PSI3542 – 2023
SISTEMAS EMBARCADOS PARA IOT

AULA 02 – A PLATAFORMA DE IOT "MATHWORKS THINGSPEAK"

SERGIO TAKEO KOFUJI

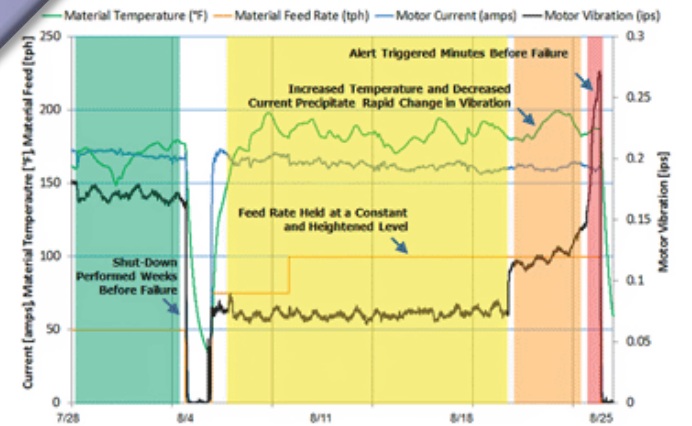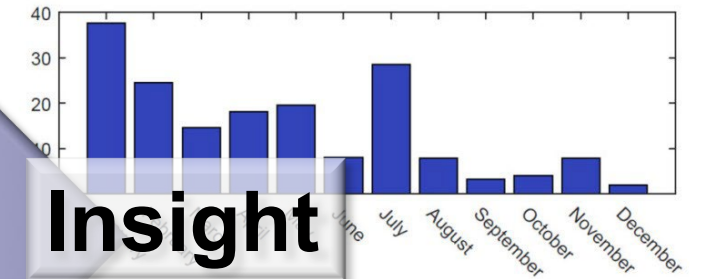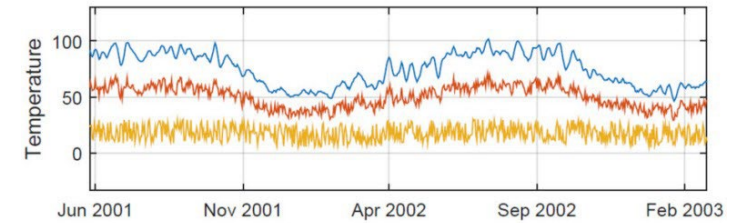KOFUJI@USP.BR

Internet of Things

Devices → **Analytics** → **Insight**

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IoT Analytics

Devices

Analytics

Access and Explore Data

Preprocess Data

Develop Predictive Models

Insight
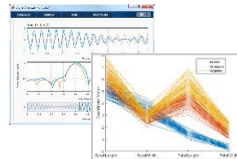
Business Data

Sensor Data

Data Reduction/ Transformation
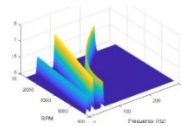
Feature Extraction

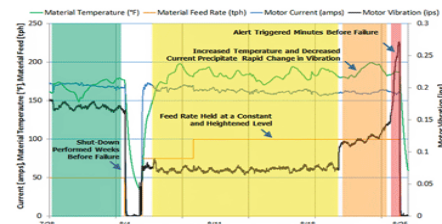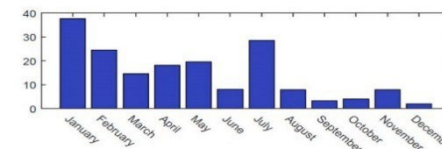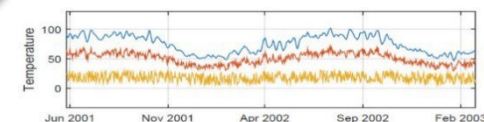**Model Creation**

Model Validation

Figure 3. Vibration analysis: Data processed by the company's vibration analysis tool, and leading up to the fan's catastrophic failure, provides an ambiguous indication of the asset's degrading condition.

IoT Analytics Framework

Communication

Connectivity

Analytic IoT Platform
- Online analytics
- Visualization and reporting

Deploy analytics to cloud

Deploy algorithm to device

Smart Connected Devices
- Local embedded algorithms
- Data reduction

Algorithm Development
- Historical analytics
- Sensor analytics
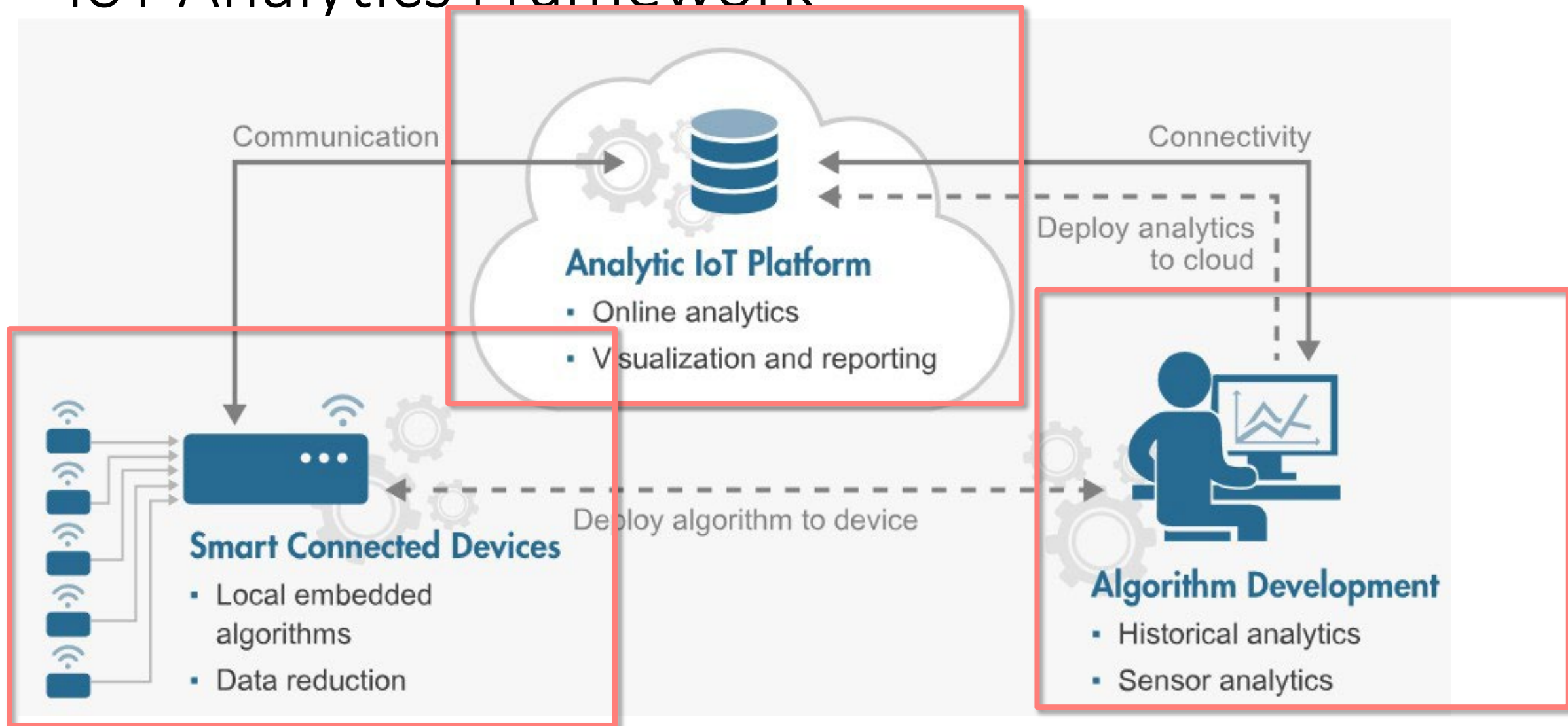
IoT Analytics Challenges

