Architecting IoT Data Ingestion with Azure Data Services

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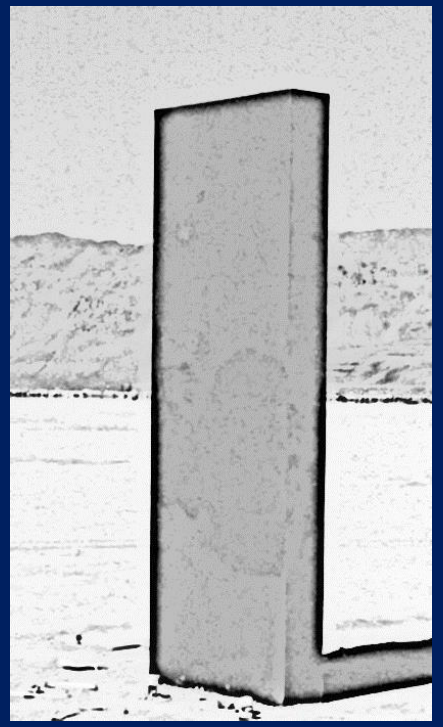
Today

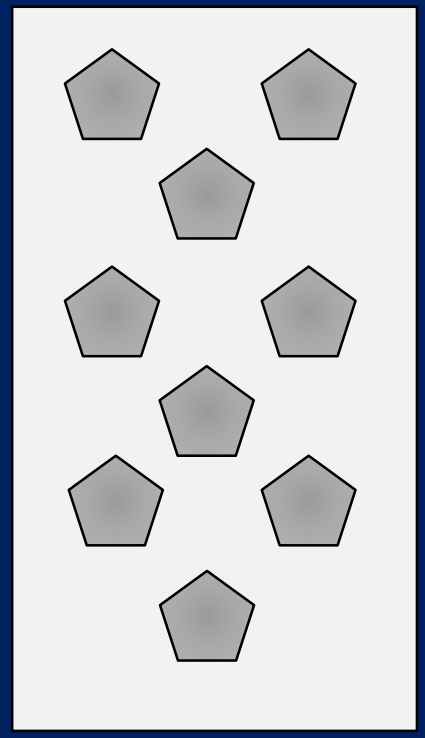
- Hello IoT
- Event Hubs
- Streaming Data
- Functions
- Machine Learning

Patterns

Monolith



MicroService



Serverless

Hello IoT

Internet of…

IoC	Internet of Coffee
IoG	Internet of Gadgets
IoT	Internet of Toast
IoB	Internet of Biology
IoH	Internet of Home
IoM	Internet of Media
IoS	Internet of Stuff

The Internet of Things (IoT)

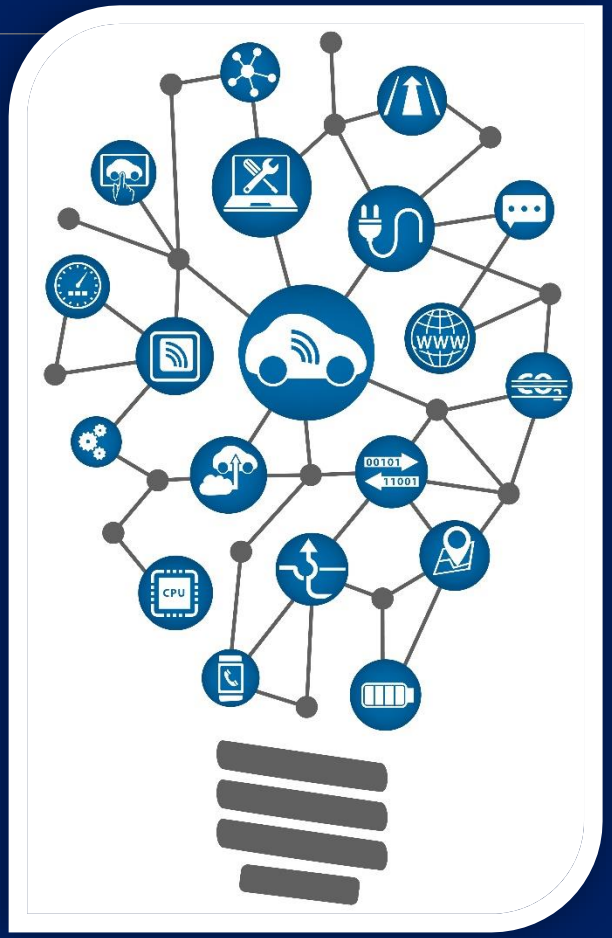
Currently 20 billion devices connected to the Internet

By 2020, expect 50 billion or more

- Health-monitoring devices
- Thermostats, wind turbines, and solar farms
- Cars, trucks, traffic lights, and drones
- EVERYTHING will be connected

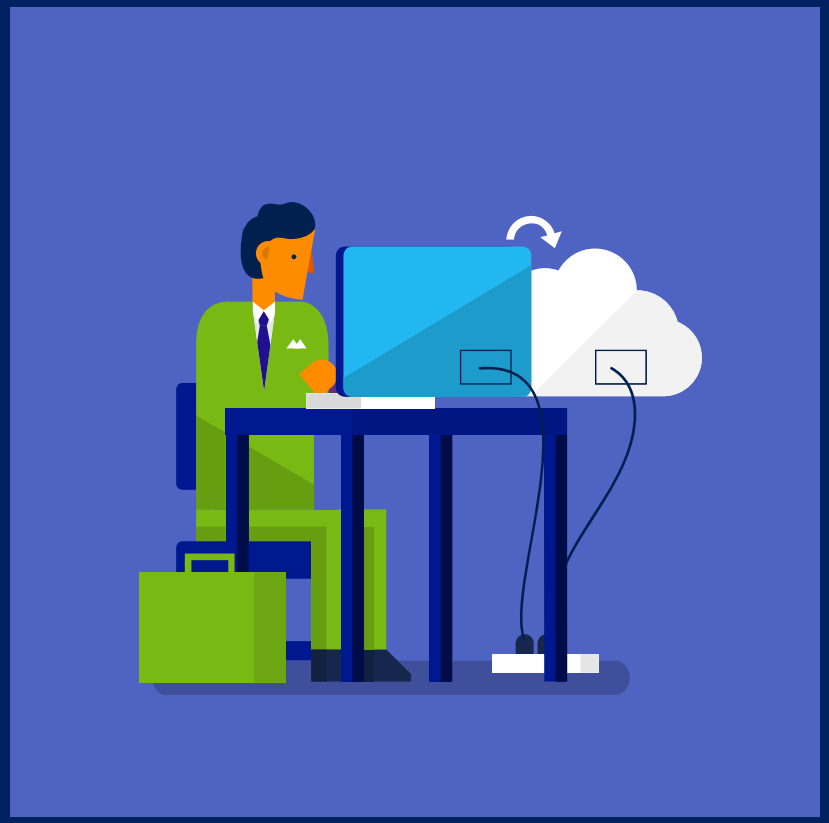
How do you process all that data?

How do you process it in real time?



IoC = Internet of Cloud

Canonical scenarios



ARCHIVING

DASHBOARDING

TRIGGERING WORKFLOWS

What are customers wanting to do?

