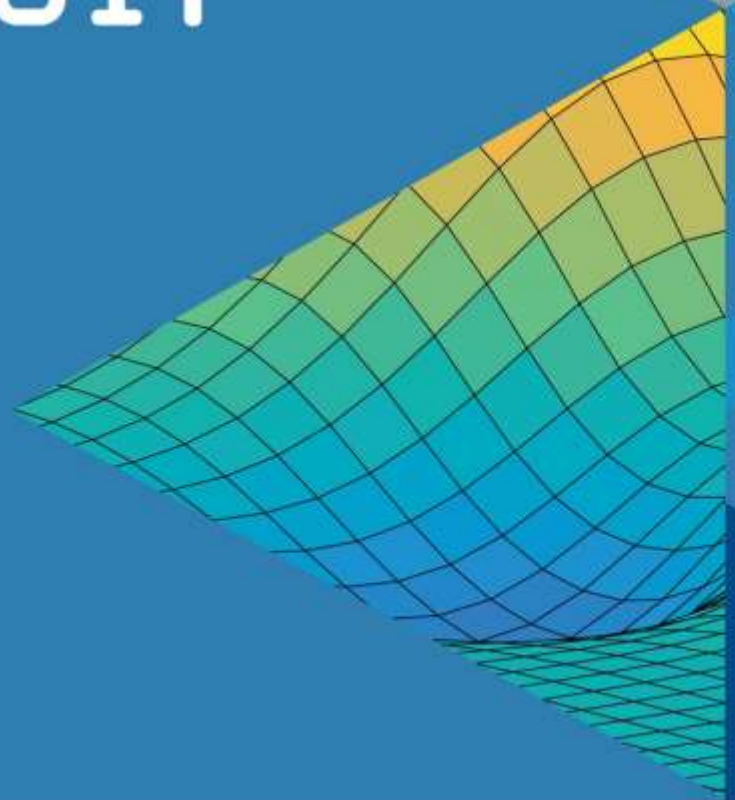
MATLAB EXPO 2017

Developing Analytics and Deploying IoT Systems

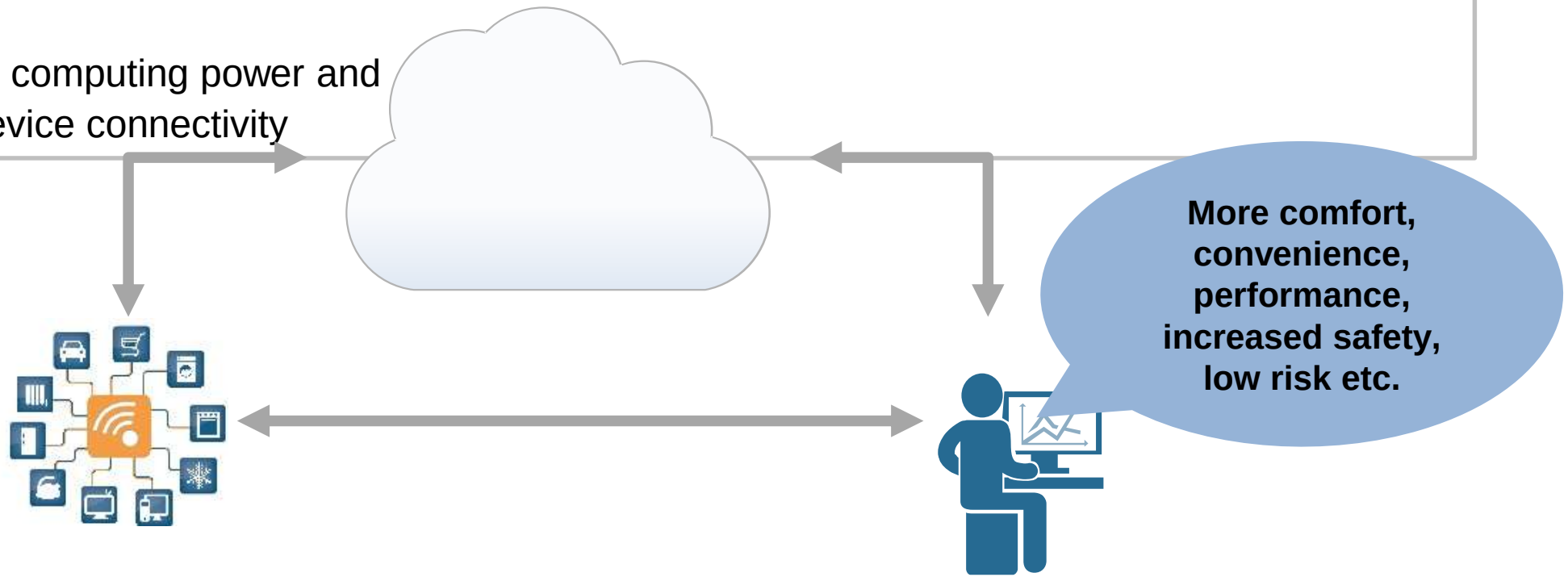


Amit Doshi
Senior Application Engineer, MathWorks India
amit.doshi@mathworks.in

What is Internet of things (IoT)?

- Internet of Things (IoT) is internetworking of a large number of **embedded devices** (“**things**”) which are **connected to the Internet**. These connected devices **communicate with people and other things** and often provide **sensor data to cloud storage and cloud computing resources** where the **data is processed and analyzed to gain important insights**.

- **Why now** –
  - Cheap cloud computing power and
  - Increased device connectivity



‘Chips in everything’ & the rise of ‘Ubiquitous sensing’

Extracting insights from sensor data… a common practice

Deloitte.

Estimates of the size of the IoT market vary. For instance, Gartner expects it to include nearly 26 billion devices, with a “global economic value-add” of $1.9 trillion by 2020.3

HealthLeaders Media

Tip of the week: Incorporate ADL tracking tools in your everyday care planning

Science & Technology

[redacted] Analytics : sensor customer behavior analysis

mobihealthnews

NIH’s $10.8M grant for sensor-enabled congestive heart failure, smoking cessation tools

DEFENSESYSTEMS

Army aims to speed up data fusion on the battlefield

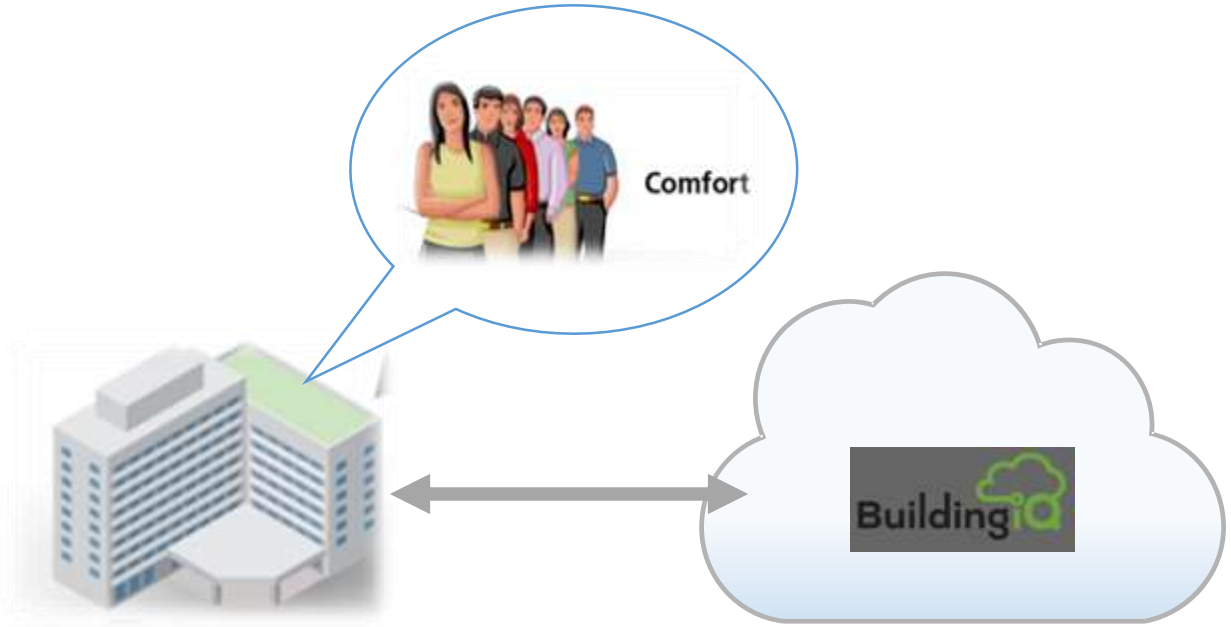
By Kevin McCaney | Mar 02, 2015

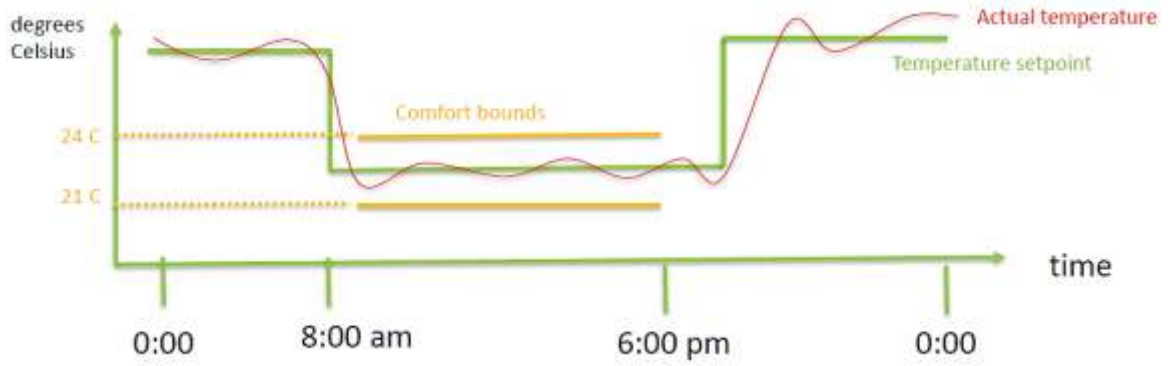
Human Applications:

- Medical
- Leasure
- Sports/Fitness
- Military
- Social
- Retail
- Security

Example – BuildingIQ

Cloud based adaptive building energy management





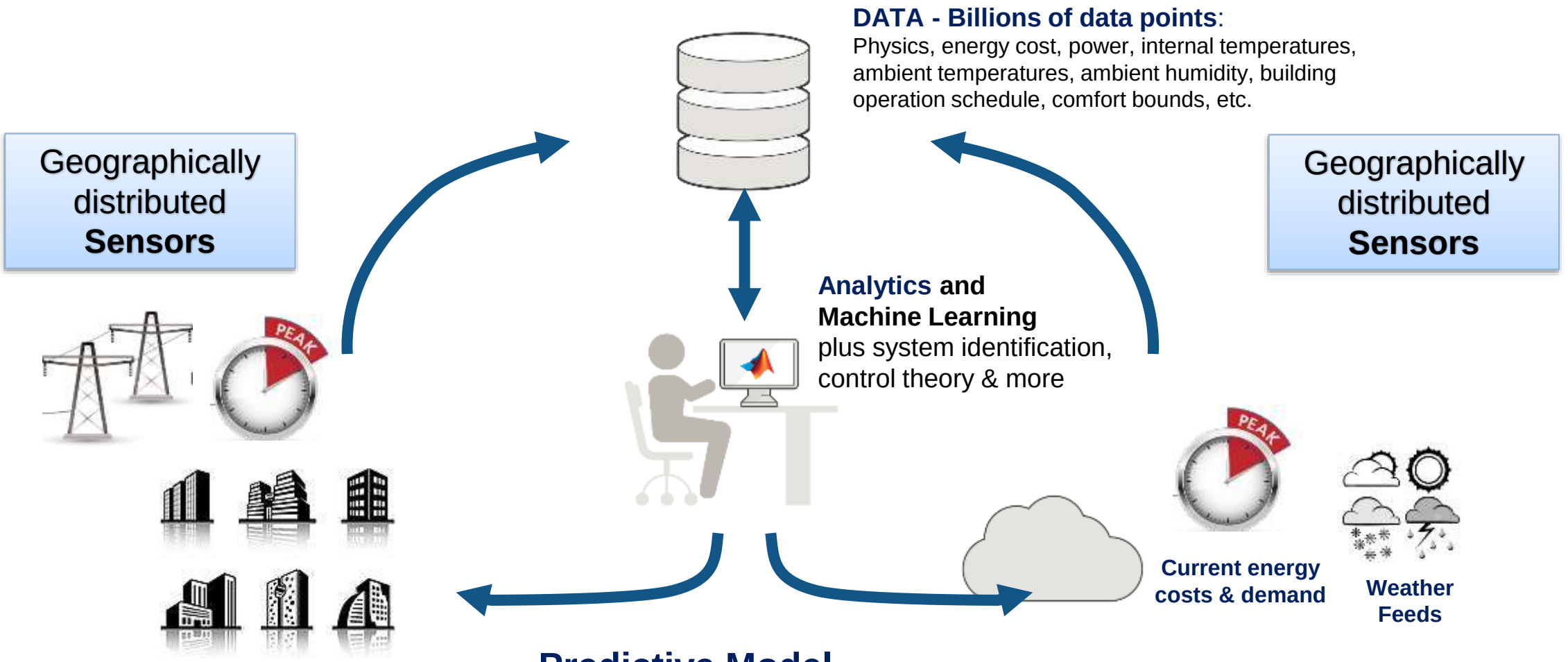
Challenge

Minimize energy costs of large-scale commercial buildings without compromising tenants comfort.