- **How do I deploy my algorithms on a smart device?**

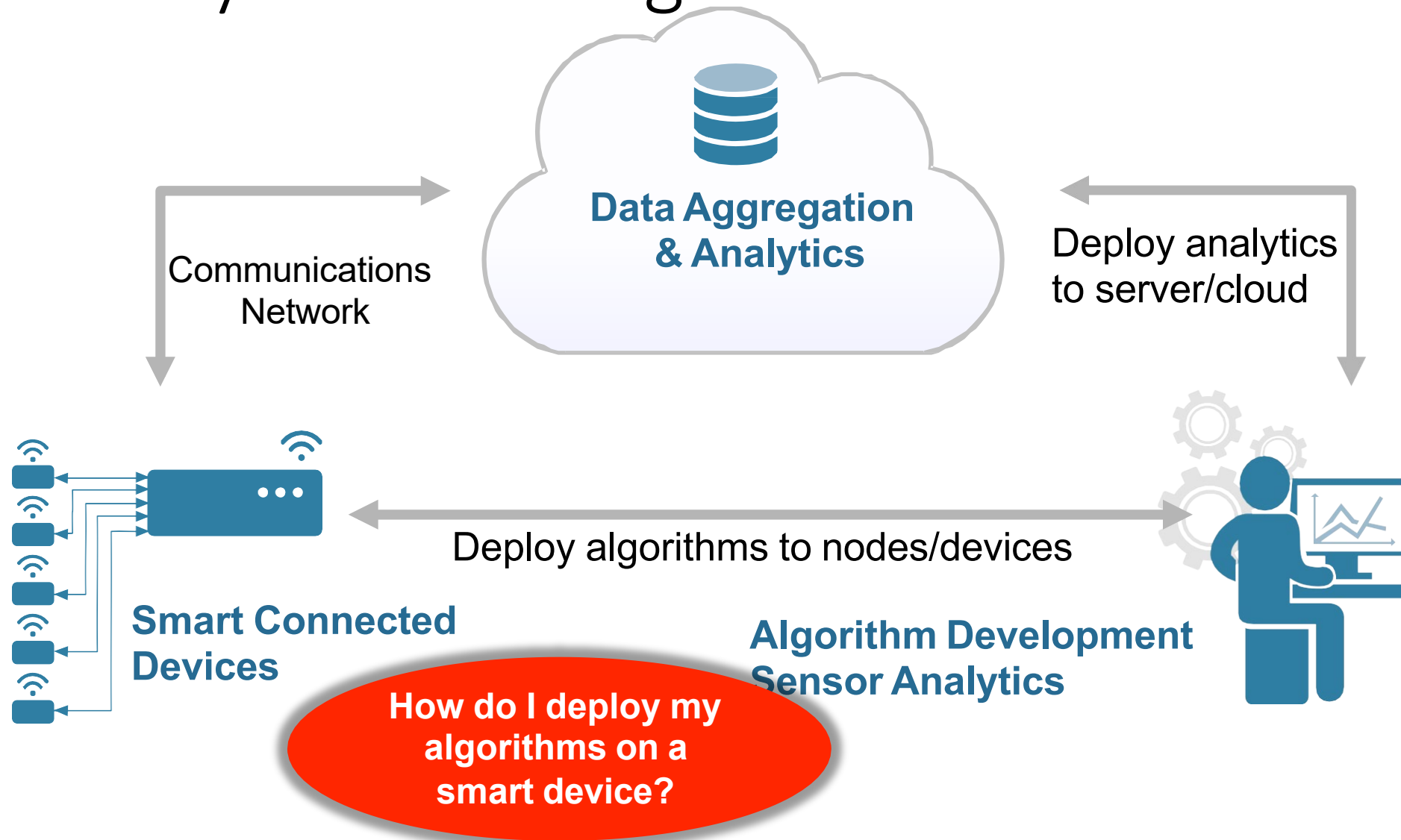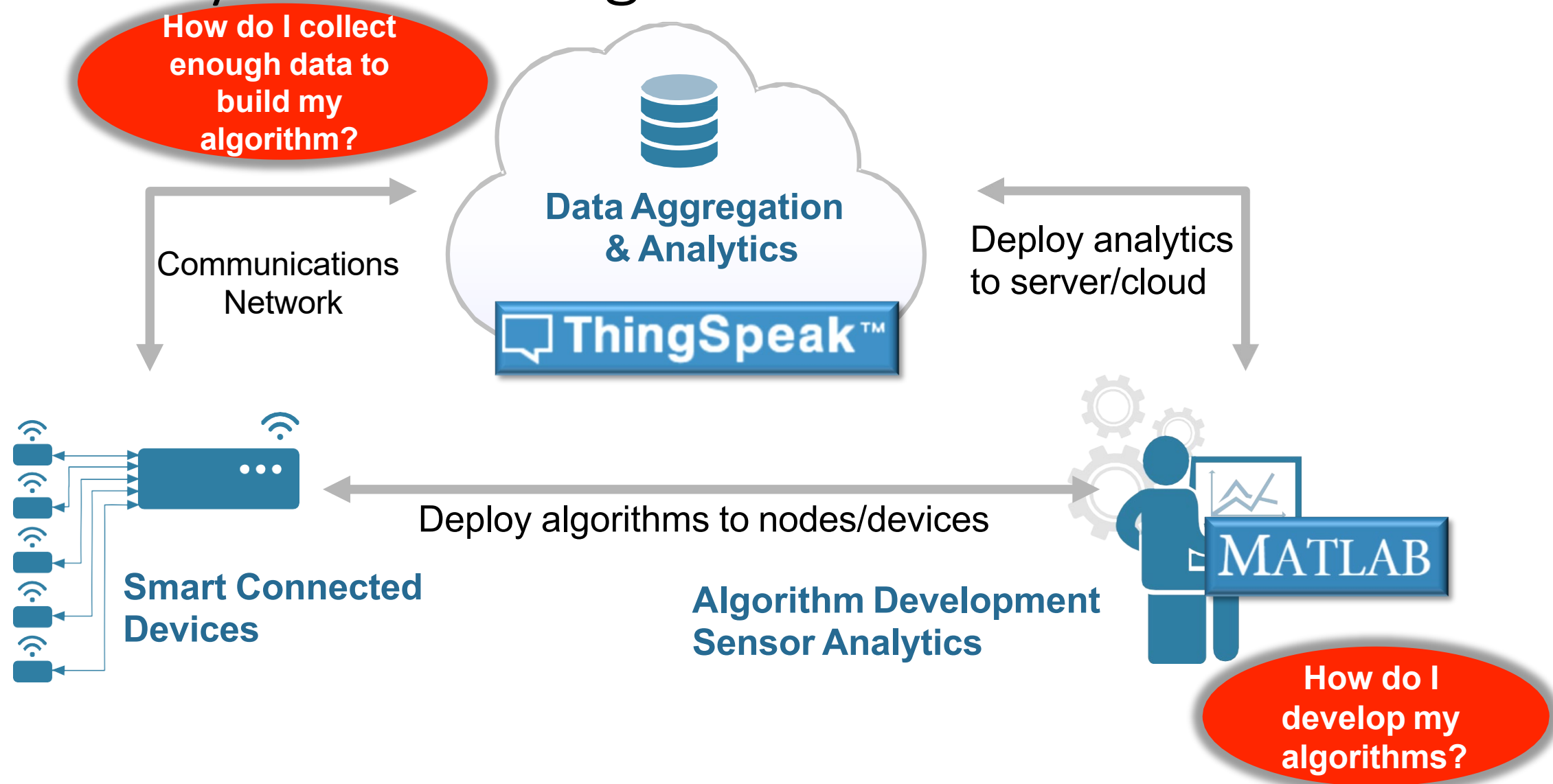- **How do I collect enough data to build my algorithm?**