Real-time fraud detection

Connected car scenario

Click-stream analysis

Real-time financial portfolio alerts

Smart grid

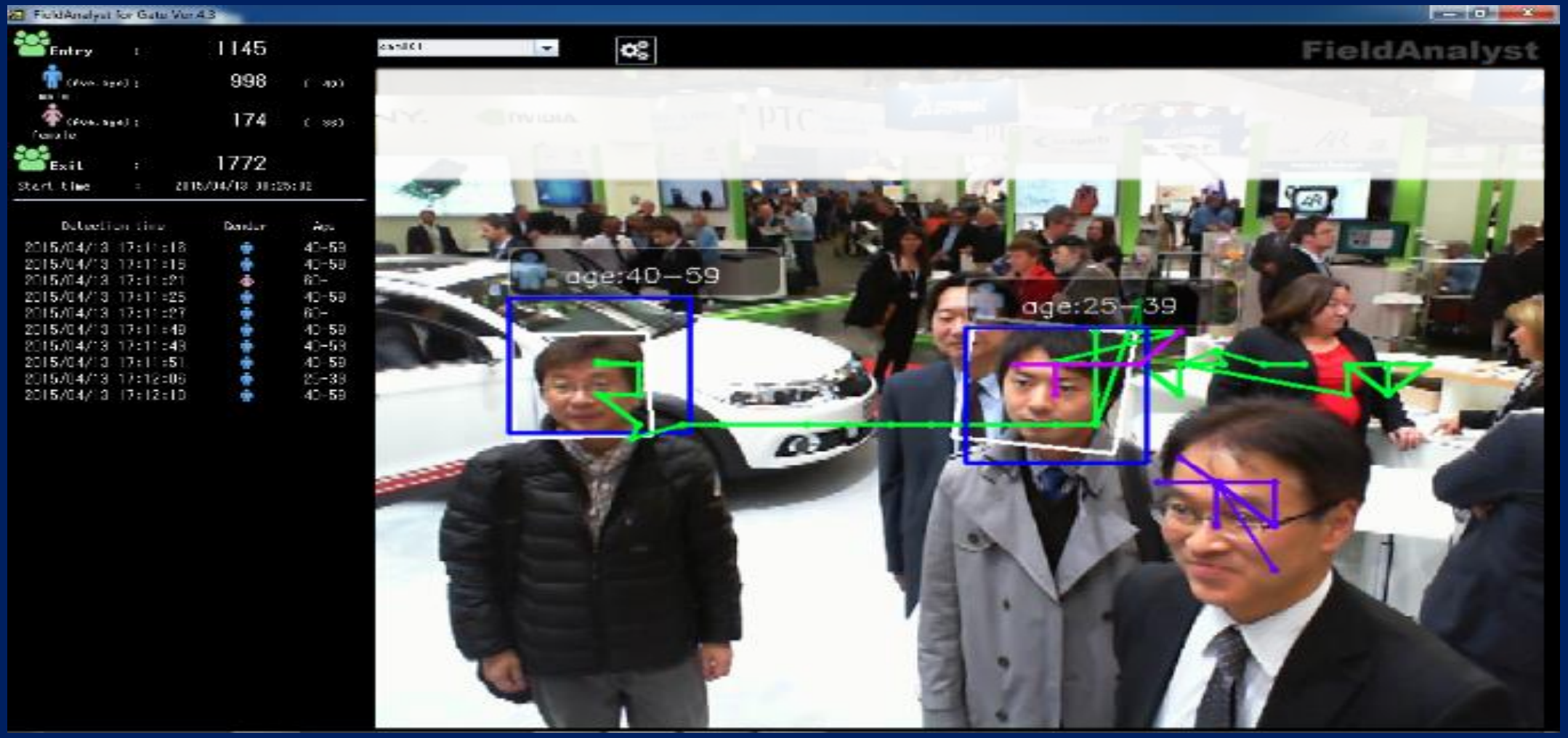
CRM alerting sales with customer scenario

Data and identity protection services

Real-time financial sales tracking

Cognitition

NEC FieldAnalyst (People count / Age / Gender) data to Azure in real-time

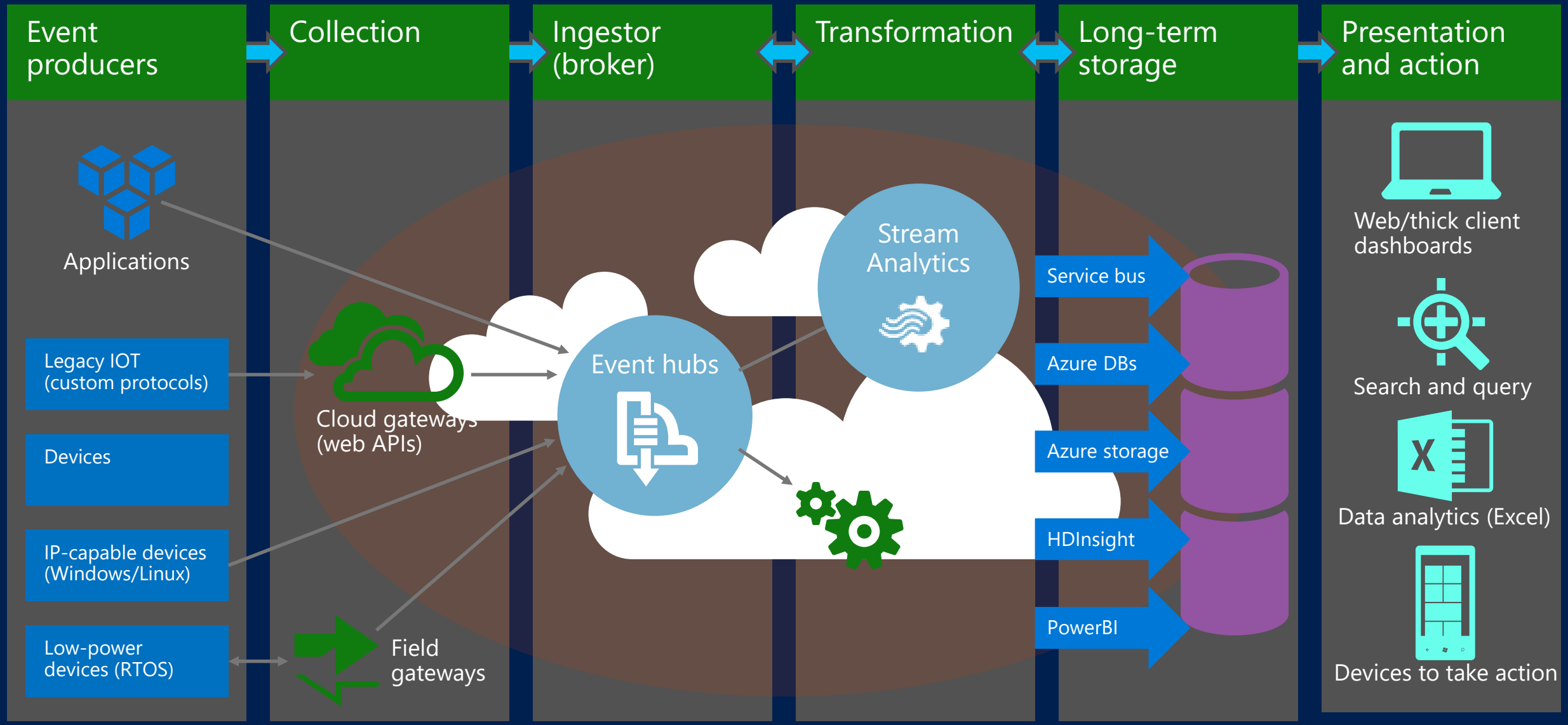


How old do I look?

www.how-old.net

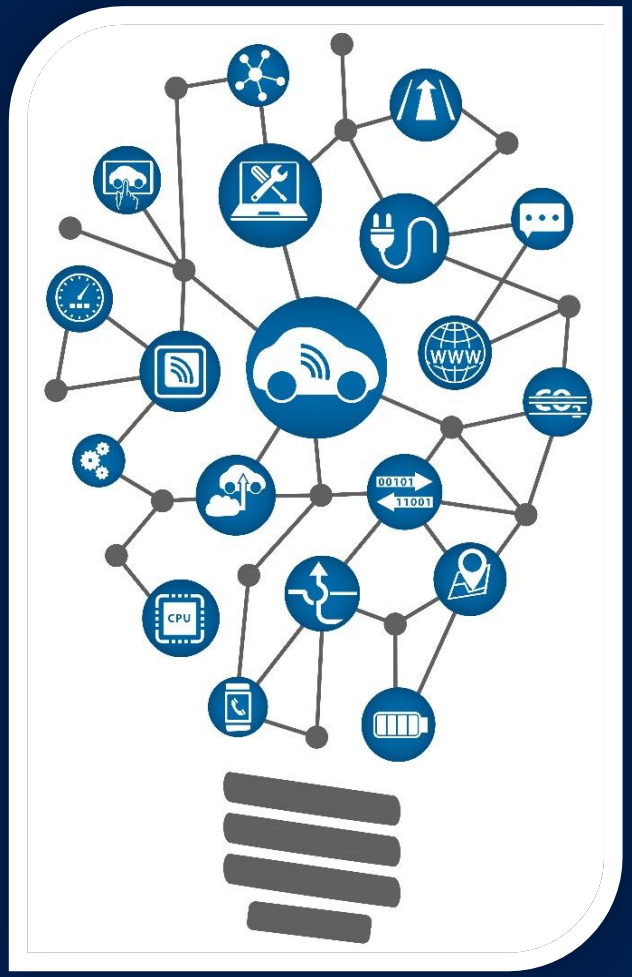
(it lies…)