Solution

Develop cloud based real-time adaptive system via proactive, predictive optimization algorithm.

Real-time, closed-loop optimization algorithms



Example – BuildingIQ

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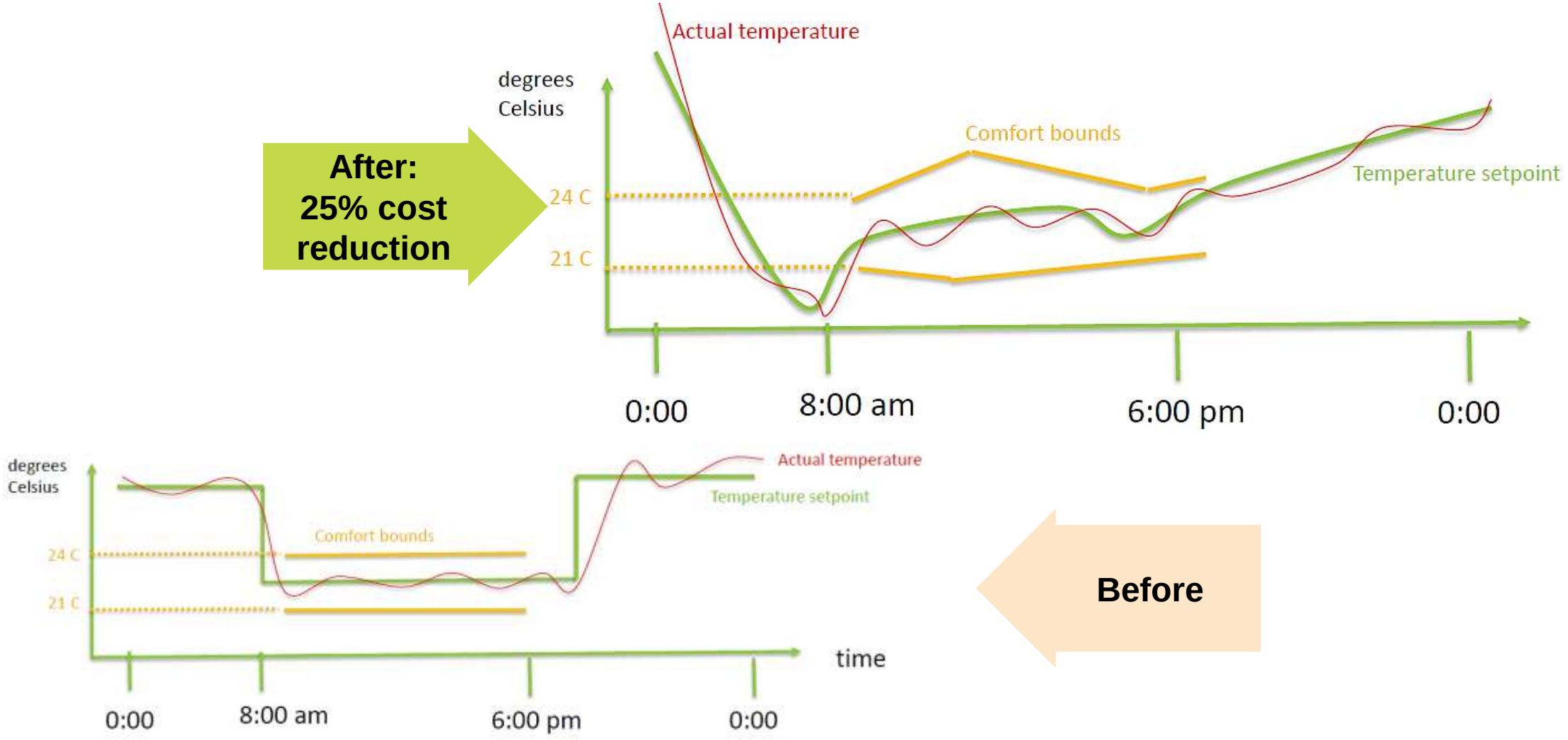
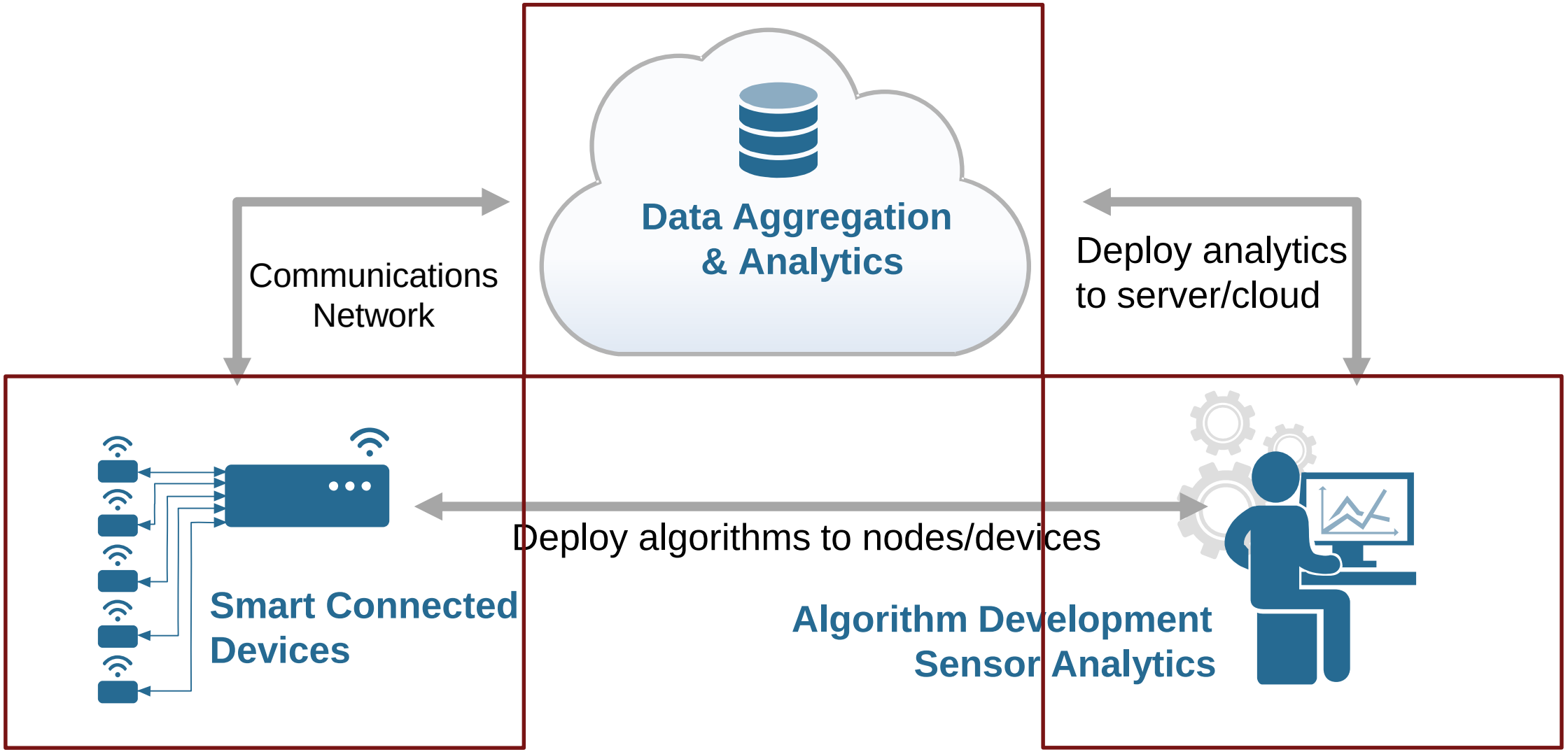
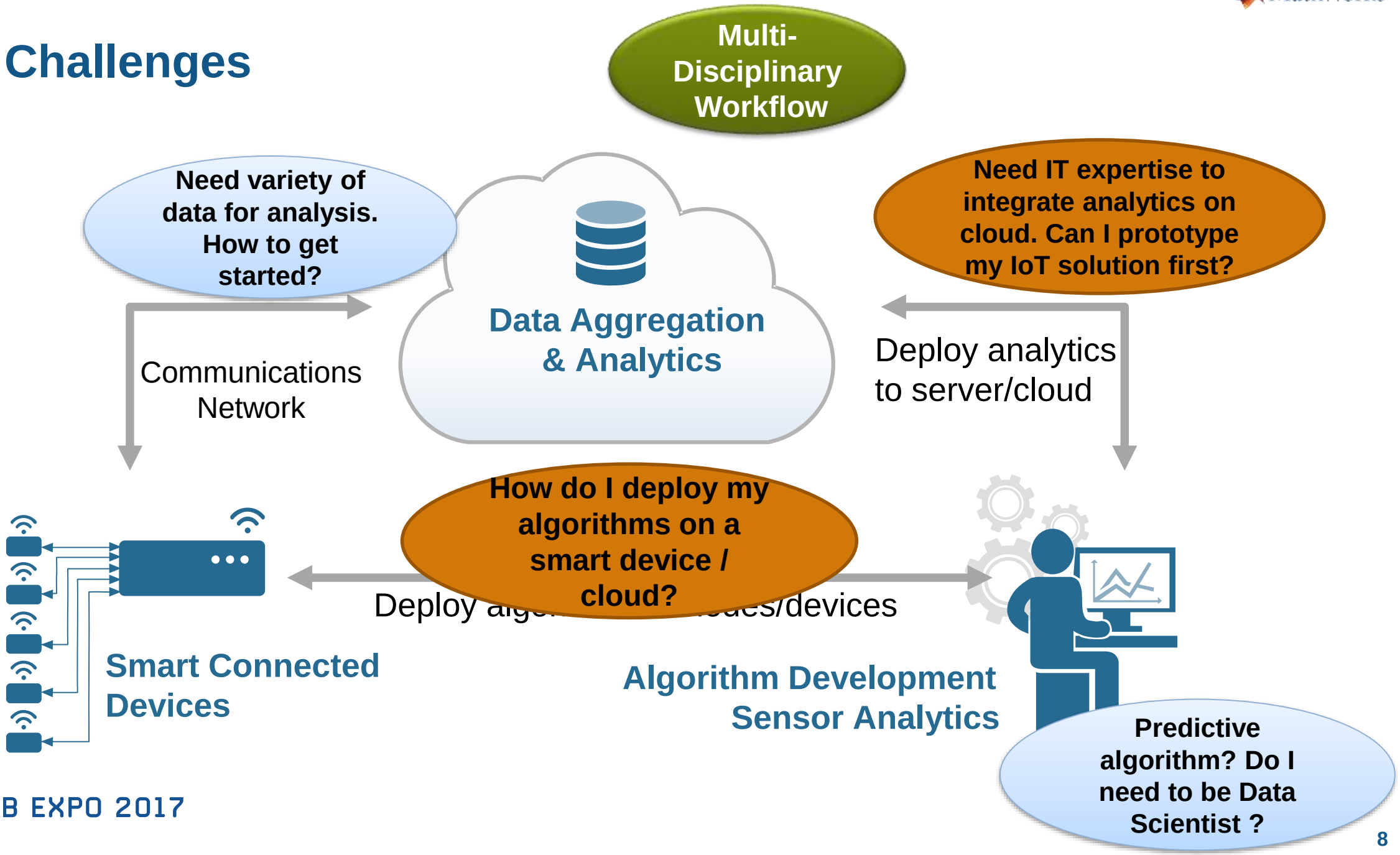