- **How do I develop my algorithms?**

- **How do I deploy my algorithms to the cloud?**

IoT Analytics Challenges

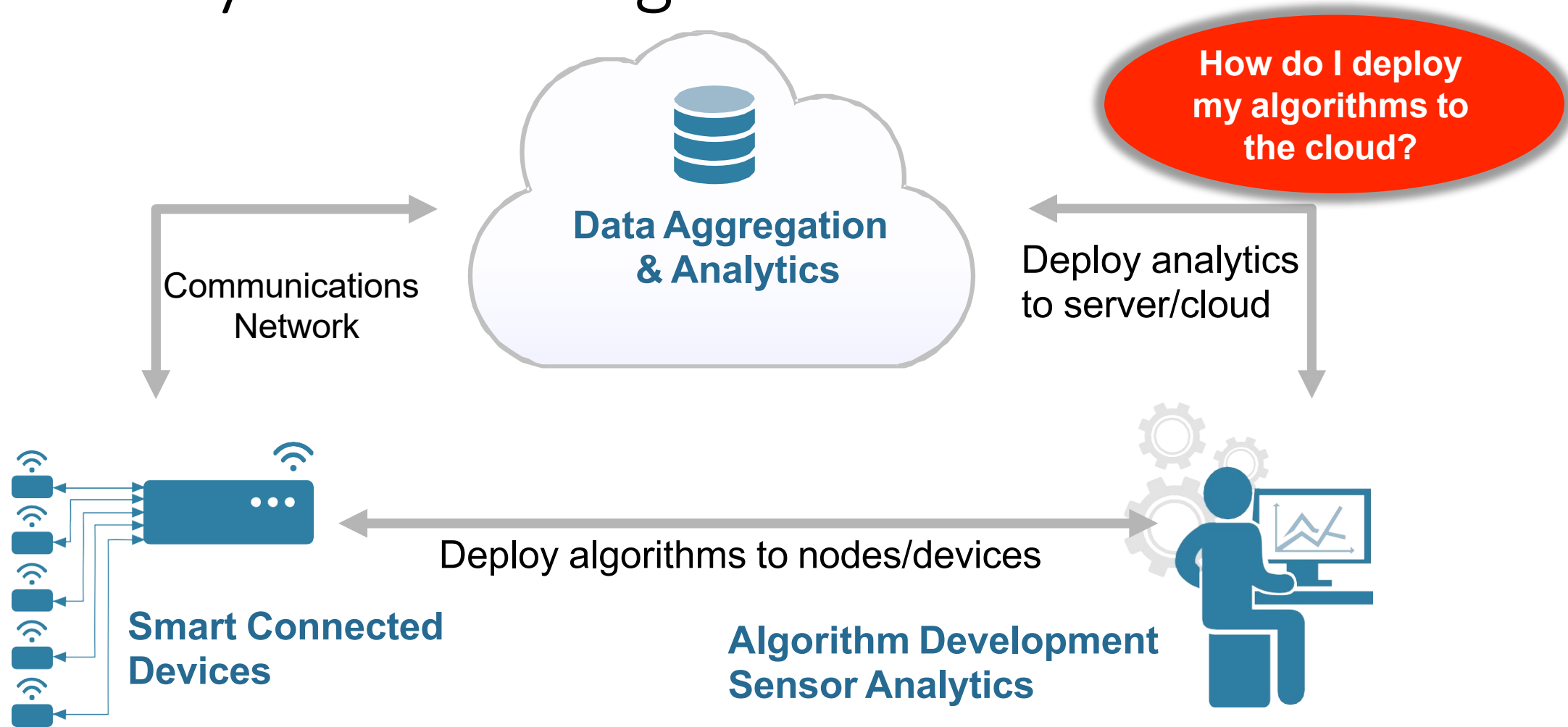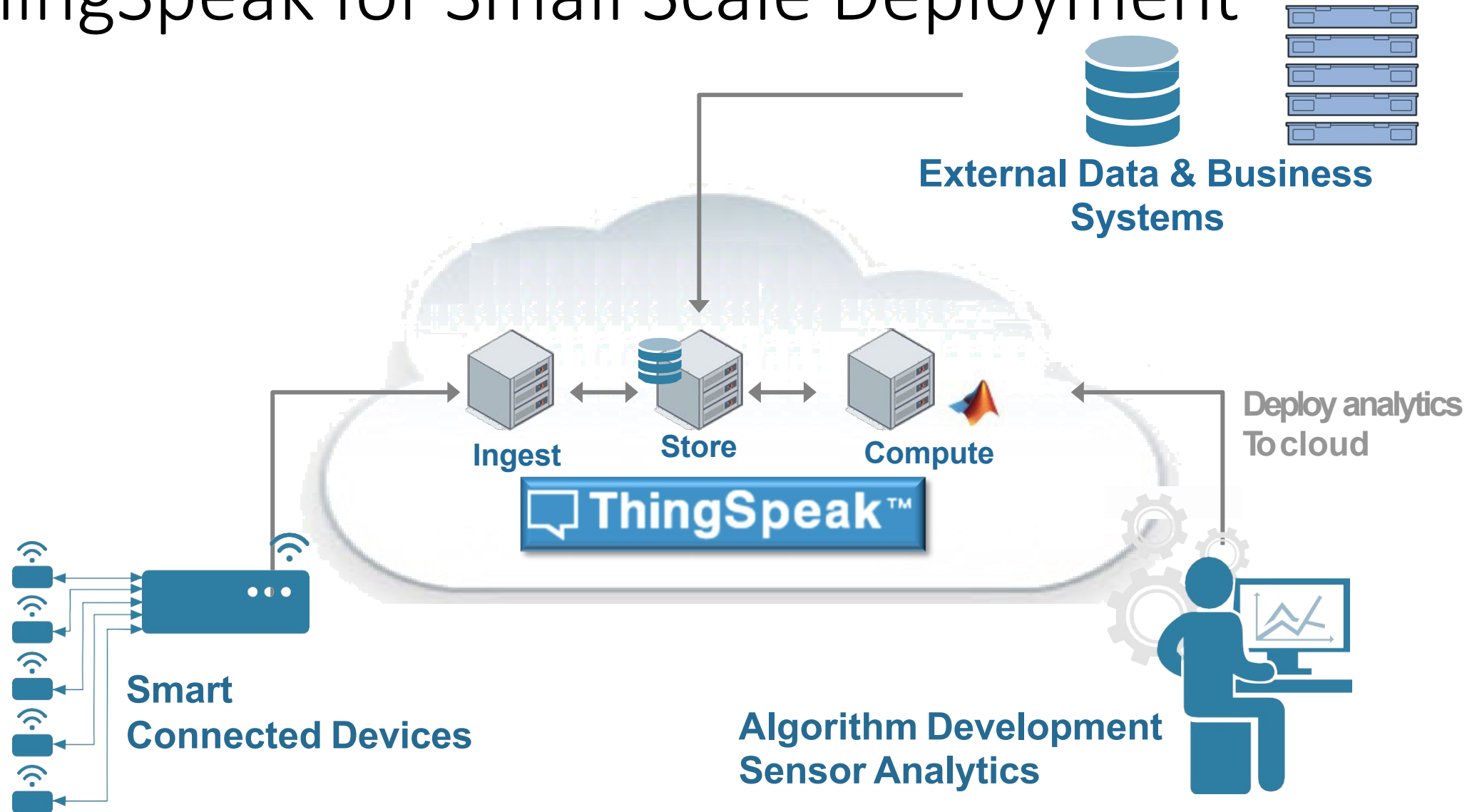**Data Aggregation & Analytics**

Communications Network

Deploy analytics to server/cloud

Deploy algorithms to nodes/devices

Smart Connected Devices

Algorithm Development Sensor Analytics

How do I deploy my algorithms on a smart device?

IoT Analytics Challenges

How do I collect enough data to build my algorithm?

Data Aggregation & Analytics

ThingSpeak™

Communications Network

Deploy analytics to server/cloud

Deploy algorithms to nodes/devices

Smart Connected Devices

Algorithm Development Sensor Analytics

MATLAB

How do I develop my algorithms?

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IoT Analytics Challenges

How do I deploy my algorithms to the cloud?

Data Aggregation & Analytics

Communications Network

Deploy analytics to server/cloud

Deploy algorithms to nodes/devices

Smart Connected Devices

Algorithm Development Sensor Analytics

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ThingSpeak for Small Scale Deployment