Canonical Eventing scenario

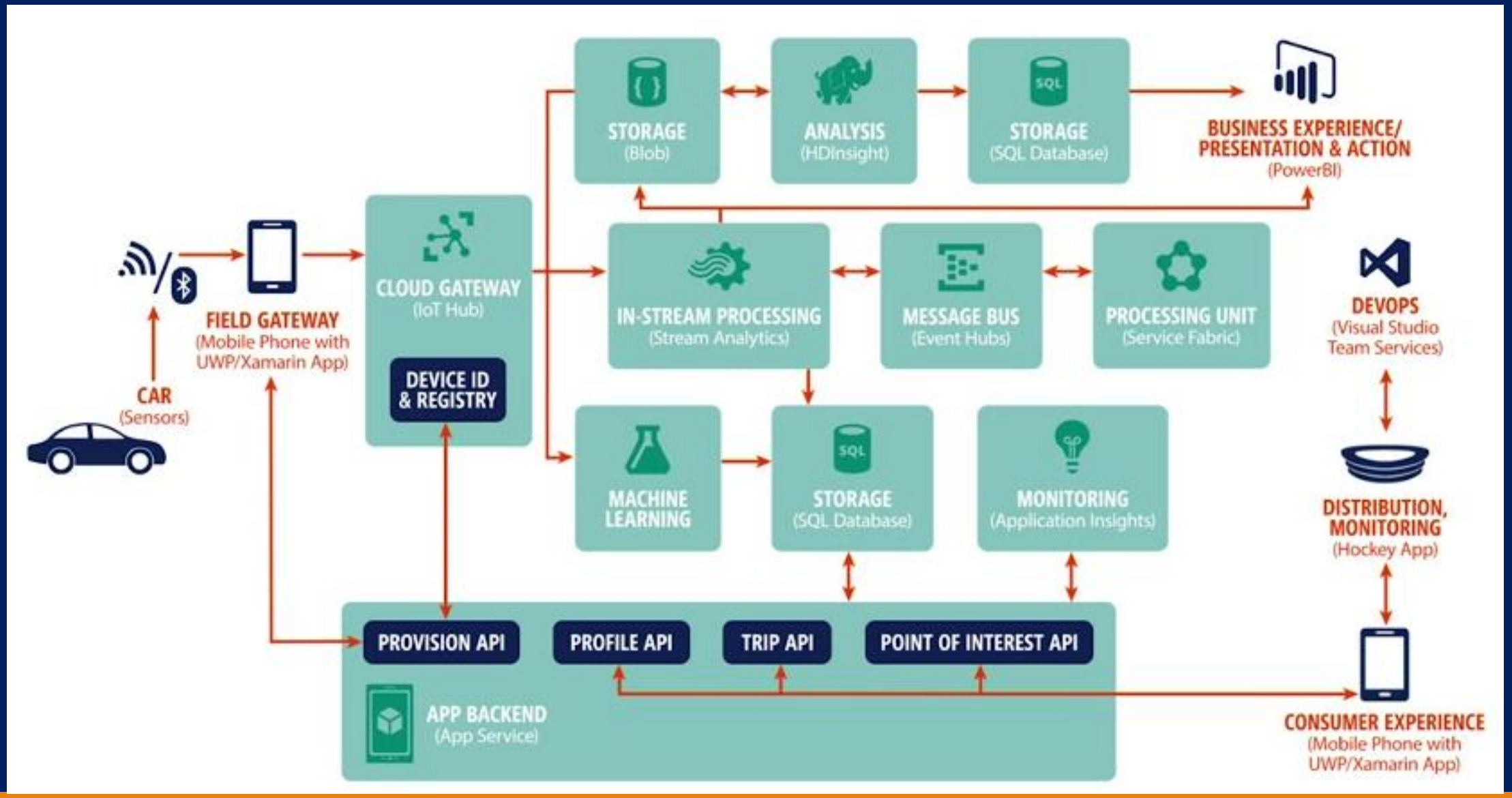


Some data ingestion components

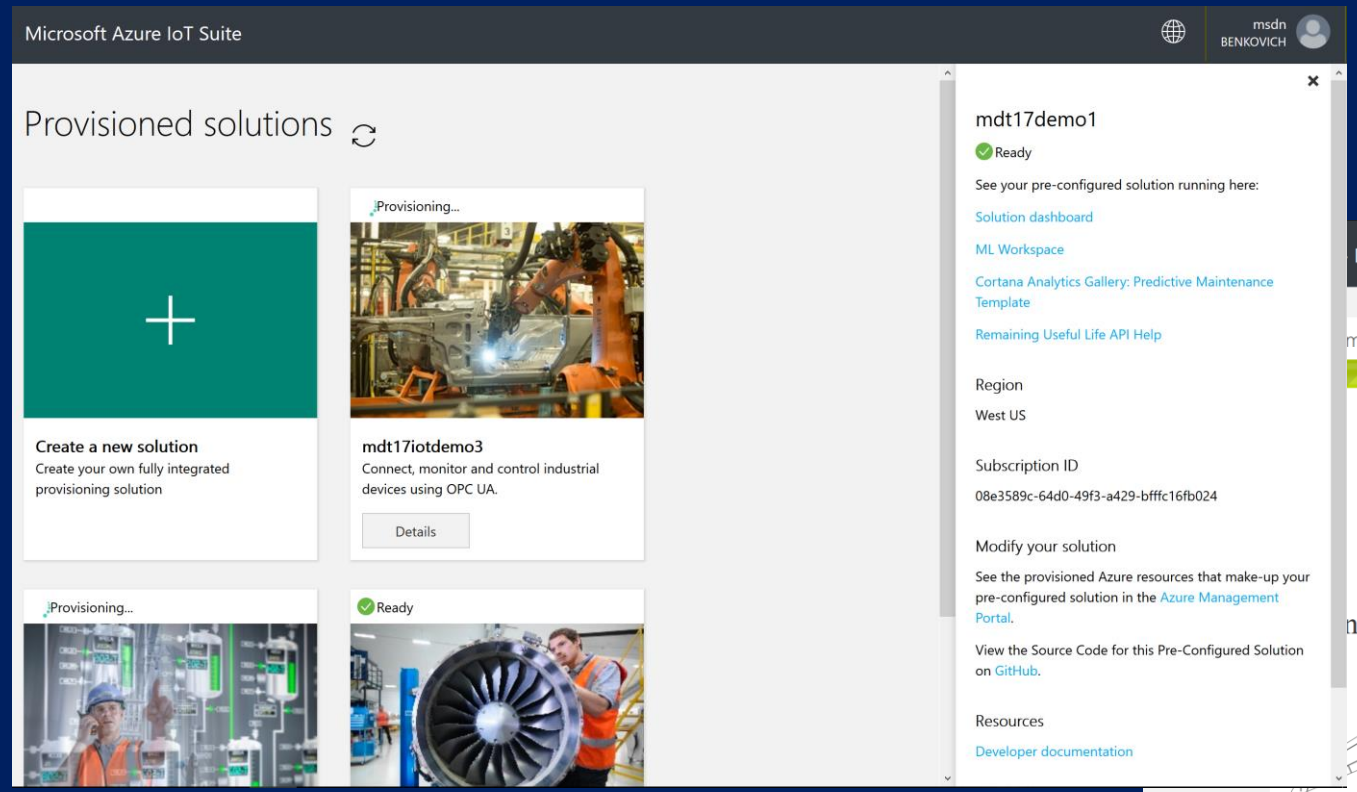
- IoT Hub
- Event Hubs
- Stream Analytics
- Azure Functions
- Data Factories
- Machine Learning