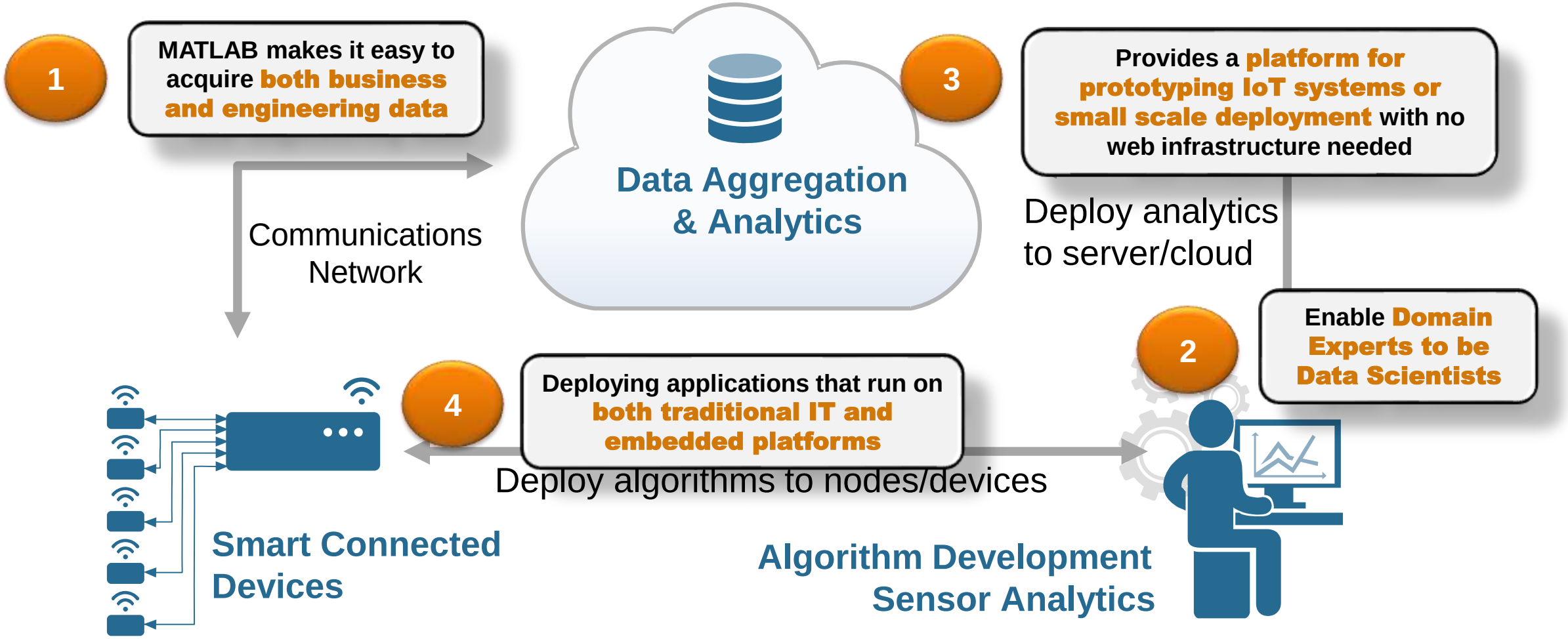
High Level Architectural View of Internet of Things



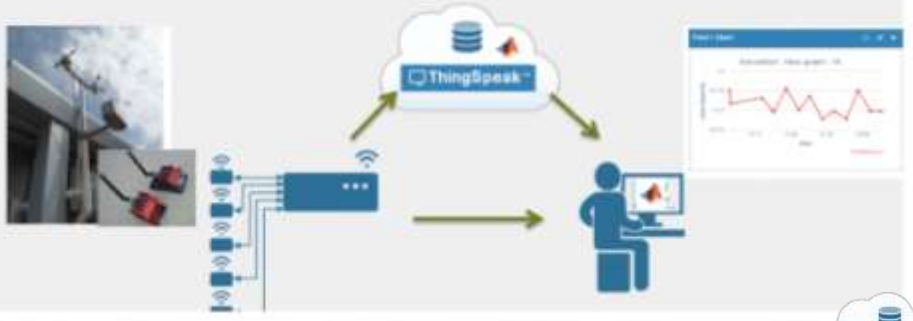
IoT Challenges

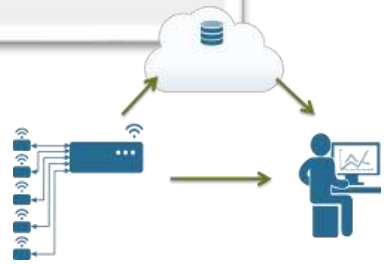


How MathWorks Addresses IoT Challenges?



Example 1: Weather monitoring using ThingSpeak and MATLAB





Example 2: Low Tide Prediction Using MATLAB And ThingSpeak

Challenge
Boats get stuck in mud at low tide

Solution
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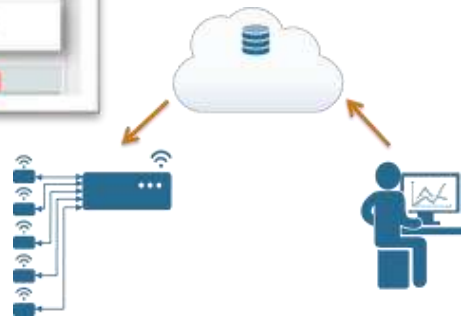
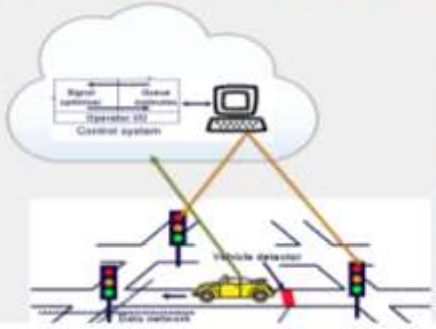
Even cooler...get notifications on mobile

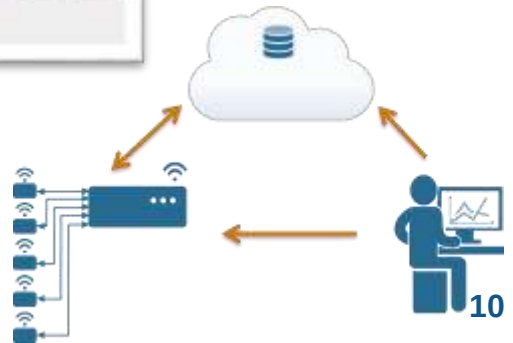


Example 3: Human Activity Analysis and Classification

Example 4: Traffic monitoring

can be used for smart traffic light management





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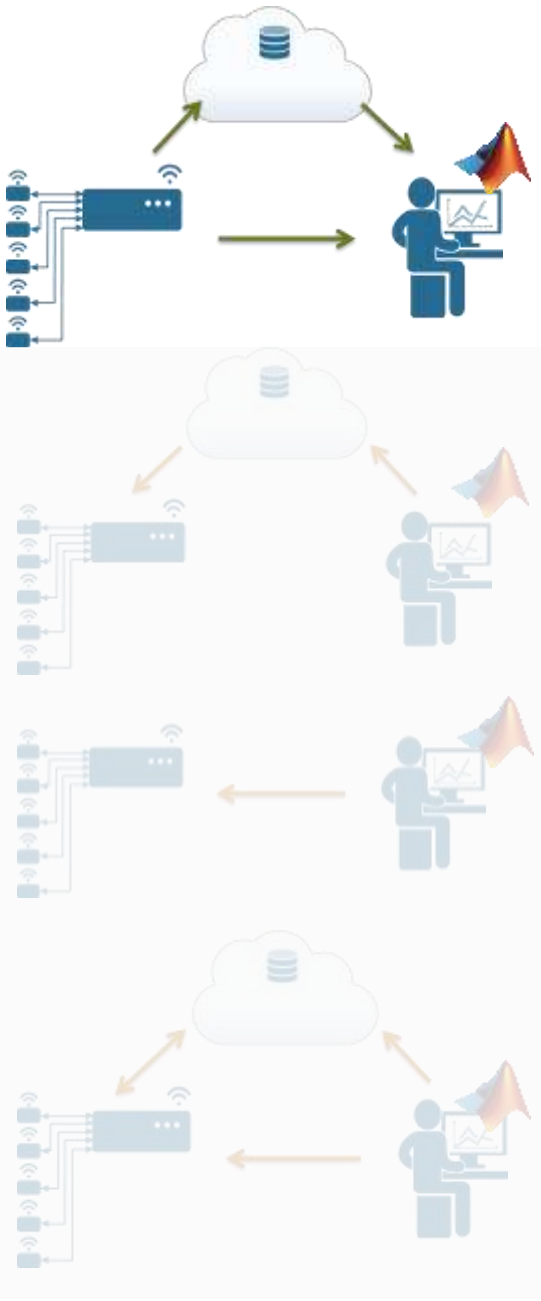

Get Started with IoT by Accessing Sensor Data in MATLAB

- Analog Input


```
[data, time]
  = StartForeground(s);
```

- Serial Port

```
s1 = serial('COM1');
I = i2c('aardvark', 0,…
Hex2dec('50')
A = fread (obj);
```

- TCP/IP
- UDP

```
t = tcpip ('localhost', 30000,
'NetworkRole', 'server');
fread (t, 10)
```

Prototyping is an important step in developing IoT system. You need only a sensor and MATLAB to get started

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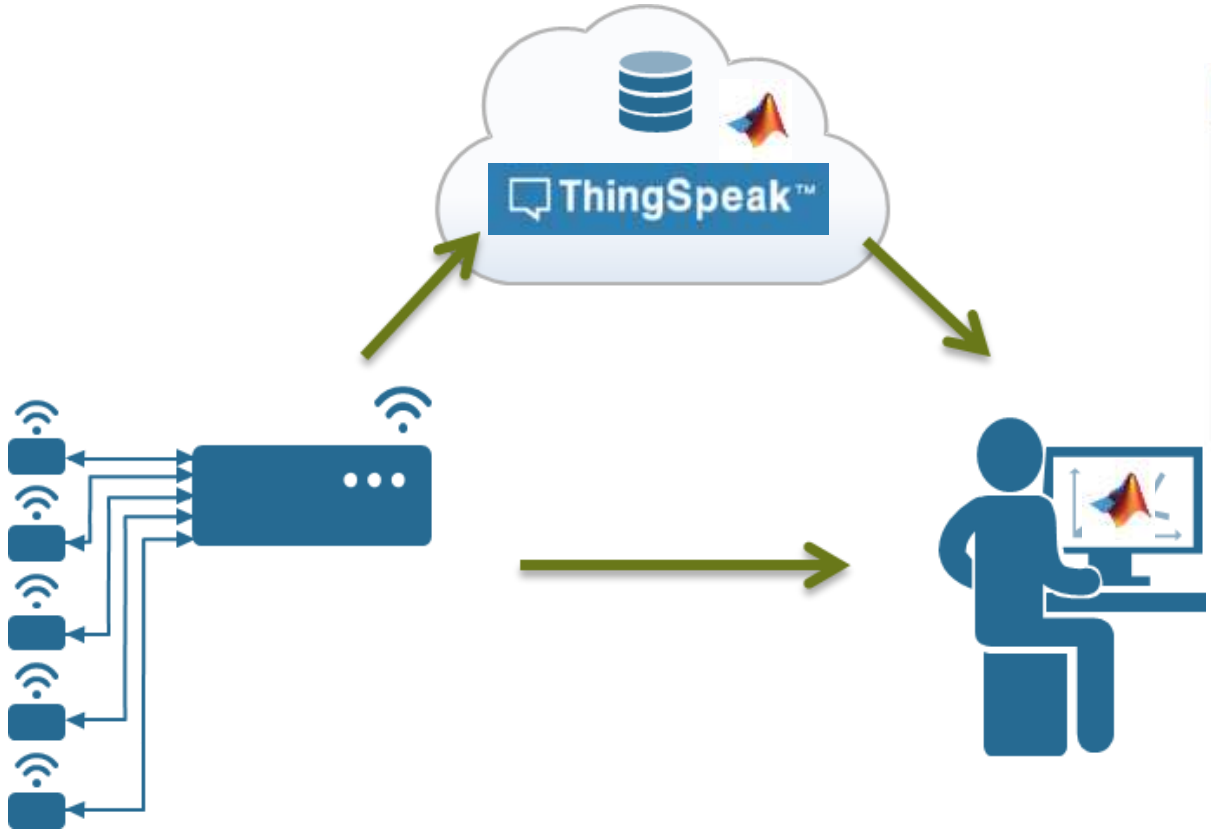