External Data & Business Systems

Ingest   Store   Compute

ThingSpeak™

Deploy analytics To cloud

Smart Connected Devices

Algorithm Development Sensor Analytics

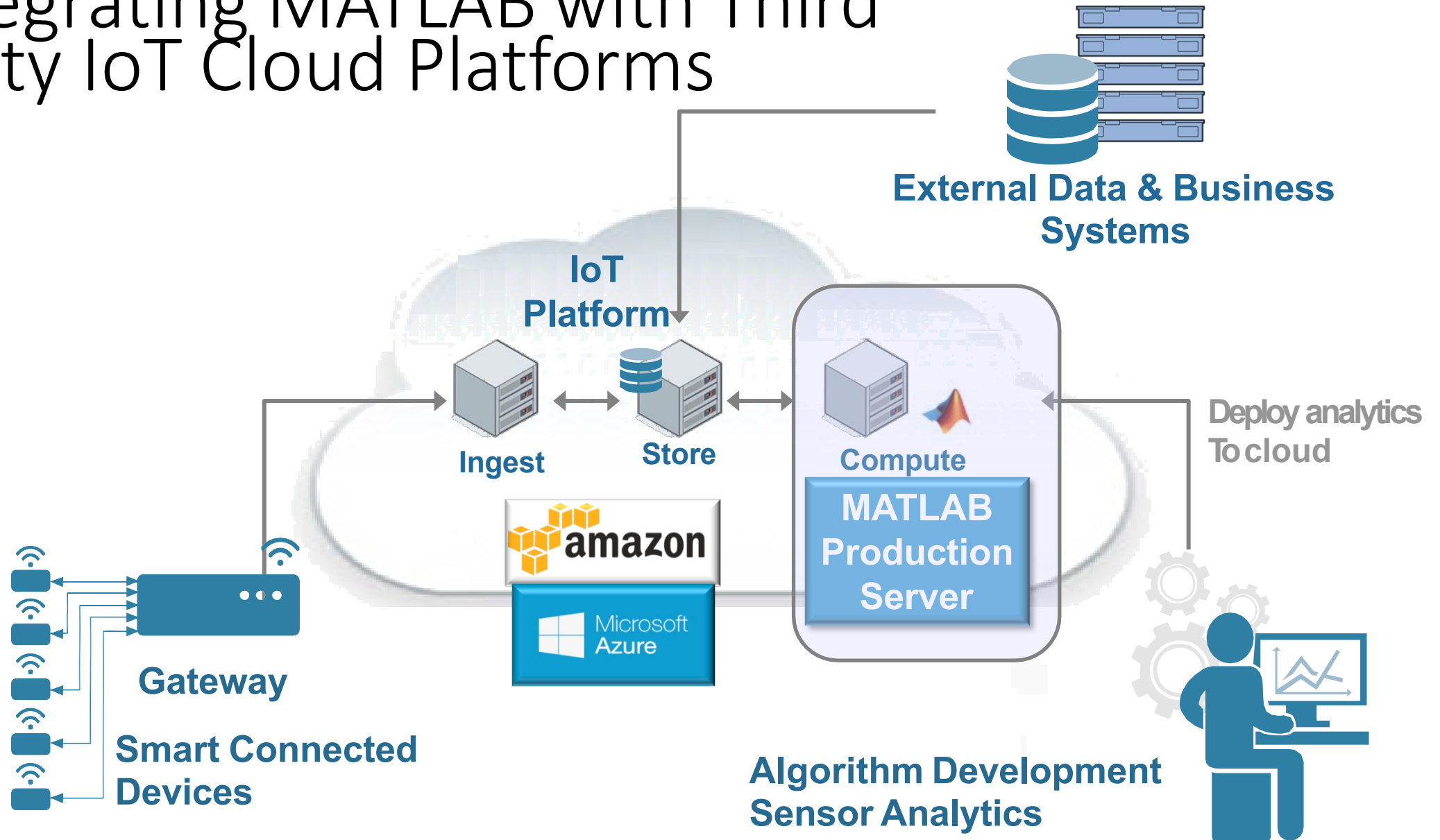# Sensor Analytics and Development of Smart Devices
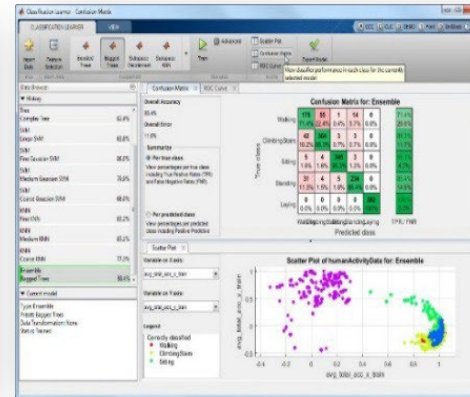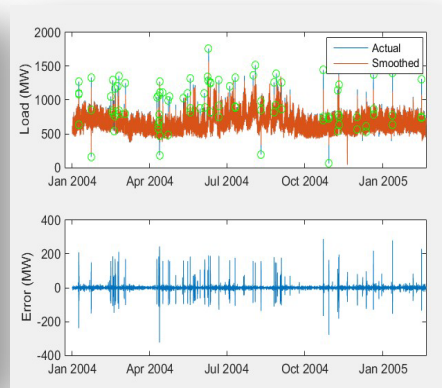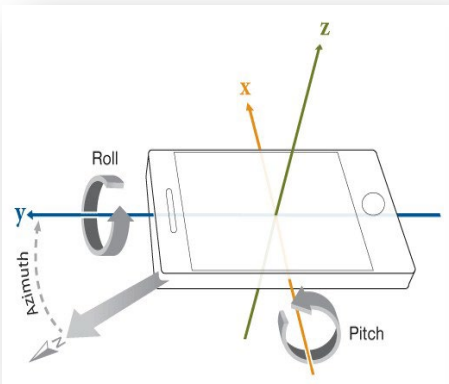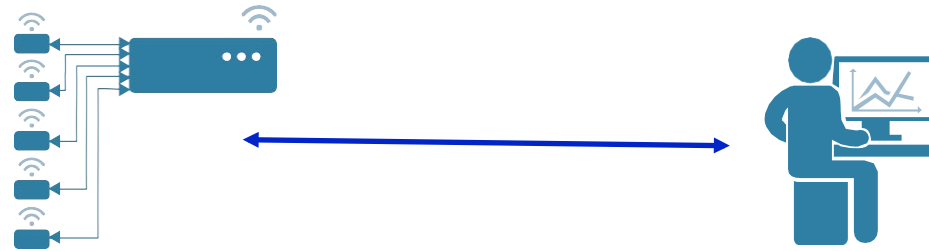
| Connect and Acquire | Signal Processing | Machine Learning | Embedded Implementation |