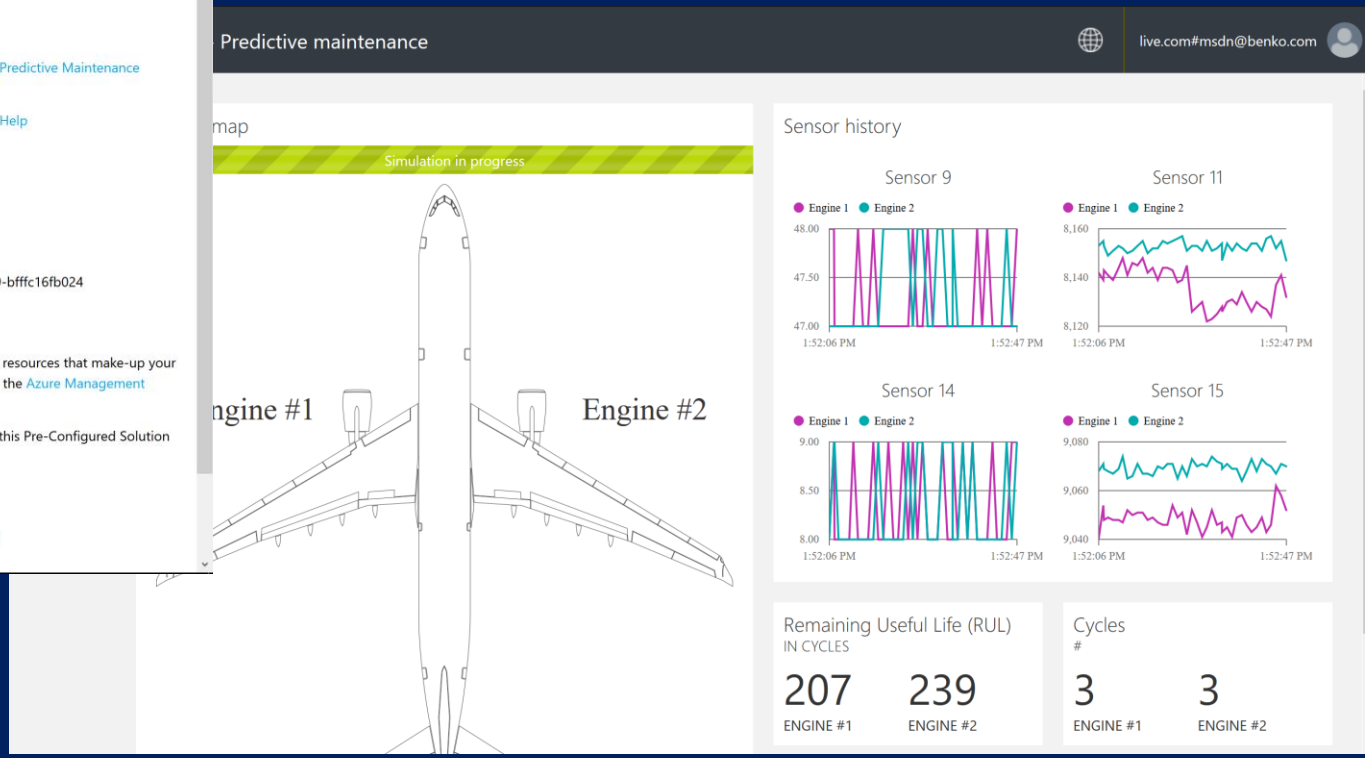


Check out www.azure.com/MyDriving



Check out http://azureiotsuite.com





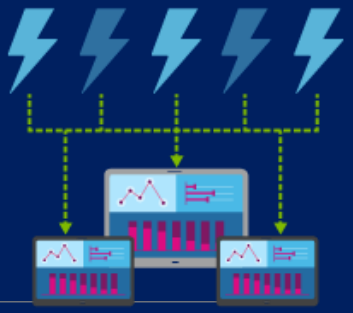
IoT Hubs & Event Hubs

What is Streaming Data?

Data at Rest

Data in Motion

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. This lets you process and analyze the massive amounts of data produced by your connected devices and applications. Once Event Hubs has collected the data, transform and store it by using any real-time analytics provider or with batching/storage adapters.

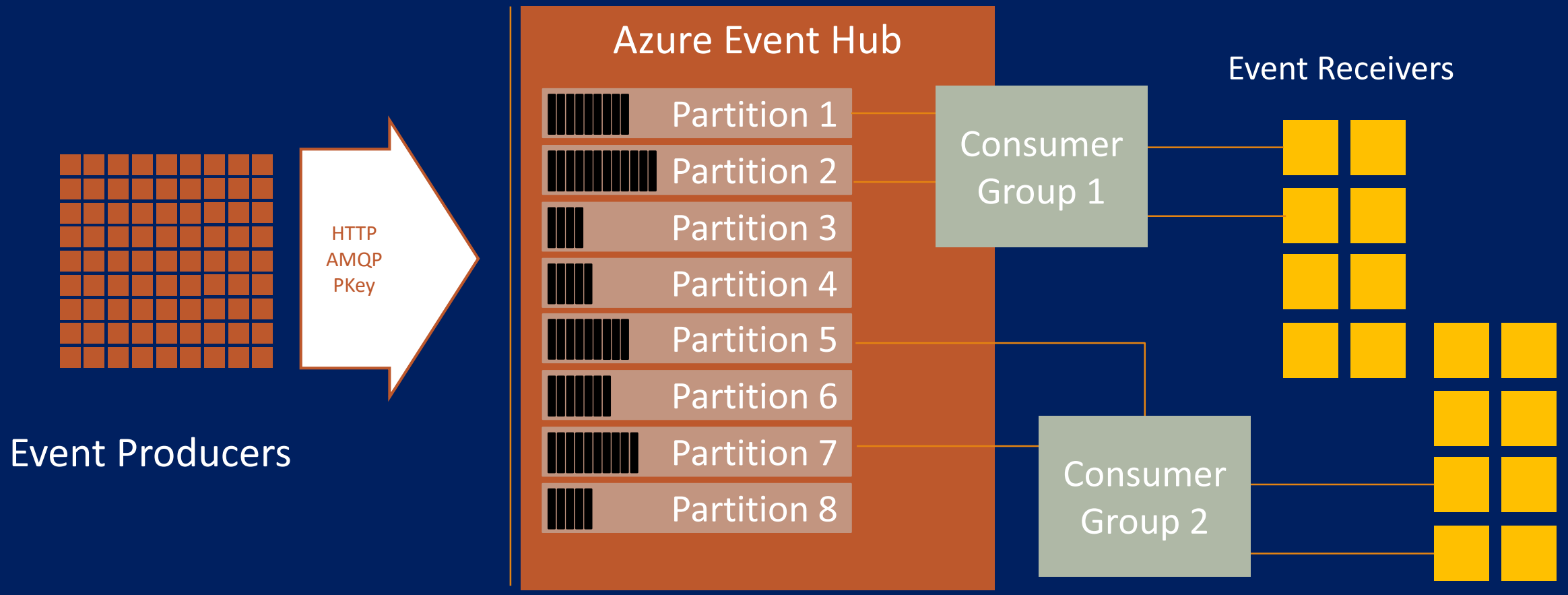
Process events with variable load profiles

Big data defines today's connected world. Big data originates from many sources with variable load profiles, such as connected cars and thermostats that produce telemetry data every few minutes, application performance counters that generate events every second, and mobile apps that capture telemetry for every user's individual action. Event Hubs is a managed service that ingests events with elastic scale to accommodate these variable load profiles and the spikes caused by intermittent connectivity.

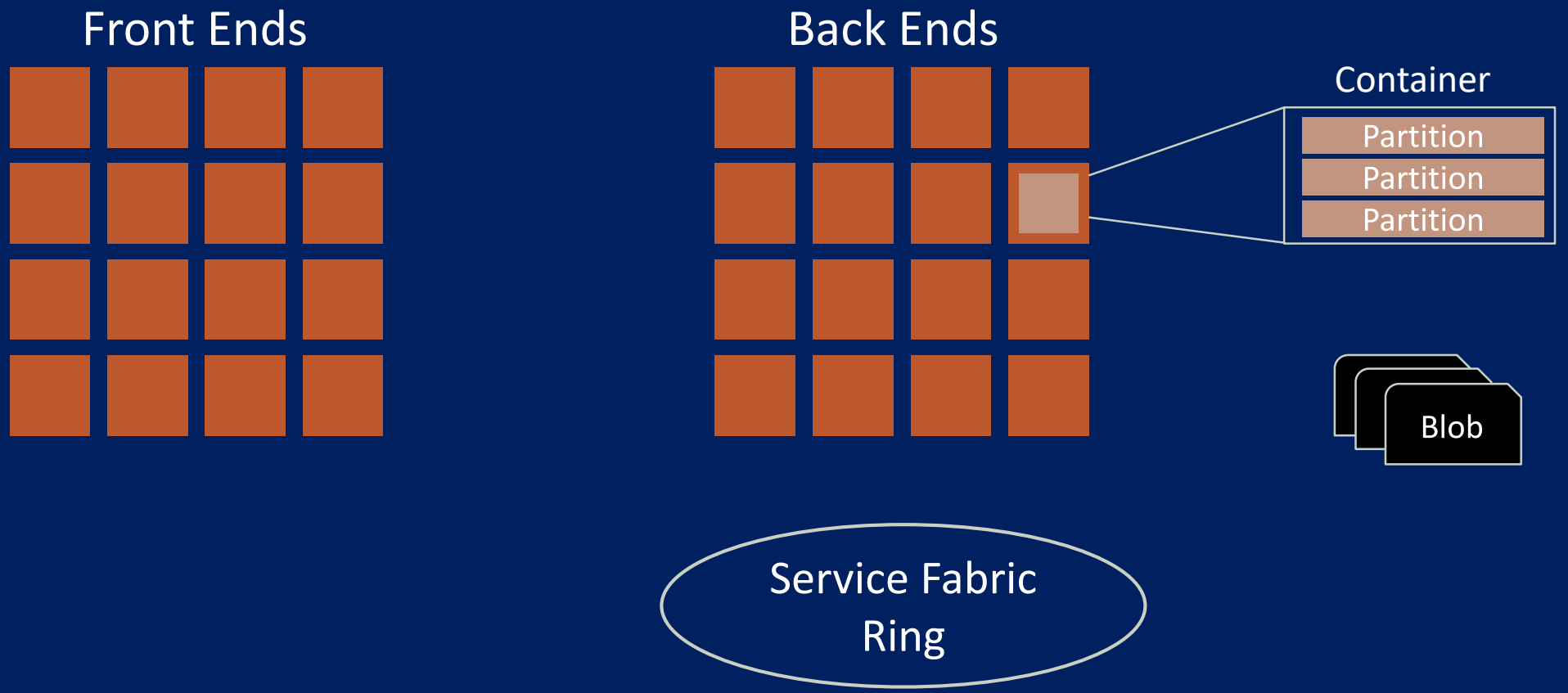
Connect millions of devices across platforms

Due to the rapid proliferation of connected devices and the variety of platforms and protocols involved, ingesting data from devices is challenging. Event Hubs meets the challenge of connecting disparate data sources while handling the scale of the aggregate stream. It lets you easily provision capacity to process events from millions of devices while preserving event order on a per-device basis. Support for Advanced Message Queuing Protocol (AMQP) and HTTP allow many platforms to work with Event Hubs. Native client libraries also exist for popular platforms.