“It’s hot out!! Don’t forget to carry a bottle of water”

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” such as Arduino®, Raspberry Pi™, BeagleBone Black, and other hardware
- Over **130,000** users worldwide
- It has **MATLAB** for IoT Analytics

Collect Analyze Act

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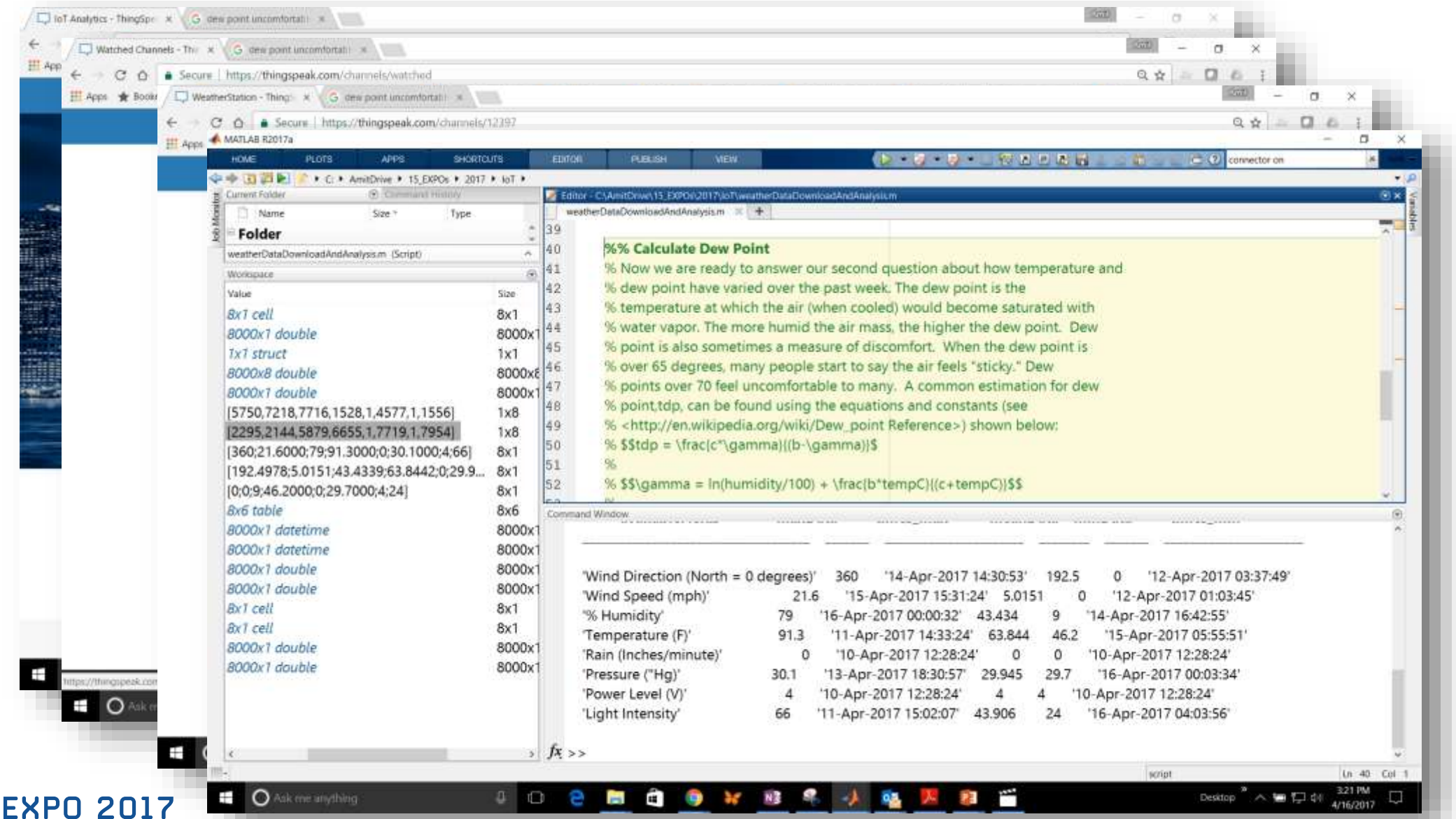

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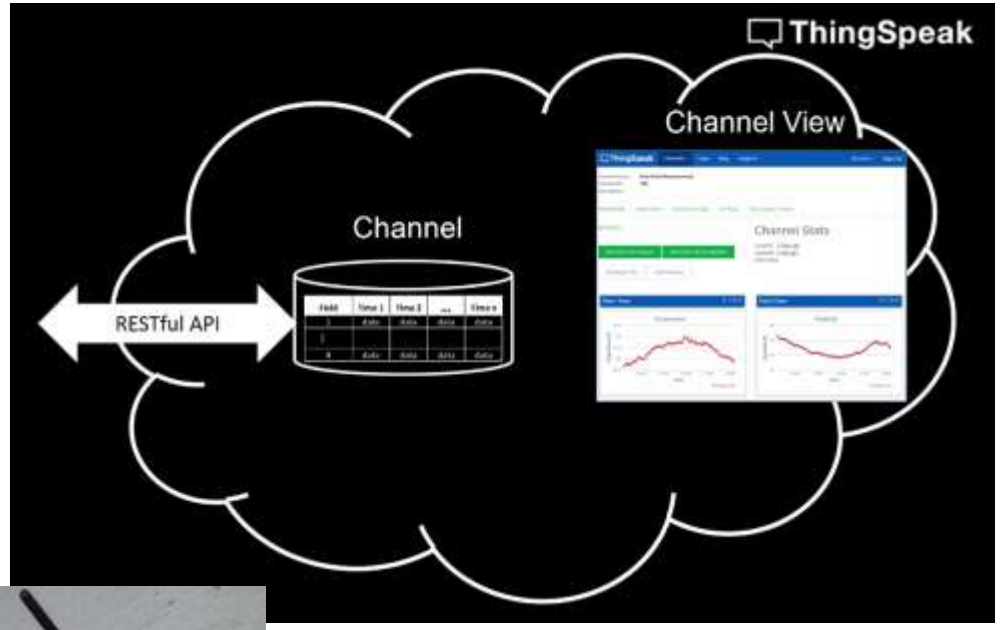
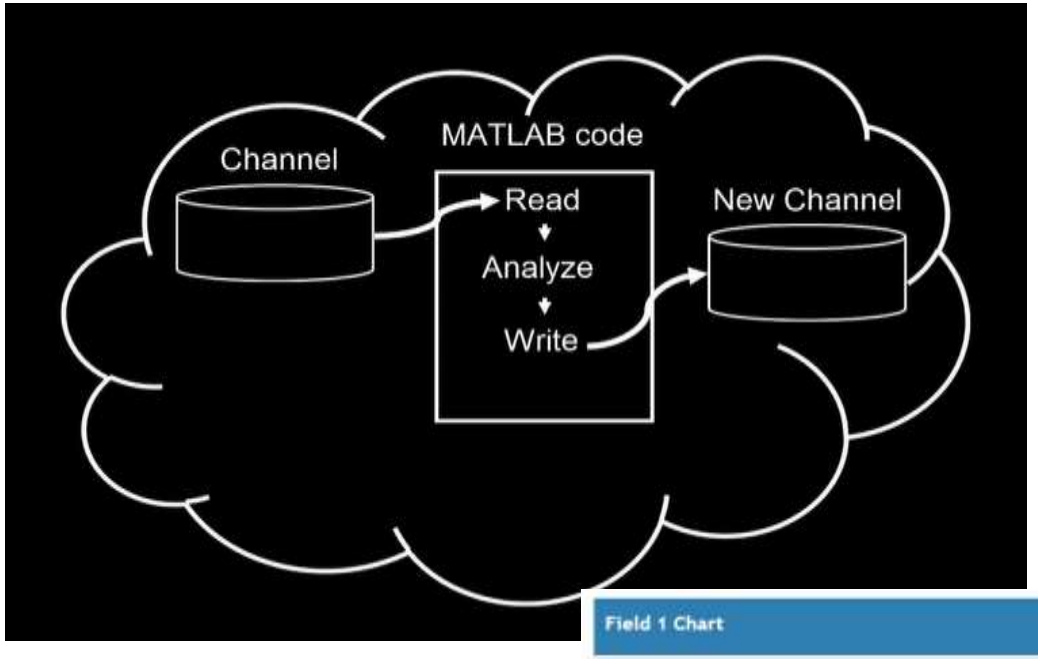
Data Aggregation



Data Analysis



Editing algorithm on cloud is very easy as it's running MATLAB

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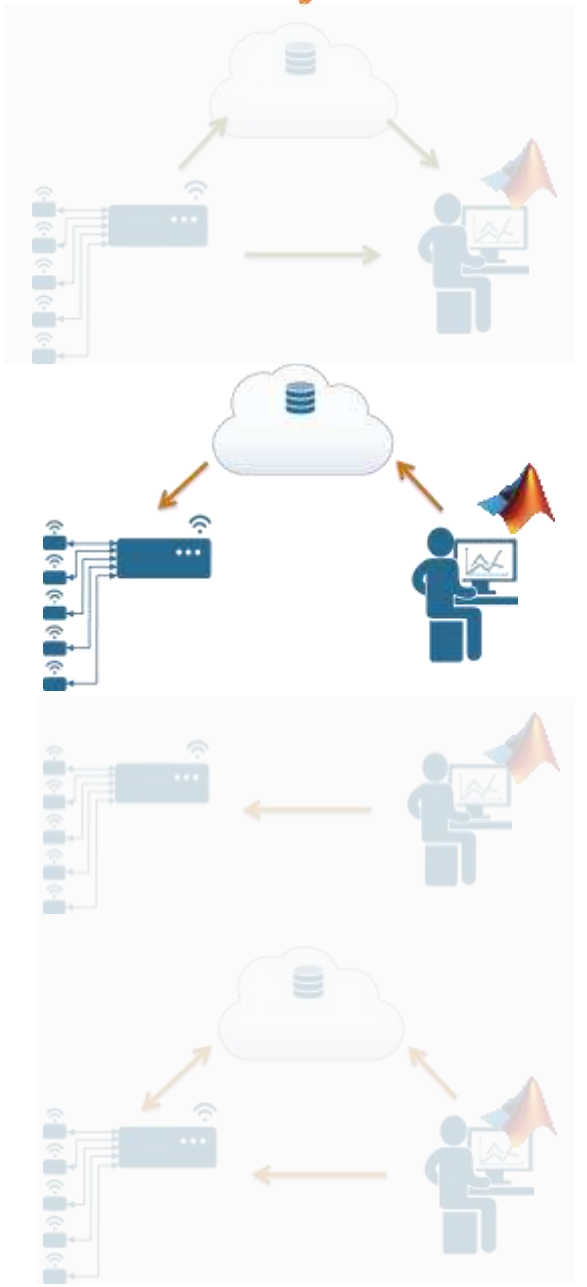


Example 2: Low Tide Prediction Using MATLAB And ThingSpeak

Challenge
Boats get stuck in mud at low tide

Solution
Advance notification of low tide

Even cooler…to get notifications on mobile

Example 2: Low Tide Prediction - Approach

Access and Explore Data

- Files
- Databases
- Sensors

Preprocess Data

- Working with Messy Data
- Data Reduction/ Transformation
- Feature Extraction

Develop Predictive Models

- Model Creation e.g. Machine Learning
- Parameter Optimization
- Model Validation

Integrate Analytics with Systems

- Desktop Apps
- Enterprise Scale Systems
- Embedded Devices and Hardware

Example 2: Low Tide Prediction Using MATLAB And ThingSpeak

ThingSpeak™ Channels Apps Community Support How to Buy Account

Un-watch Tweet Like 0 Shar

Predicted and Measured Ockway Bay Tide Chart

Channel ID: **137305**
Author: mawrey
Access: Public

Tide measurement and forecasting with the effect of wind predicted using neural networks.