Integrating MATLAB with Third Party IoT Cloud Platforms

External Data & Business Systems

IoT Platform

Ingest

Store

Compute

amazon

Microsoft Azure

MATLAB Production Server

Deploy analytics To cloud

Gateway

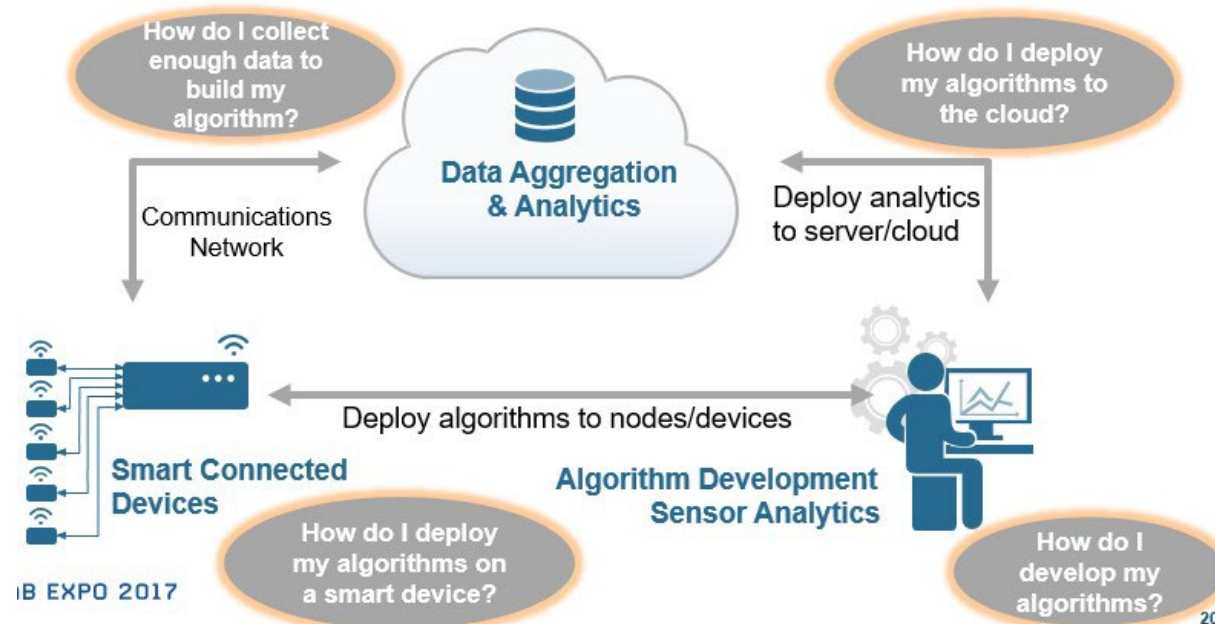Smart Connected Devices

Algorithm Development Sensor Analytics

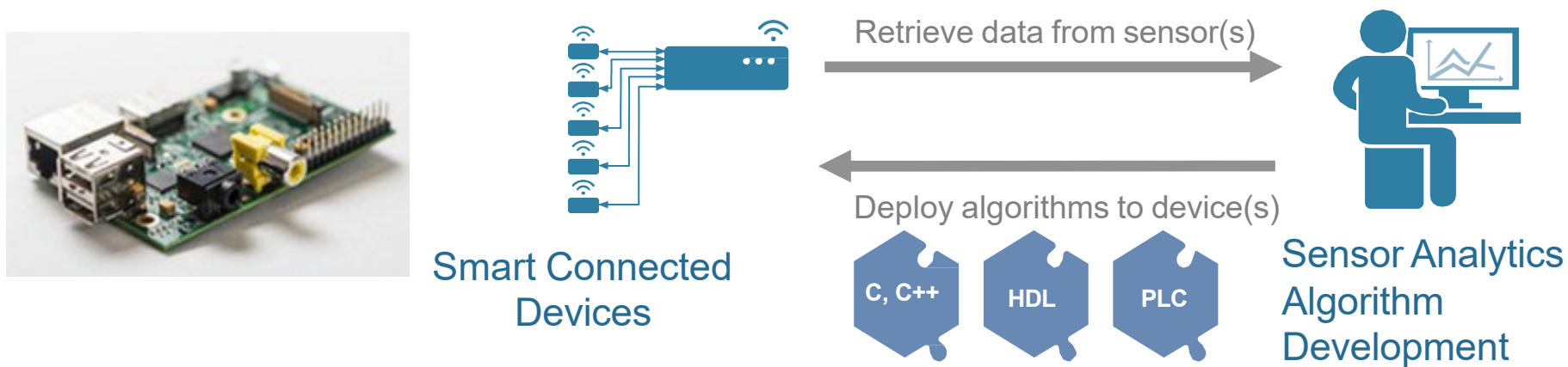# Integrating MATLAB in Large Scale Production Systems
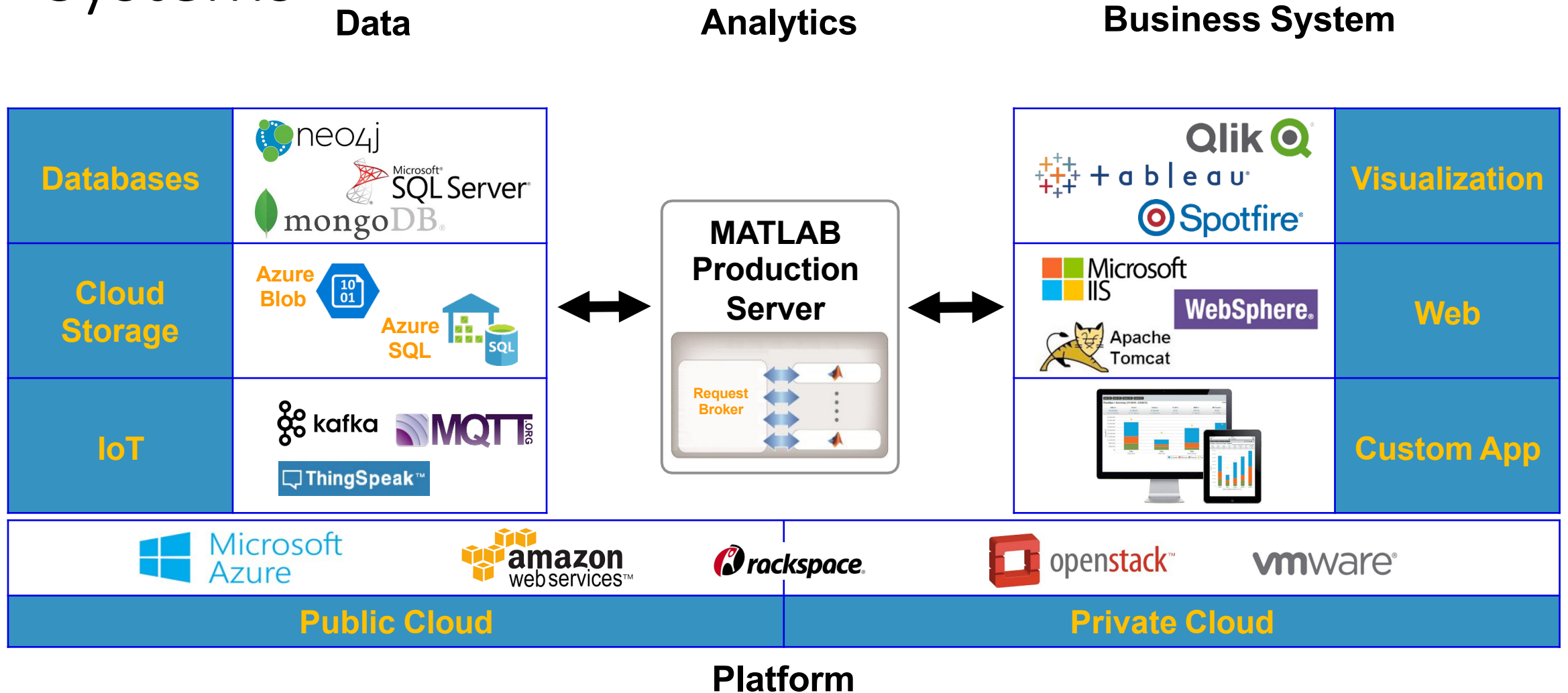
MathWorks Addresses IoT Analytics Challenges