Event Hubs Overview



Event Hubs High Level Architecture



Stream Analytics

Stream Analytics

Gain real-time insights

Azure Stream Analytics lets you rapidly develop and deploy low-cost solutions to gain real-time insights from devices, sensors, infrastructure, and applications. Use it for Internet of Things (IoT) scenarios, such as real-time remote management and monitoring or gaining insights from devices like mobile phones and connected cars.

Enable rapid development

Reduce friction and complexity and use fewer lines of code when developing analytic functions for scale-out distributed systems. Describe the desired transformation with SQL-based syntax, and Stream Analytics automatically distributes it for scale, performance, and resiliency. No need to manage complex infrastructure and software.

Perform real-time analytics

Stream Analytics is integrated out-of-the-box with Azure Event Hubs to ingest millions of events per second. Stream Analytics processes ingested events in real-time, comparing multiple streams or comparing streams with historical values and models. I detects anomalies, transforms incoming data, triggers an alert when a specific error or condition appears in the stream, and displays this real-time data in your dashboard.

Azure Stream Analytics

Highly scalable service for analyzing data in motion

Supports SQL-like query language for data analysis

Scales using Streaming Units (1 SU ~= 1 MB/sec)

Stream Analytics Query Language

SQL-like language for querying live data streams

- Subset of T-SQL
- Supports bigint, float, nvarchar(max), datetime, record, and array
- Supports SELECT, FROM, WHERE, GROUP BY, and other common Data Manipulation Language (DML) statements
- Supports COUNT, AVG, DATEDIFF, and other common functions

Adds extensions such as TIMESTAMP BY and System.Timestamp

Supports temporal grouping of events via "windowing"

Querying a Data Stream

List all Connecticut cars that enter a toll booth, and include the entry time, toll booth ID, and license-plate number

```
SELECT EntryTime, TollId, LicensePlate
FROM EntryData
WHERE State = 'CT'
```

ENTRYTIME	TOLLID	LICENSEPLATE
2014-09-10T12:02:00+00:00	3	ABC 1004
2014-09-10T12:03:00+00:00	2	XYZ 1003
2014-09-10T12:11:00+00:00	1	NJB 1006

Designating a Field as the Event Time

Designate the EntryTime field as the event time for calculations that involve event time

```
SELECT System.Timestamp AS [Entry Time],
    TollId, LicensePlate
FROM EntryData TIMESTAMP BY EntryTime
WHERE State = 'CT'
```

ENTRYTIME	TOLLID	LICENSEPLATE
2014-09-10T12:02:00+00:00	3	ABC 1004
2014-09-10T12:03:00+00:00	2	XYZ 1003
2014-09-10T12:11:00+00:00	1	NJB 1006

JOINing Two Data Streams

How long does it take each car that enters a tool booth to pay the toll and exit the booth?

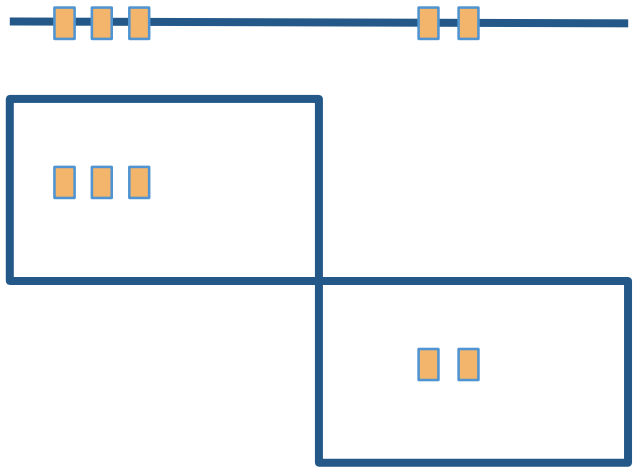
```
SELECT EN.TollId, EN.EntryTime, EN.LicensePlate,
   DATEDIFF(minute, EN.EntryTime, EX.ExitTime) AS Minutes
FROM EntryData EN TIMESTAMP BY EntryTime
JOIN ExitData EX TIMESTAMP BY ExitTime
   ON EN.TollId = EX.TollId
   AND EN.LicensePlate = EX.LicensePlate
   AND DATEDIFF(minute, EN, EX) BETWEEN 0 AND 60
```

TOLLID	ENTRYTIME	LICENSEPLATE	MINUTES
1	2014-09-10T12:01:00.000Z	JNB 7001	2
1	2014-09-10T12:02:00.000Z	YXZ 1001	1
3	2014-09-10T12:02:00.000Z	ABC 1004	2

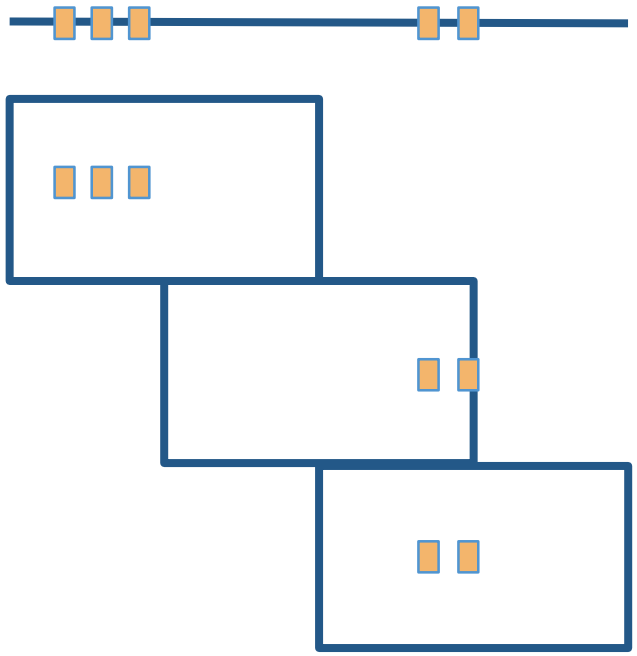
Windowing

Count or aggregate events over a specified time period

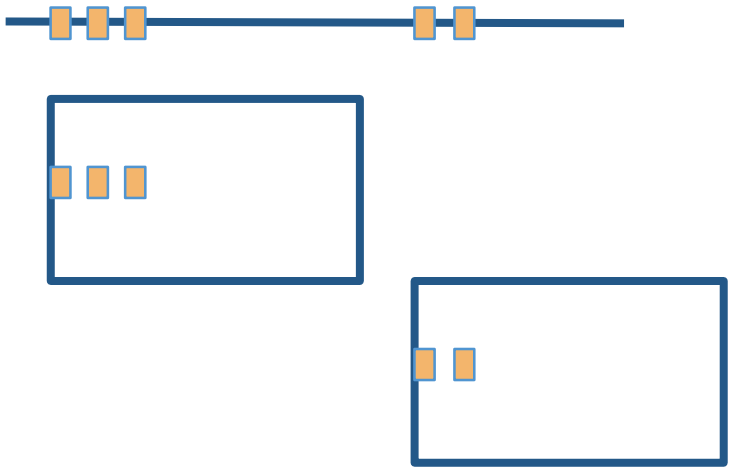
TumblingWindow



HoppingWindow



SlidingWindow



Using TumblingWindow

How many New York cars enter a toll booth every 5 minutes?

```
SELECT DateAdd(minute, -5, System.TimeStamp)
   AS [Start Time], System.TimeStamp AS [End Time],
   COUNT(*)
FROM EntryData TIMESTAMP BY EntryTime
WHERE State = 'NY'
GROUP BY TumblingWindow(minute, 5)
```

START TIME	END TIME	COUNT
2014-09-10T12:00:00.000Z	2014-09-10T12:05:00.000Z	3
2014-09-10T12:05:00.000Z	2014-09-10T12:10:00.000Z	6
2014-09-10T12:15:00.000Z	2014-09-10T12:20:00.000Z	2

Using HoppingWindow

What is the average wait time at all toll booths for the last 5 minutes, updated every 1 minute?

```
SELECT DateAdd(minute, -5, System.TimeStamp)
   AS [Start Time], System.TimeStamp AS [End Time],
   AVG(DATEDIFF(minute, EN.EntryTime, EX.ExitTime))
   AS [Average Wait Time]
FROM EntryData EN TIMESTAMP BY EntryTime
JOIN ExitData EX TIMESTAMP BY ExitTime
   ON EN.TollId = EX.TollId
   AND EN.LicensePlate = EX.LicensePlate
   AND DATEDIFF(minute, EN, EX) BETWEEN 0 AND 60
GROUP BY HoppingWindow(minute, 5, 1)
```

START TIME	END TIME	AVERAGE WAIT TIME
2014-09-10T11:58:00.000Z	2014-09-10T12:03:00.000Z	1.5
2014-09-10T11:59:00.000Z	2014-09-10T12:04:00.000Z	1.6666666666666667
2014-09-10T12:00:00.000Z	2014-09-10T12:05:00.000Z	1.6666666666666667

Using SlidingWindow

In which 5-minute windows does at least one Connecticut car enter a toll booth?