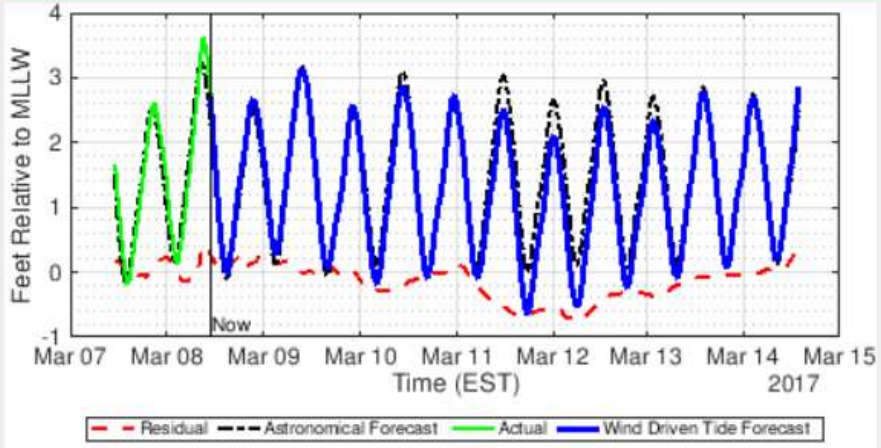
tide, wind surge, neural network

Data Export More Information

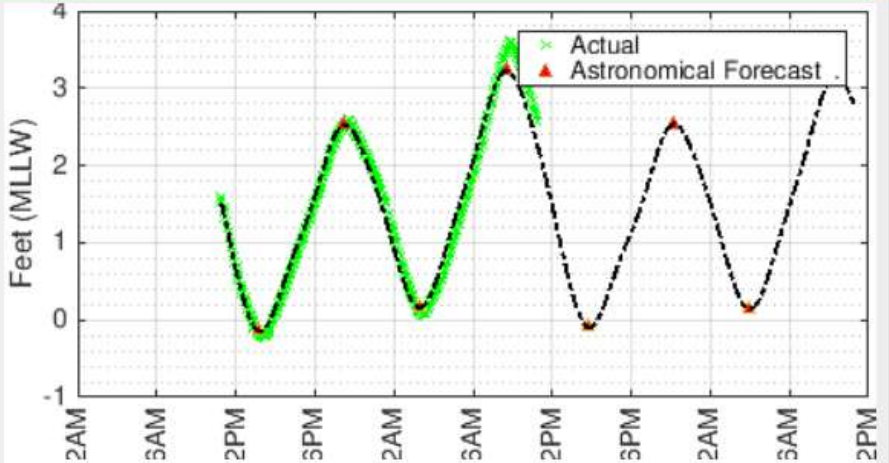
MATLAB Analysis MATLAB Visualiz

Historical and Tide

Neural Wind Forecast



Predicted and Measured Ockway Bay Tide Chart



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Learn Further: Which Toolboxes Work in ThingSpeak?

- Statistics and Machine Learning Toolbox™
- Curve Fitting Toolbox™
- Control System Toolbox™
- Signal Processing Toolbox™
- Mapping Toolbox™
- System Identification Toolbox™
- Neural Network Toolbox™
- DSP System Toolbox™
- Datafeed Toolbox™
- Financial Toolbox™

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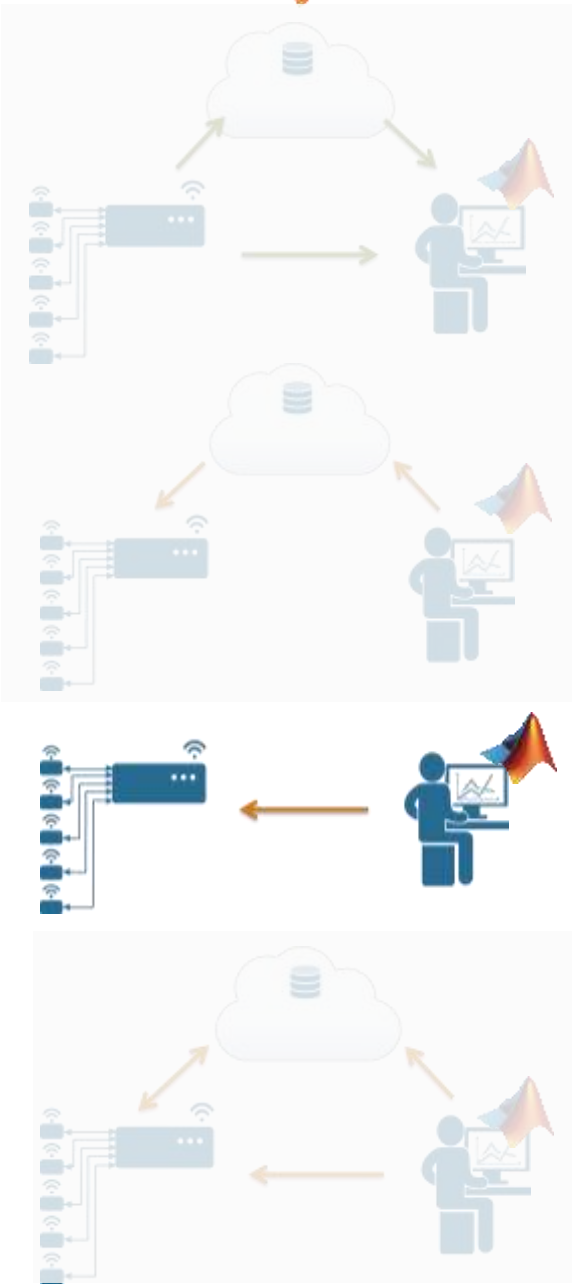
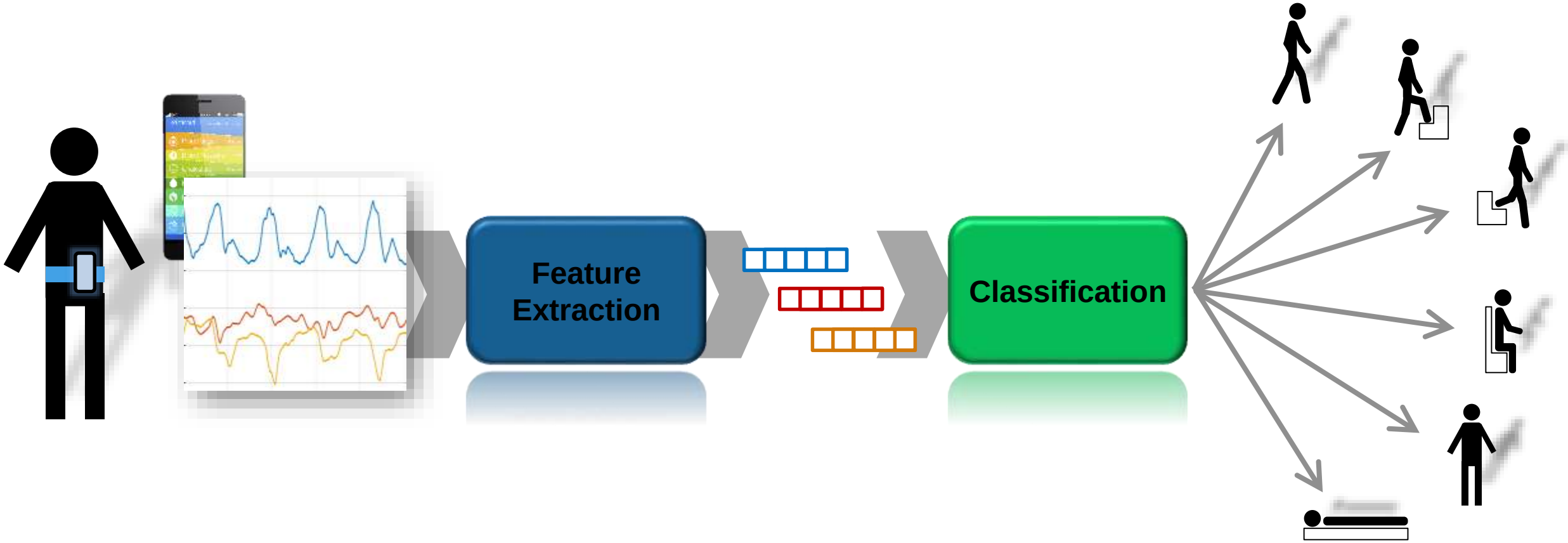
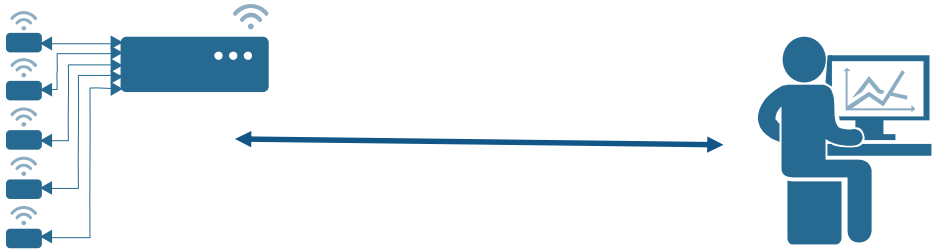
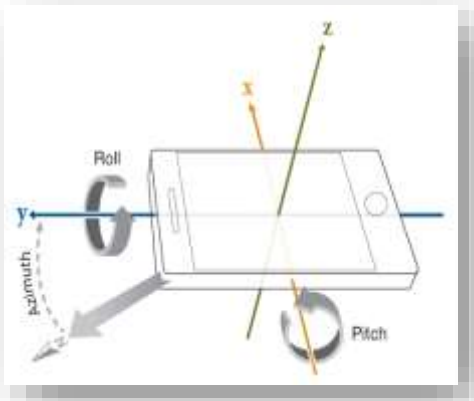


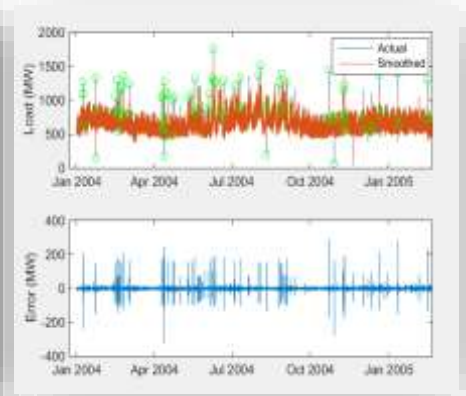
Example 3: Sensor Analytics and Development of Smart Connected Devices



Example 3: Sensor Analytics and Development of Smart Connected Devices - workflow

