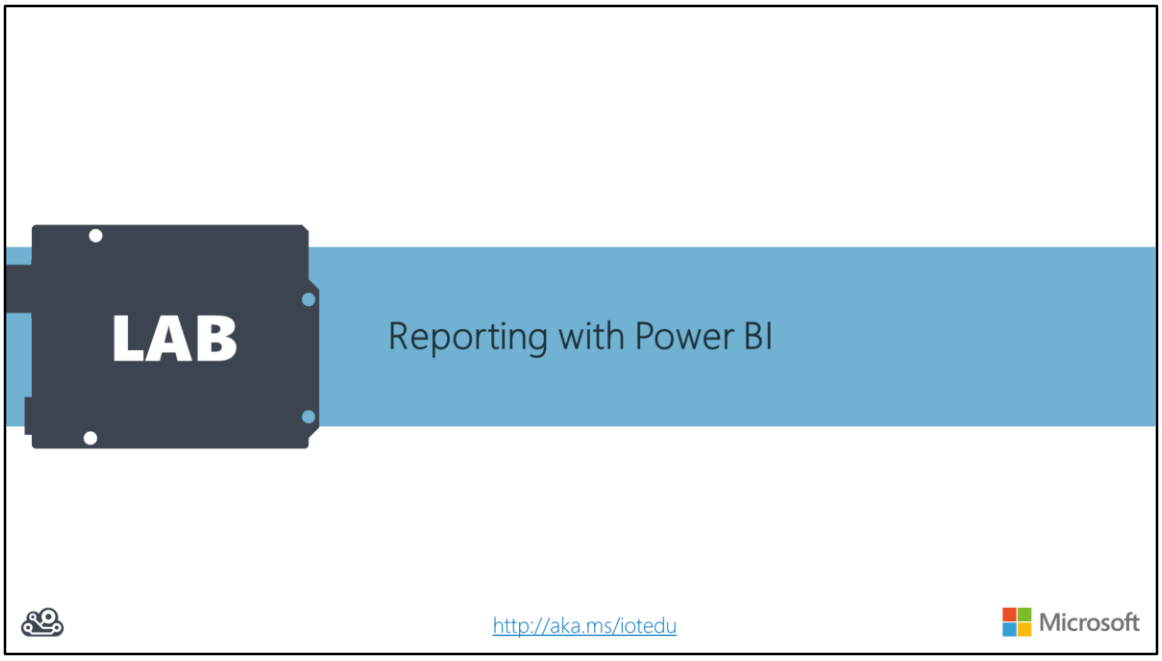


Tips site: https://powerbi.microsoft.com/en-us/documentation/powerbi-service-tips-for-designing-a-great-dashboard/

Questions to ask around these tips:
Audience: What are the key metrics that will help them make decisions? How will the dashboard be used? What learned or cultural assumptions may affect design choices? What information does your audience need to be successful? Where is the dashboard going to be displayed?

Story on one screen: Can you avoid scroll bars on your dashboard? Is the dashboard too cluttered?

Easy to read and interpret: Keep in mind that it is difficult for the human brain to interpret circular shapes. Be consistent with scales. If numbers get too long use words instead (3.4 million instead of 3,400,000) or scientific notation. Note on pie charts: less than 8 categories and they are good generally for conveying part-to-whole relationships.



Please go to the file “LabPBI.md” under “Labs” on the class site or here: https://github.com/michhar/data-pipeline-education/blob/master/Labs/LabsPBI.md

Given extra time or if you finish early, change the ASA query back to the original query saved from the last lab. Observed changes in the BI report and dashboard. You may wish to download the report to examine it more closely. Please explain this change.

WHAT YOU HAVE LEARNED TODAY

- GitHub as a resource and it's importance in the community
- Gained some familiarity and practice with Web Jobs
- Gained some familiarity with what Event Hubs do for us
- Learned in some detail about Stream Analytics, scenarios and practiced monitoring and managing it
- Gained some knowledge and practice of Power BI and some tips on use

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TOMORROW – WHAT TO EXPECT

- Learn a bit about relevant machine learning (basics to remind you) and Azure Machine Learning – get a chance to practice
- Become familiar with Azure Data Factory and how it's the glue that binds together many components of our architecture
- Gain some understanding around options for security and compliance
- End of training wrap-up

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