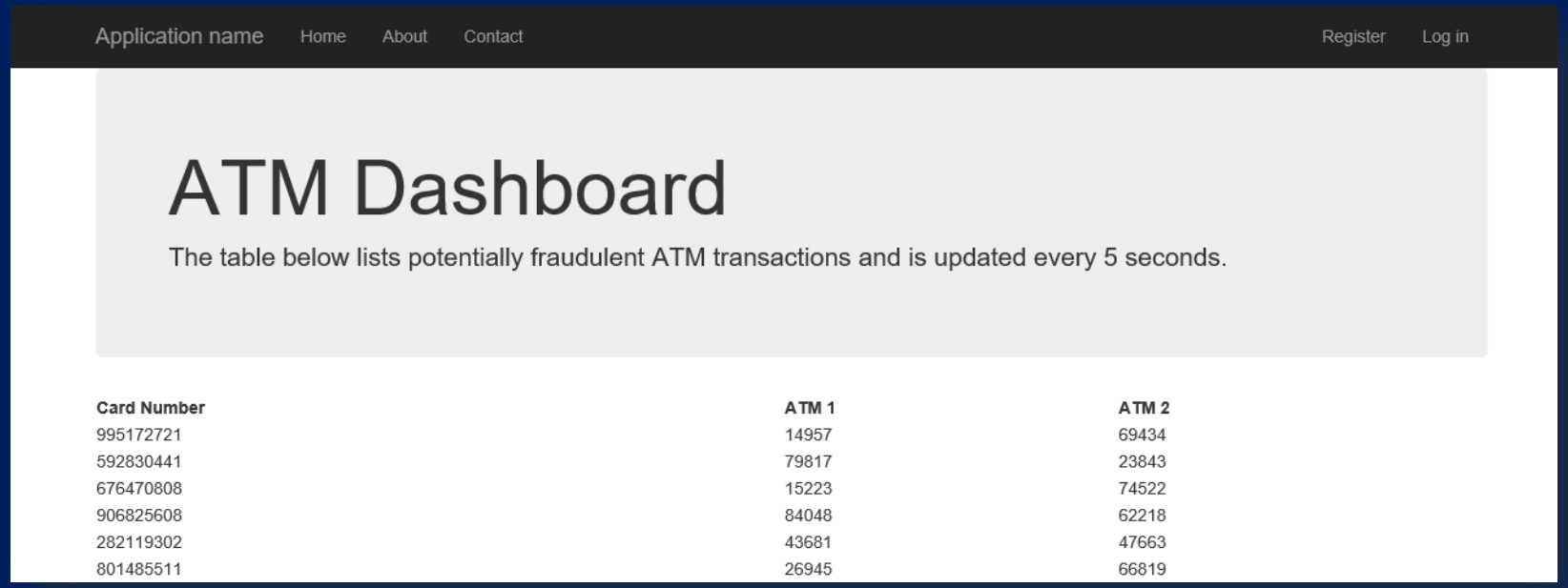
```
SELECT DateAdd(minute, -5, System.TimeStamp)
   AS [Start Time], System.TimeStamp AS [End Time],
   TollId, COUNT(*)
FROM EntryData TIMESTAMP BY EntryTime
WHERE State = 'CT'
GROUP BY TollId, SlidingWindow(minute, 5)
HAVING COUNT(*) > 0
```

START TIME	END TIME	TOLLID	COUNT
2014-09-10T11:57:00.000Z	2014-09-10T12:02:00.000Z	3	1
2014-09-10T11:58:00.000Z	2014-09-10T12:03:00.000Z	2	1
2014-09-10T12:06:00.000Z	2014-09-10T12:11:00.000Z	1	1

Building Real-Time Dashboards

Direct Stream Analytics output to an Azure event hub

Write code that subscribes to events from the event hub



Azure Functions

Azure Functions

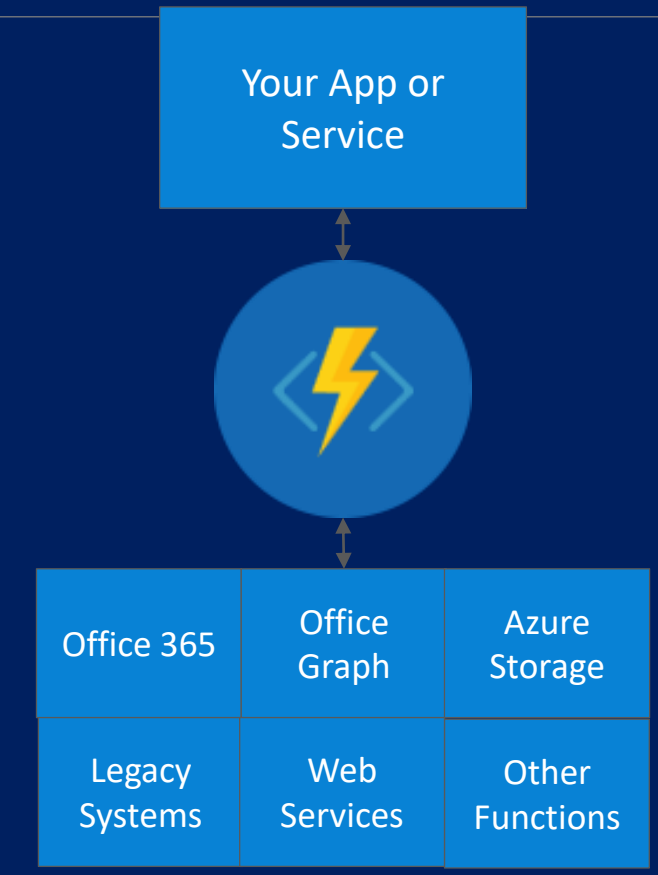
Real-time stream processing

For example, IoT devices send messages to Azure Stream Analytics, which then calls an Azure Function to transform the message. This function processes the data and creates a new record in an Azure SQL Database.

Azure Functions supports triggering an event based on an activity in an Azure service. For example, you could execute code that reads newly discovered test log files in an Azure Blob Storage container and transforms this into a row in an Azure SQL Database table