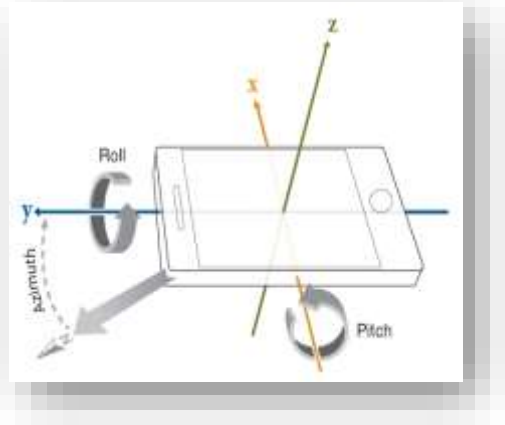






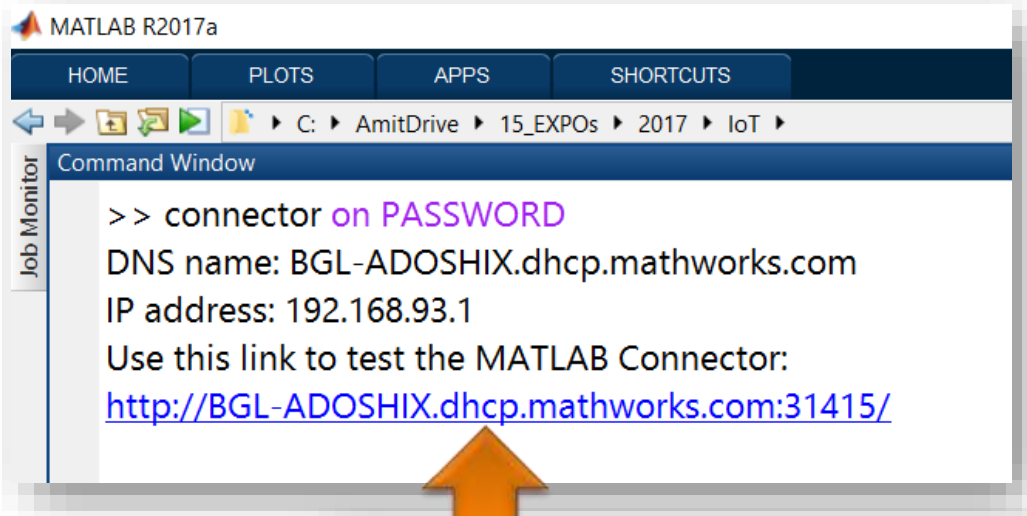
Connect and Acquire → **Signal Processing** → **Machine Learning** → **Embedded Implementation**

Example 3: Sensor Analytics and Development of Smart Connected Devices - Workflow



Connect and Acquire

1



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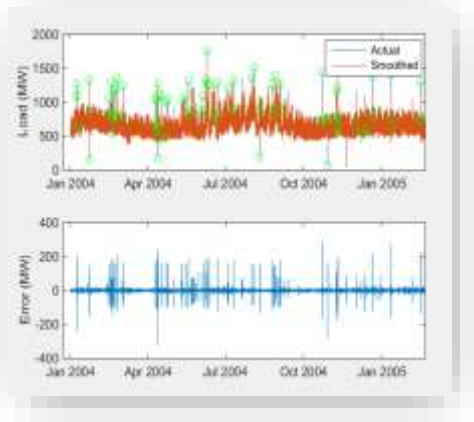
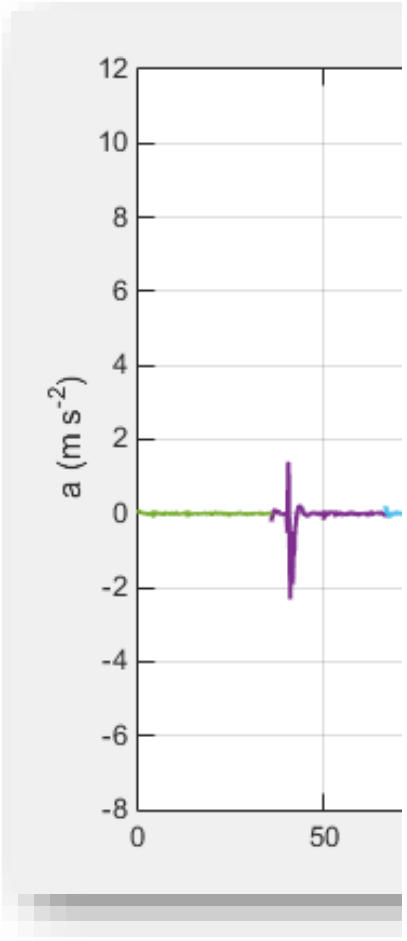
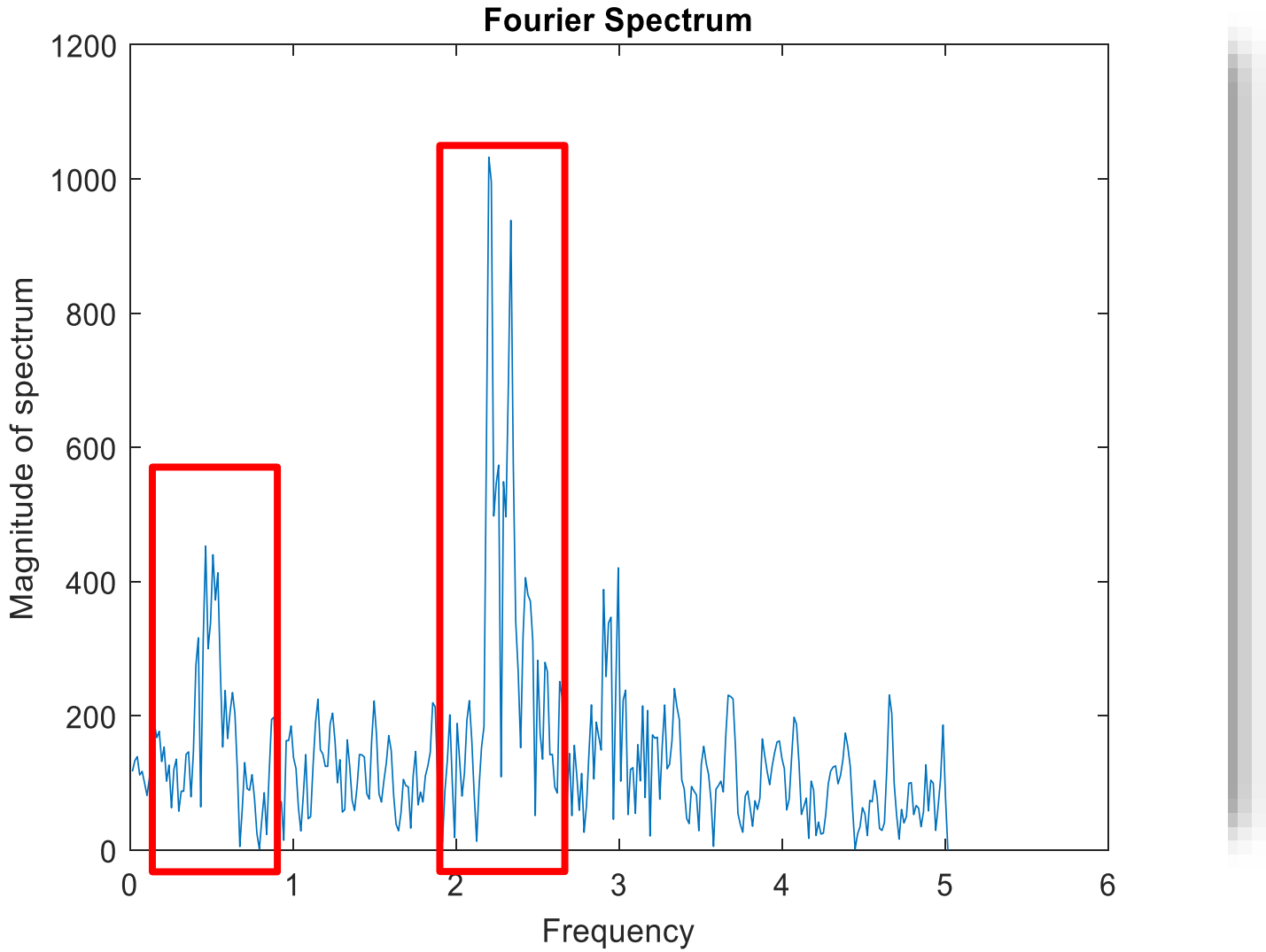


Signal Processing and feature extraction

2

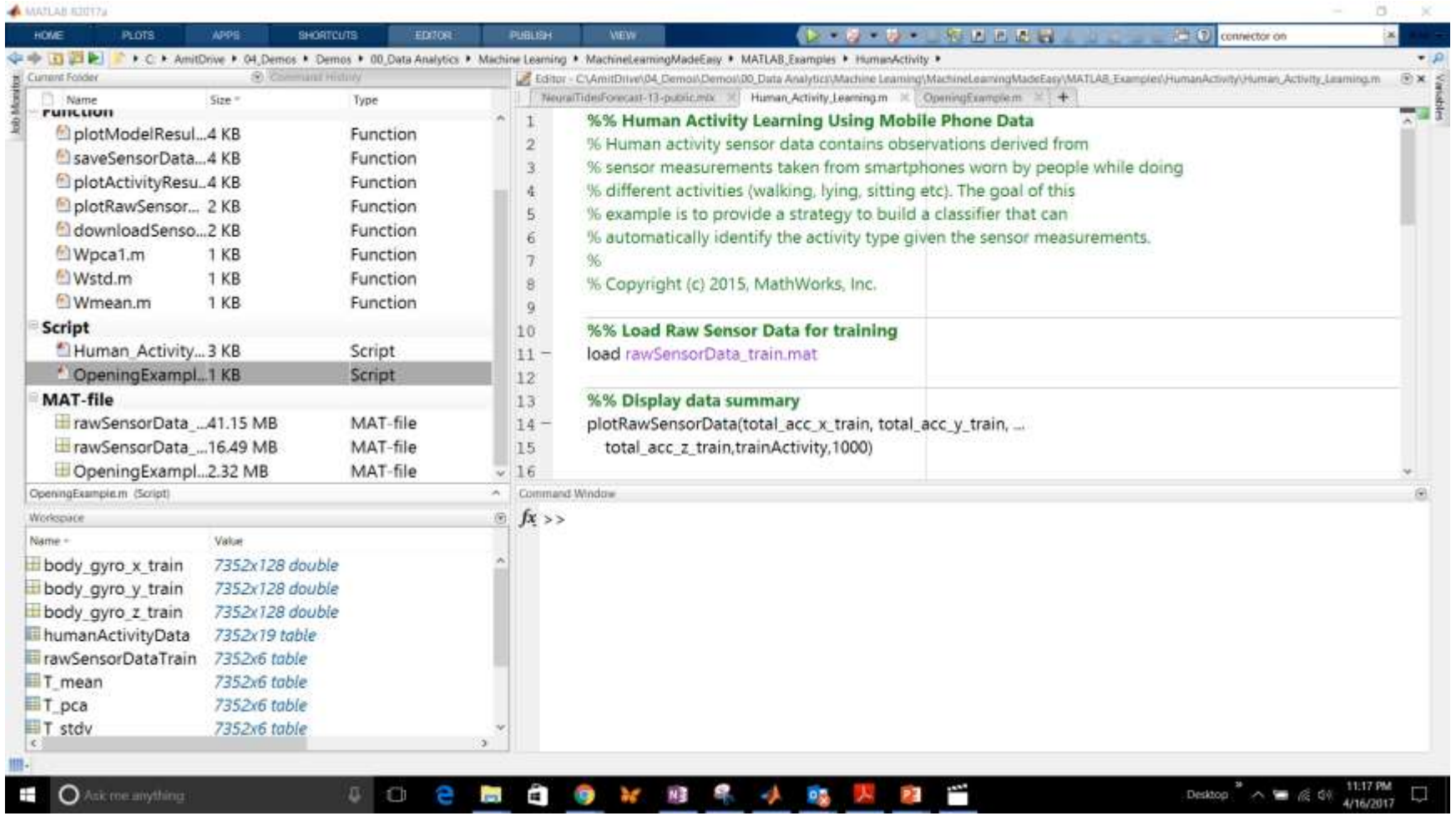




Example 3: Sensor Analytics and Development of Smart Connected Devices - Workflow