- **Quickly collect and analyze IoT data with ThingSpeak and MATLAB**

- **Develop analytics algorithms using MATLAB and toolboxes**

- **Deploy on smart devices using code generation and embedded target support**

- **Deploy on cloud using ThingSpeak and MATLAB Production Server**

How do I collect enough data to build my algorithm?

Data Aggregation & Analytics

How do I deploy my algorithms to the cloud?

Communications Network

Deploy analytics to server/cloud

Deploy algorithms to nodes/devices

Smart Connected Devices

Algorithm Development Sensor Analytics

IB EXPO 2017

How do I deploy my algorithms on a smart device?
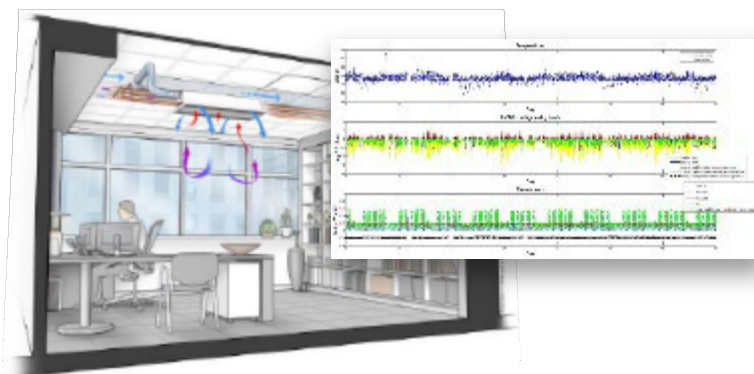
How do I develop my algorithms?

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Designing Smart Connected Devices

- **Gather data from sensors using I2C/SPI and other interfaces**

- **Use pre-built libraries for signal processing , computer vision, machine learning and more**

- **Automatically generate C / C++, HDL, PLC code**

- **Embedded targeting packages for a wide variety of hardware**

Retrieve data from sensor(s)

Smart Connected Devices

Deploy algorithms to device(s)

C, C++   HDL   PLC

Sensor Analytics Algorithm Development

Industrial Customer Examples

Online optimization of building energy use

- **Real-time, cloud-based system**
- **Combines analytics with optimization for predictive control of single-building HVAC**
- **Energy consumption reduced 15-25%**
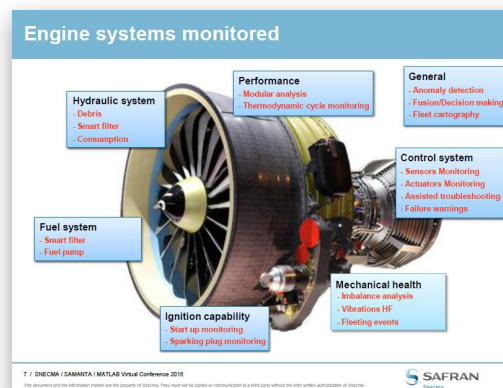
Online engine health monitoring

- **Real-time analytics integrated with enterprise service systems**
- **Predict sub-system performance (oil, fuel, liftoff, mechanical health, controls)**
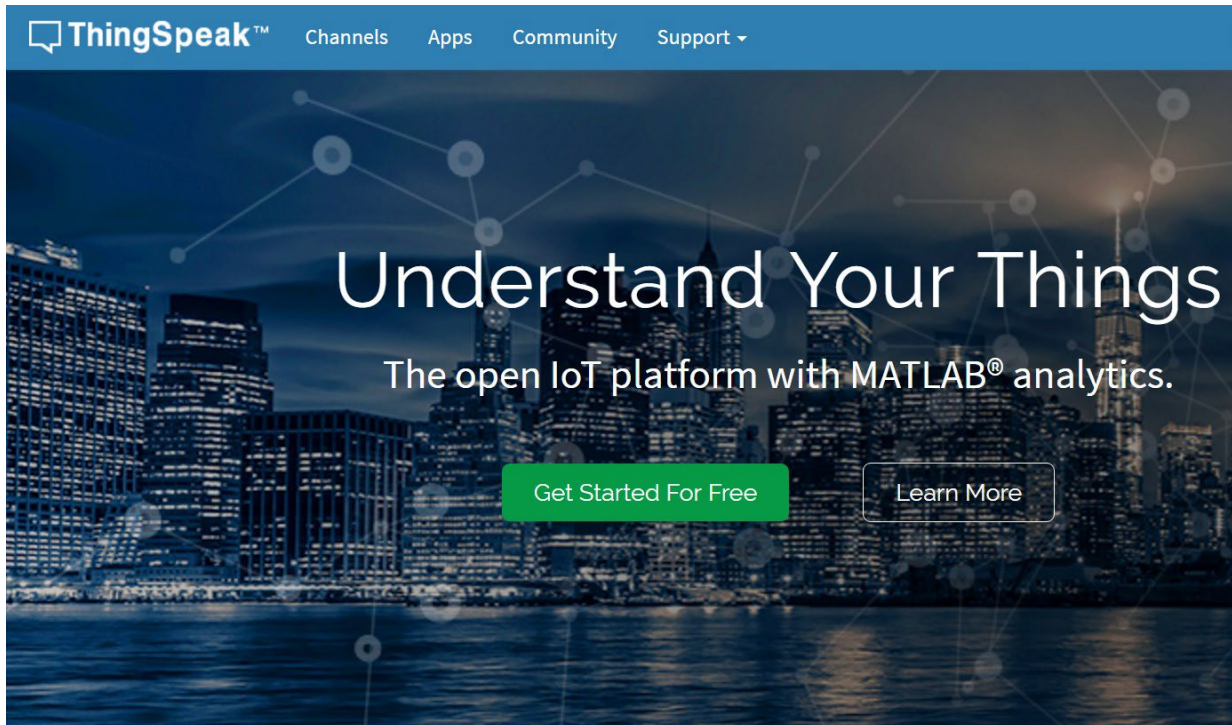- **Improve aircraft availability and reduce maintenance costs**