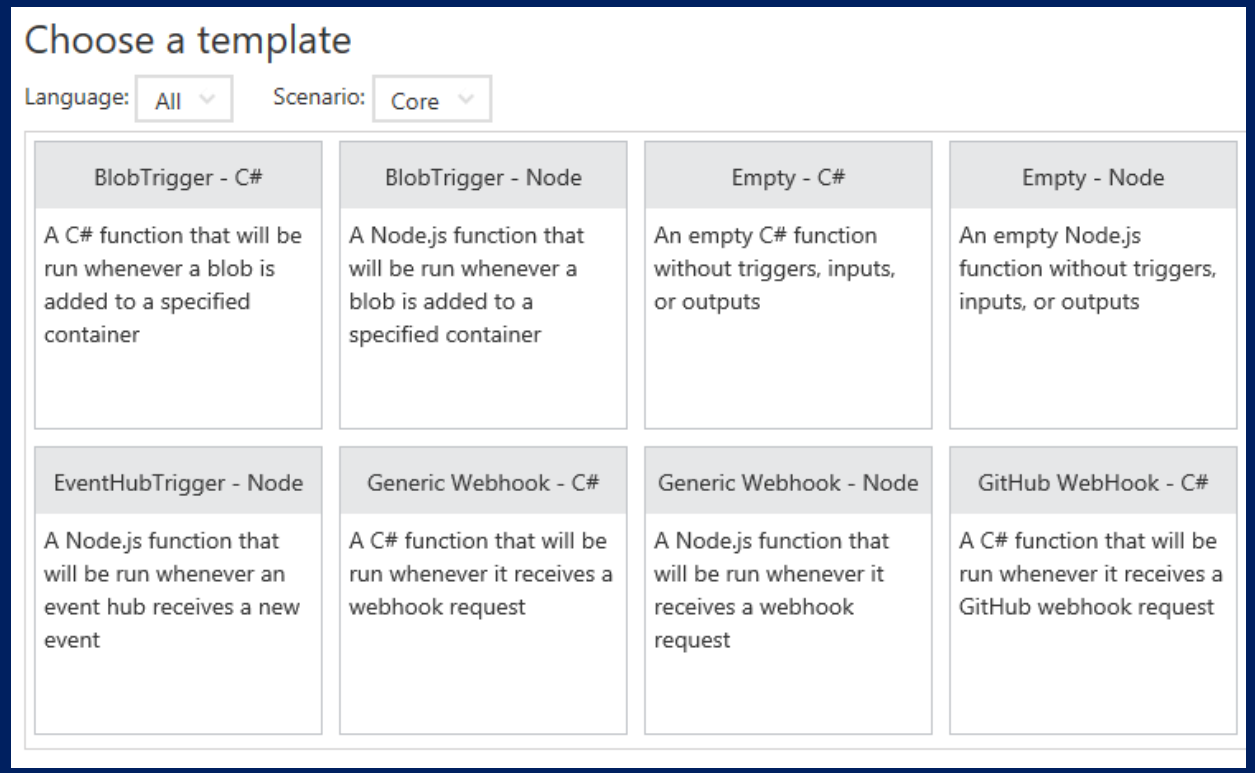
Common Scenarios

- Timer-based processing
- Azure service event processing
- SaaS event processing
- Serverless web application architectures
- Serverless mobile backends
- Real-time stream processing
- Real-time bot messaging



Function App Templates

Function App templates are categorized into general areas of Timer, Data Processing, and Webhook & API



- BlobTrigger
- EventHubTrigger
- Generic webhook
- GitHub webhook
- HTTPTrigger
- QueueTrigger
- ServiceBusQueueTrigger
- ServiceBusTopicTrigger
- TimerTrigger
- Blank & Experimental

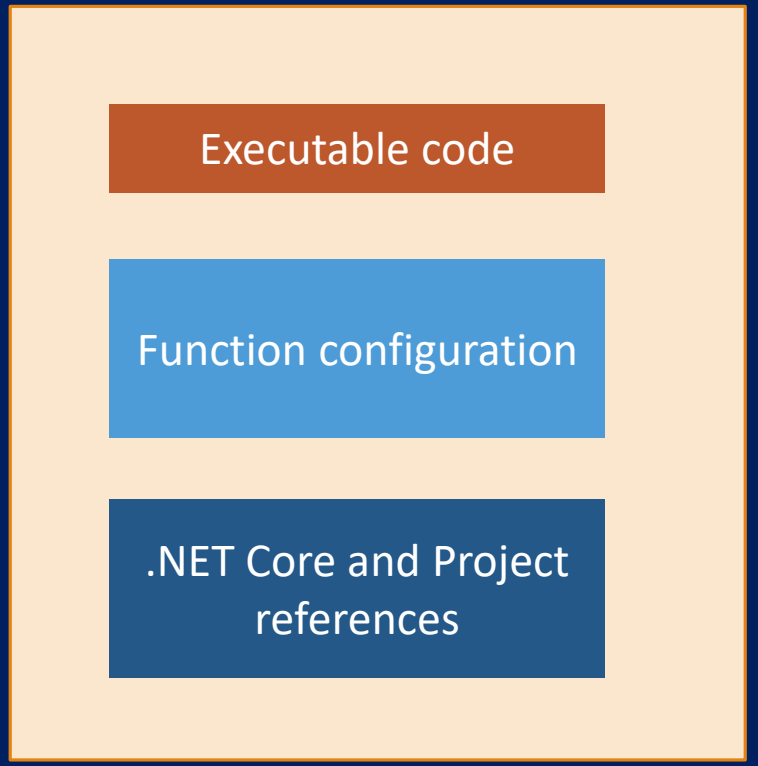
Anatomy of a Function

A “Run” file that containing the function code

A “Function” file containing all service and trigger bindings and parameters

A “Project” file containing project assembly and NuGet package references

App Service settings, such as connection strings and API keys



Function Bindings

Bindings serve as the basis for all connections to and from a function. Many bindings can be “bi-directional” as well.

Type	Service	Trigger	Input	Output
Schedule	Azure Functions	✓		
HTTP (REST or webhook)	Azure Functions	✓		✓*
Blob Storage	Azure Storage	✓	✓	✓
Events	Azure Event Hubs	✓		✓
Queues	Azure Storage	✓		✓
Tables	Azure Storage		✓	✓
Tables	Azure Mobile Apps		✓	✓
No-SQL DB	Azure DocumentDB		✓	✓
Push Notifications	Azure Notification Hubs			✓

Machine Learning

What is Machine Learning?

Branch of computer science in which a computer "learns" from data in order to perform predictive analytics

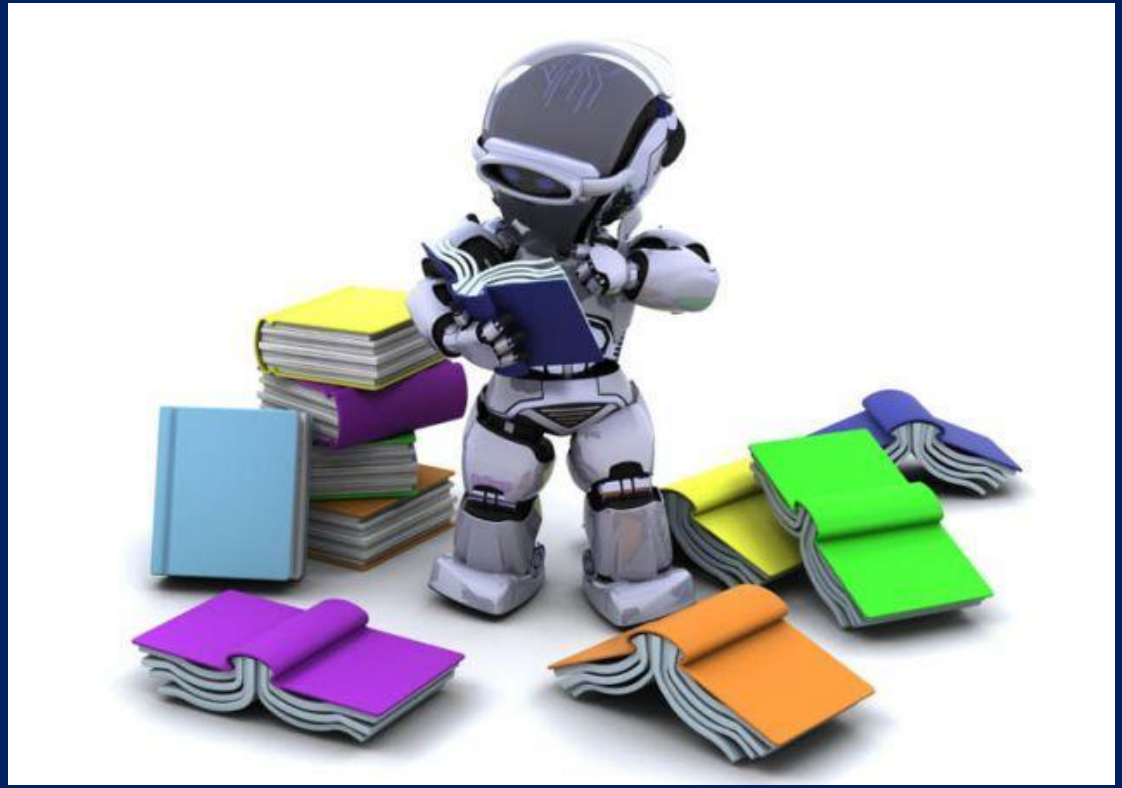
- Credit-card fraud detection
- Online shopping recommendations
- Self-driving cars and more