Machine Learning

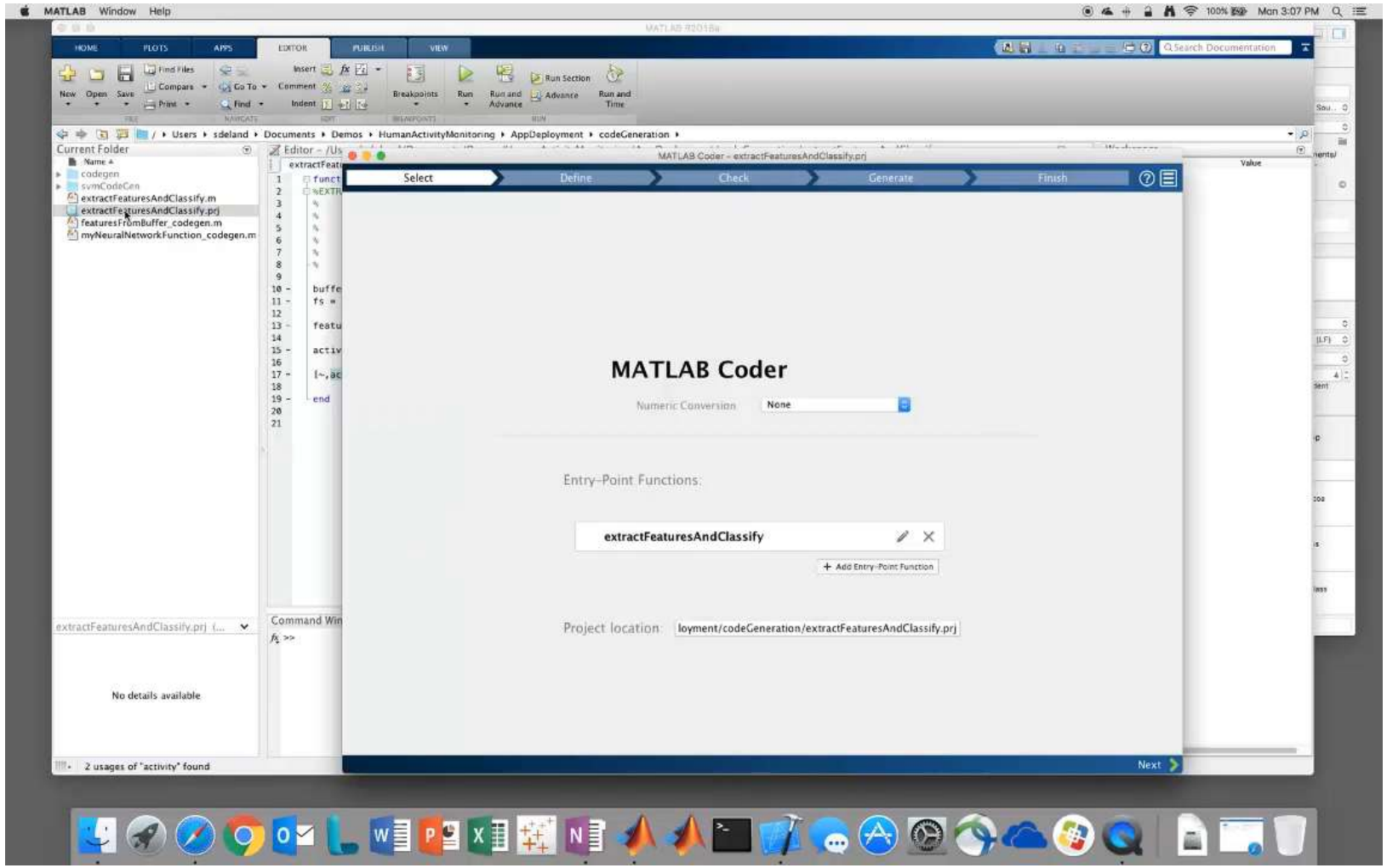
3



Example 3: Sensor Analytics and Development of Smart Connected Devices - Workflow

Embedded Implementation

4



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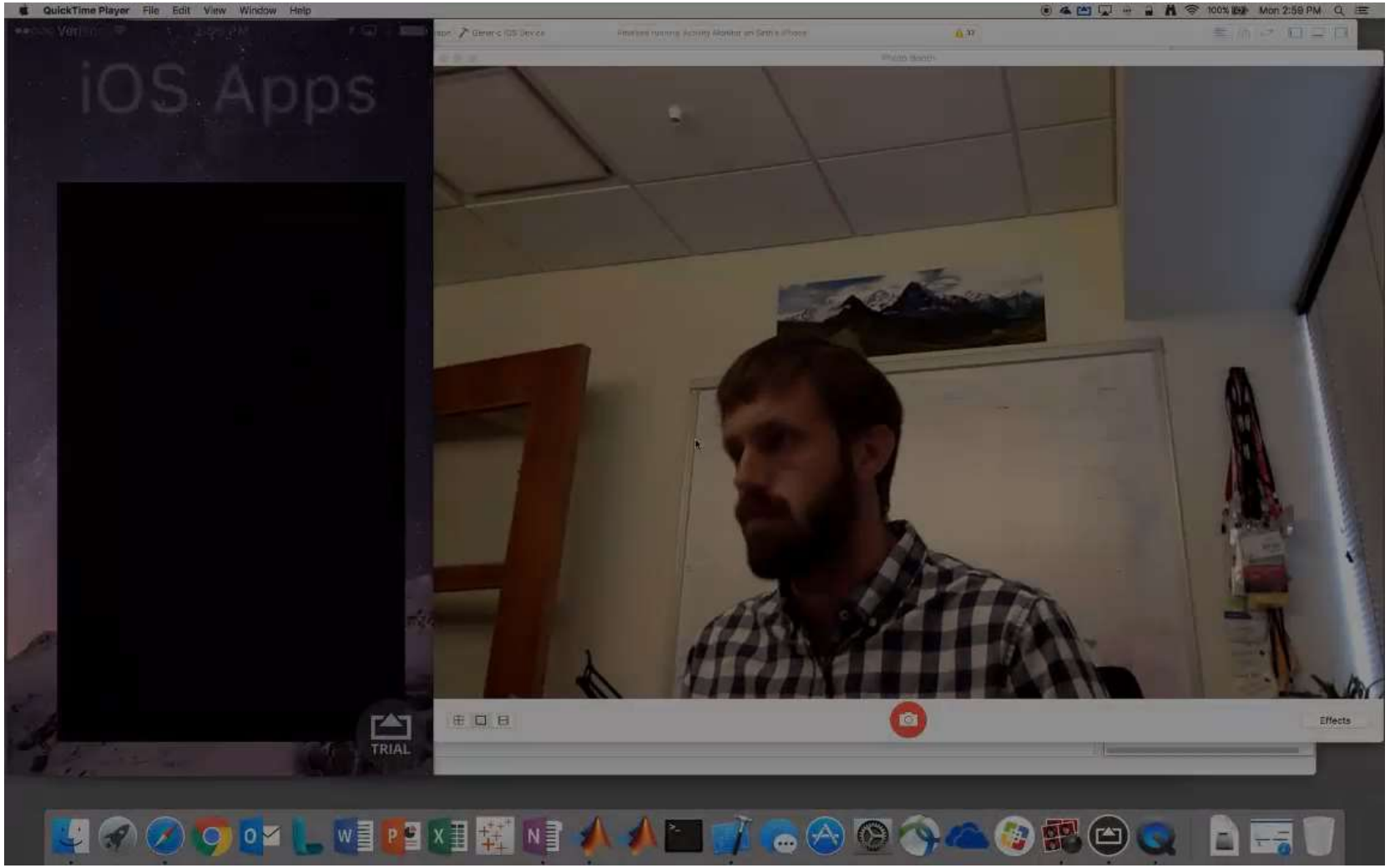
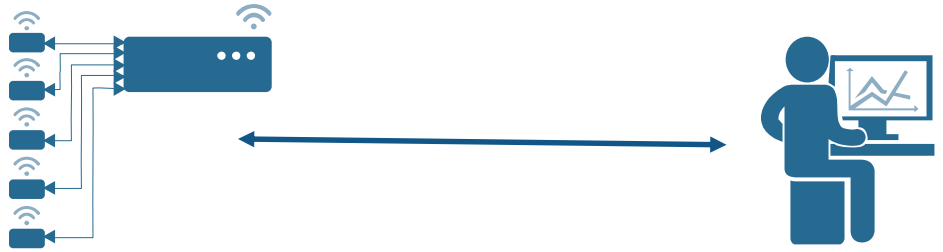
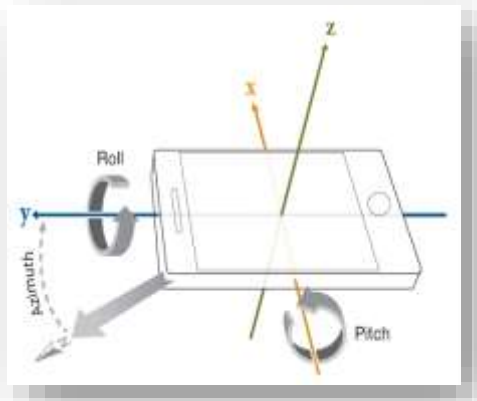
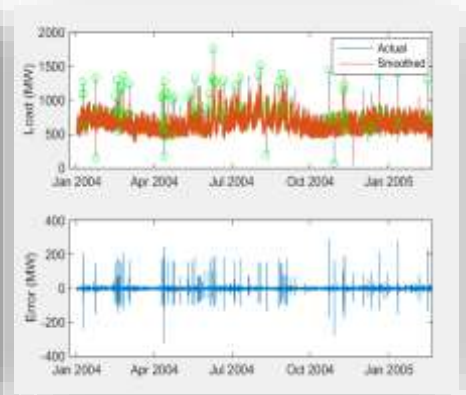
App in action



Example 3: Summary of Sensor Analytics Development and Deployment







Connect and Acquire → **Signal Processing** → **Machine Learning** → **Embedded Implementation**

Code Generation using MathWorks Product

"Embedded Coder generated C code that was error-free and efficient—so much so that the team only needed to write code for our device drivers. This saved us 6 months of development time." - Dr. Christian Robl, System Architect at Vodafone Group R&D.