Cloud-based wheeze analysis

- **Medical device to monitor and manage asthma and COPD**
- **Leverages analytics in cloud and embedded system**

What Is ThingSpeak?

Web Site For People   **Web Service for Devices**

```
{
  - channel: {
      id: 38629,
      name: "Car Counter",
      description: "Counting number of cars passing a reference line in 15 sec interval",
      latitude: "42.28",
      longitude: "-71.35",
      field1: "Number of Westbound Cars",
      field2: "Number of Eastbound Cars",
      created_at: "2015-05-19T20:14:03Z",
      updated_at: "2016-05-19T10:36:35Z",
      last_entry_id: 1477231
  },
  - feeds: [
    - {
        created_at: "2016-05-19T10:36:20Z",
        entry_id: 1477230,
        field1: "18.000000",
        field2: "8.000000"
    },
    - {
        created_at: "2016-05-19T10:36:35Z",
        entry_id: 1477231,
        field1: "18.000000",
        field2: "14.000000"
    }
  ]
}
```

ThingSpeak

- **New MathWorks web service hosted on AWS**

- **Lets you collect, analyze and act on data from "things"**

- **Over 130,000 users worldwide**

https://thingspeak.com

- **It has MATLAB for IoT Analytics**

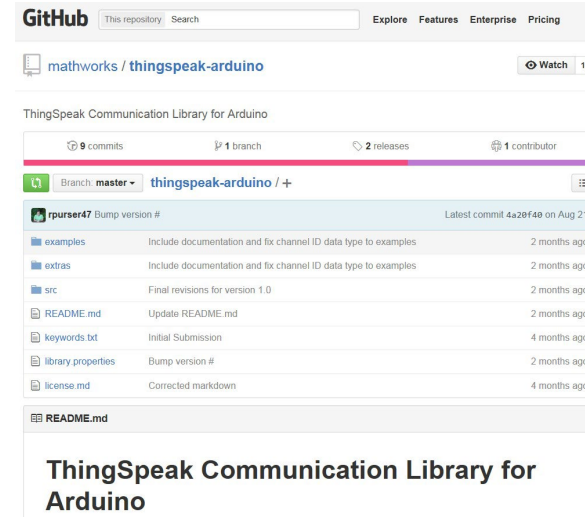- **It's free to get started**
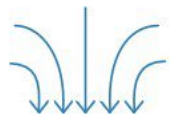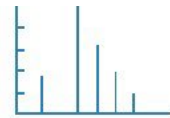
Collect   Analyze   Act

Getting data into ThingSpeak

- **Rest API**

- **MQTT API**

- **Native Libraries**

  – **Arduino**

  – **Particle**

- **Simulink Support Packages**

  – **Raspberry Pi**

  – **Arduino**

  – **BeagleBone Black**

  – **iPhone**
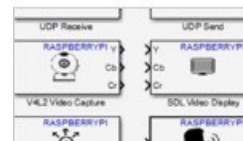
  – **Android**

Getting data into ThingSpeak

- For any new data, first login and create a channel in ThingSpeak

- Channels have read and write API keys and can be public or private

- A channel is made up of 8 fields and can store 8 streams of data (Temp, Humidity, etc.)

- Channels can be updated at a maximum rate of once every 15 seconds (free) or 1 second (paid)

IoT Solutions Examples

Data Aggregator

ThingSpeak

Analyze
Analyze and visualize your data.

RASPBERRYPI

ThingSpeak Write

```
thingSpeakRead(12397,'Fiel
```

Traffic Volume for the week of July 25

West Bound Traffic
East Bound Traffic

Edge Nodes

Live Car Counting with Raspberry Pi Hardware

Exploratory Analysis
- **Historical analytics**
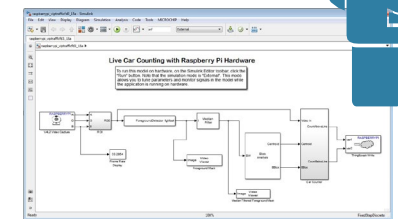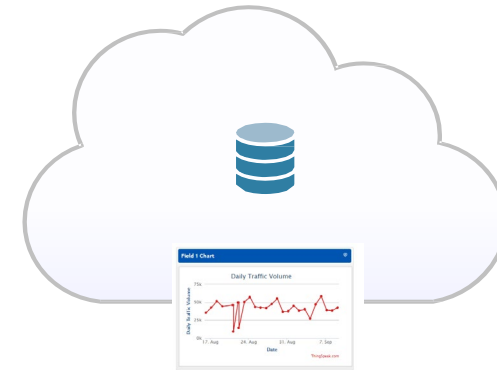- **Algorithm development**

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Monitoring Traffic

- **Objectives**
  - **Measure, explore, discover traffic patterns**
  - **Provide live local traffic information service**
- **Solution**
  - **RaspberryPi + webcam**
  - **Automated deployment of vision algorithms on embedded sensor**

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