Supervised learning

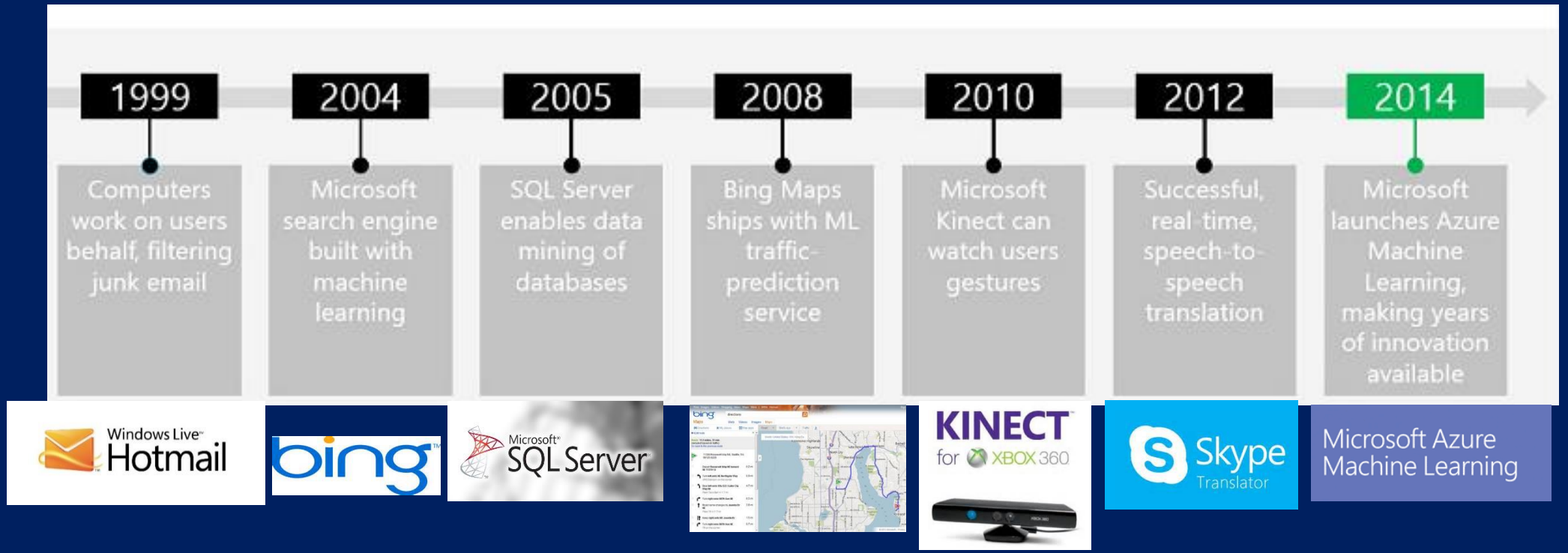
- Regression and classification

Unsupervised learning

- Clustering



Microsoft and Machine Learning



Modified from http://pulsweb.fr/predict-wine-quality-azureml

Azure Machine Learning

Fully managed cloud service for building and operationalizing ML models

Fully managed

No software to install, no hardware to manage, and one portal to view and update.

Integrated

Simple drag, drop and connect interface for Data Science. No need for programming for common tasks.

Best in Class Algorithms + R

Built-in collection of best of breed algorithms. Support for R and popular CRAN packages.

Deploy in minutes

Operationalize models with a single click. Monetize in Machine Learning Marketplace.

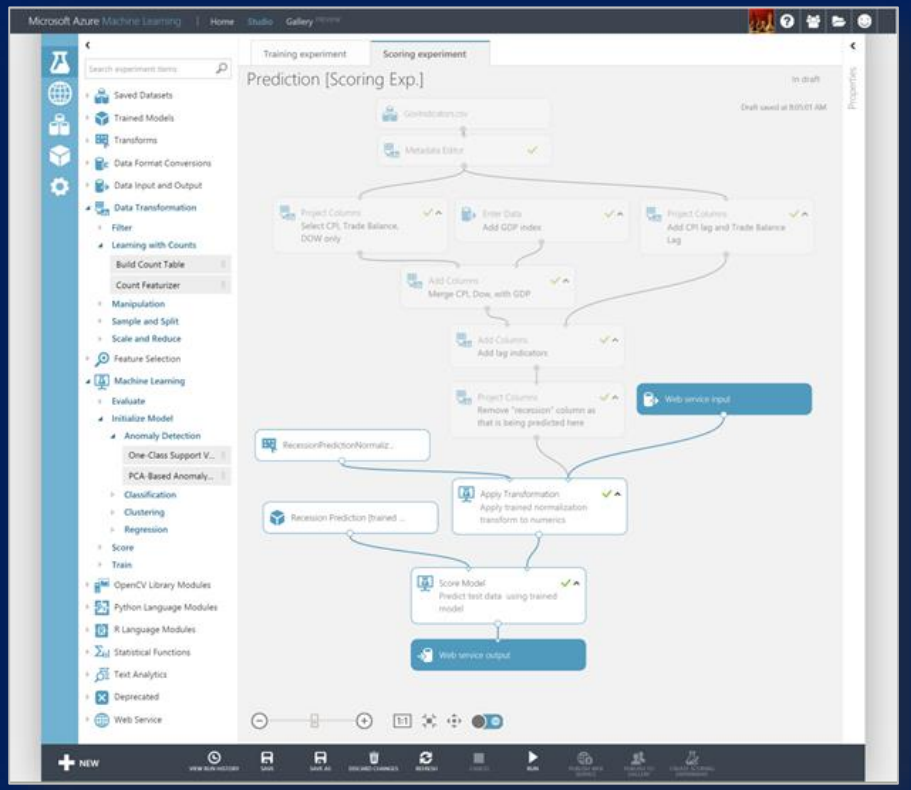
“I spent last semester building a regression model in Python, and I just did the same thing in 10 minutes with Azure ML”

Azure Machine Learning Studio

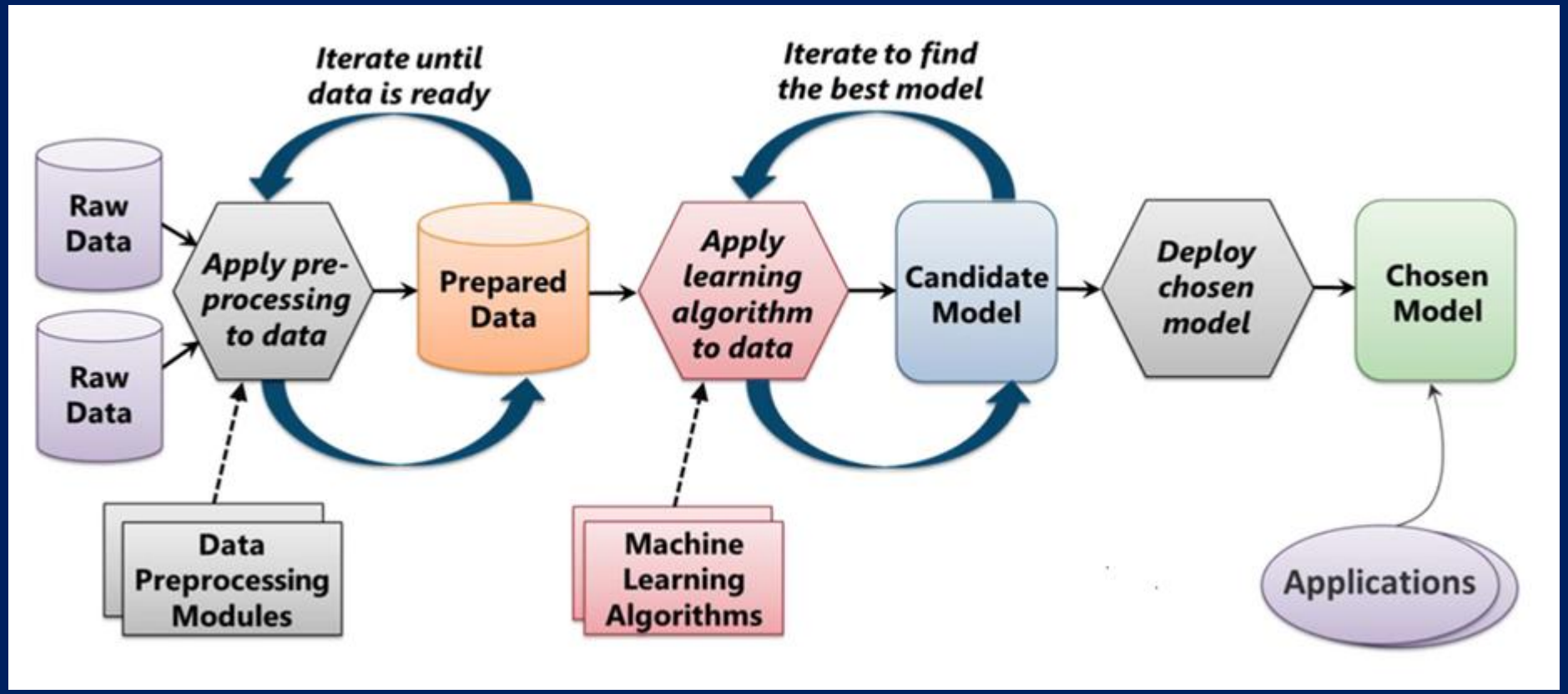
Visual editor for composing, testing, refining, and deploying machine-learning models

- Includes hundreds of modules
- Includes common algorithms for classification, regression, and more
- Supports numerous input formats
- Supports R and Python

Machine learning for the masses



The Machine Learning Process



From "Introduction to Microsoft Azure" by David Chappell

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