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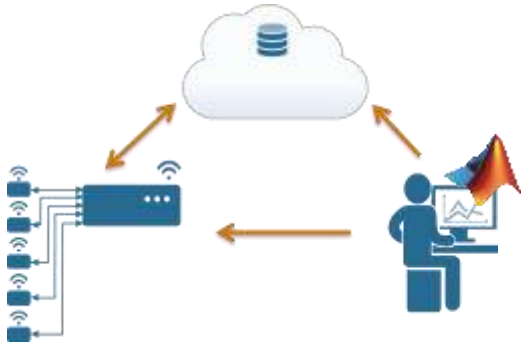
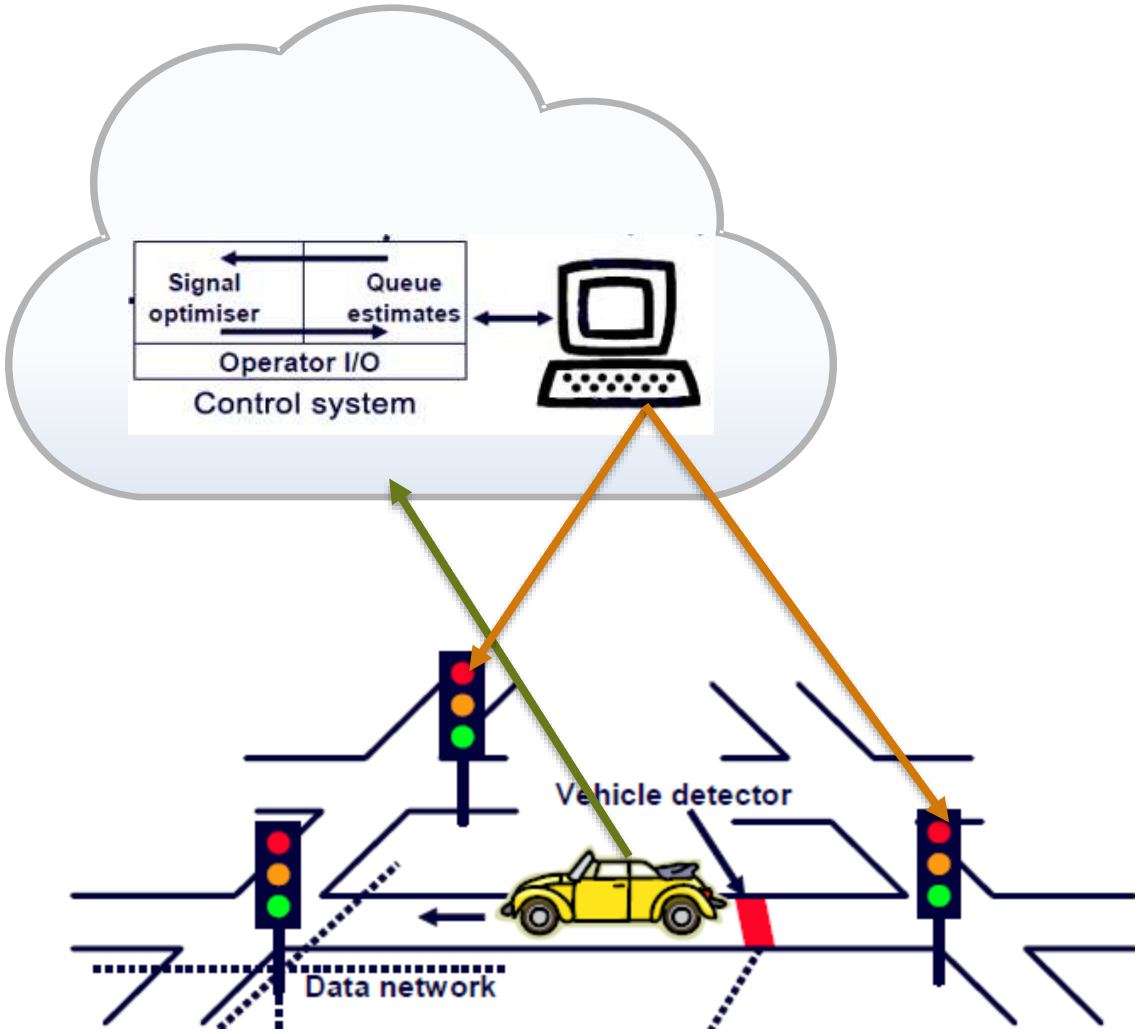


Example 4: Traffic monitoring

can be used for smart traffic light management



Example 4: Traffic Monitoring

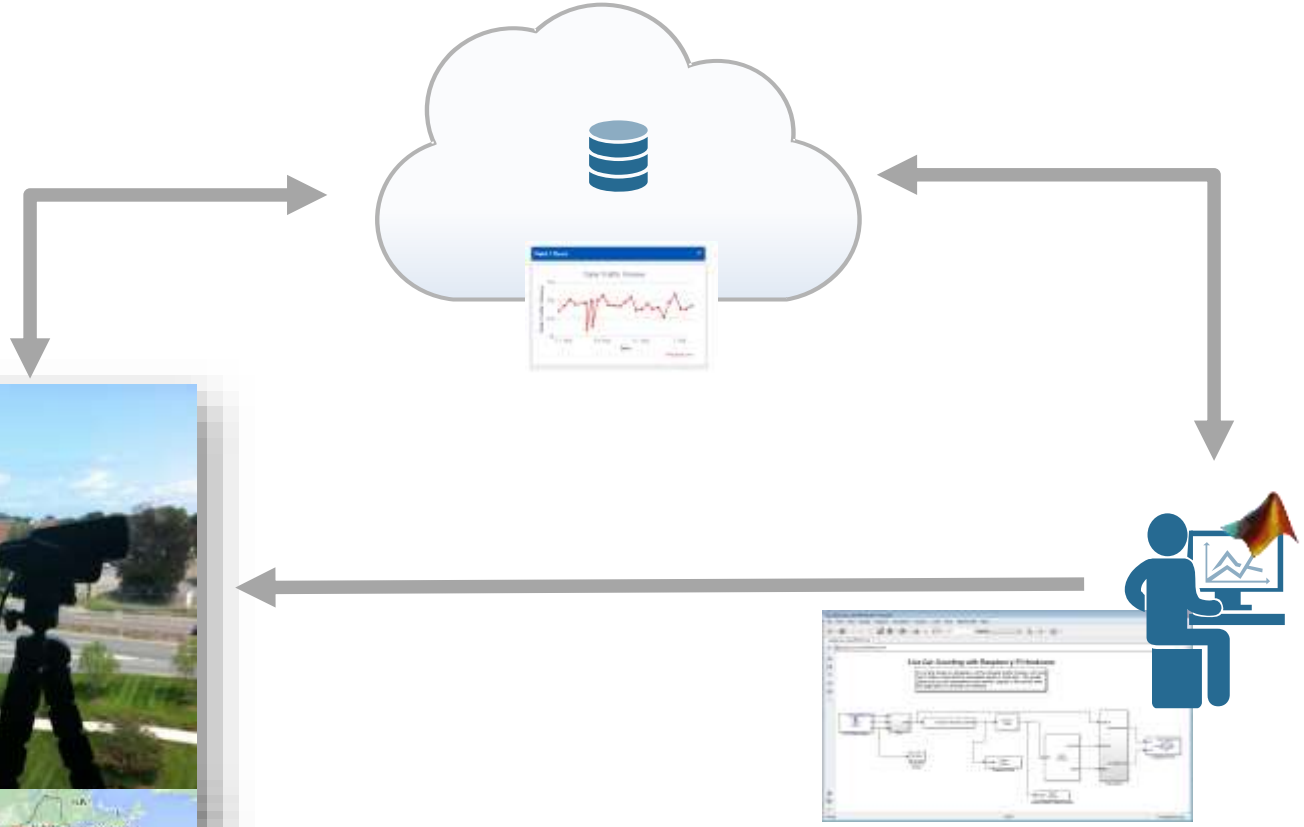
Cloud needs only car count and not all video data

Objectives

- Measure, explore, discover traffic patterns
- Provide live local traffic information service

Solution

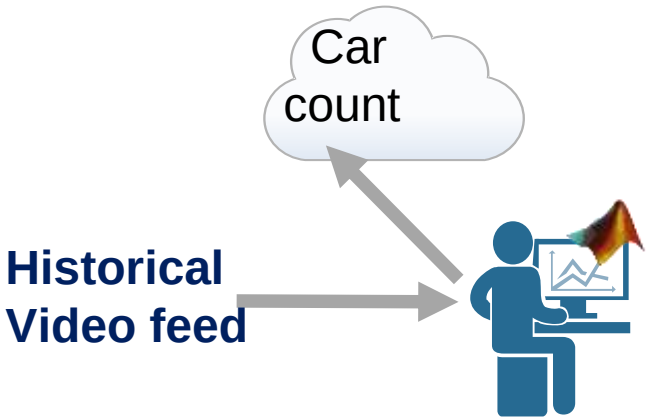
- RaspberryPi + webcam
- **Automated deployment of vision algorithms on embedded senso**
- Full example available at makerzone.ma

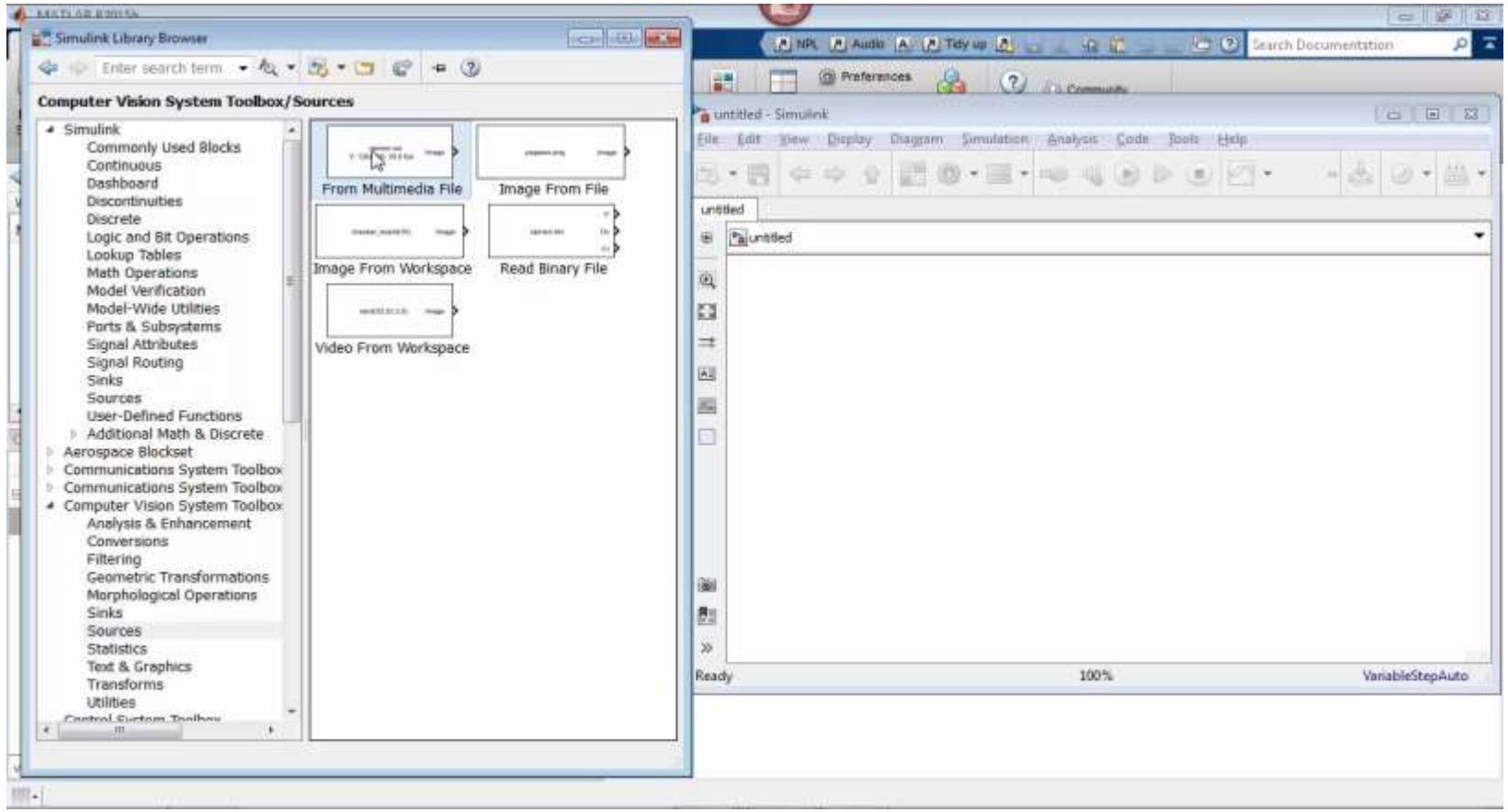


Example 4: Traffic Monitoring - Approach

Step 1: Prototyping

- Create a prototype in Simulink and develop a logic
- Just Simulink and a camera feed

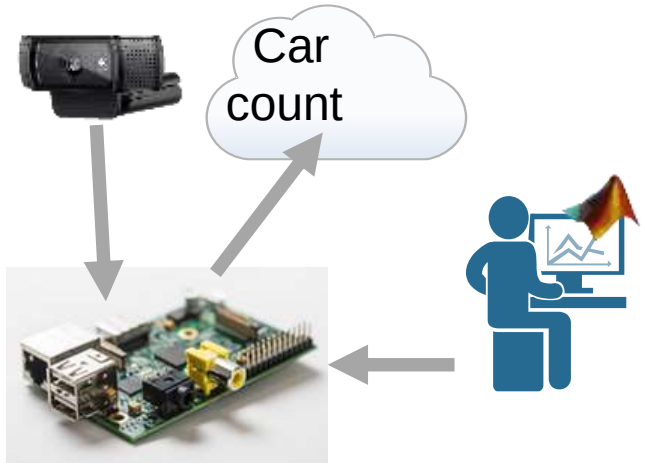


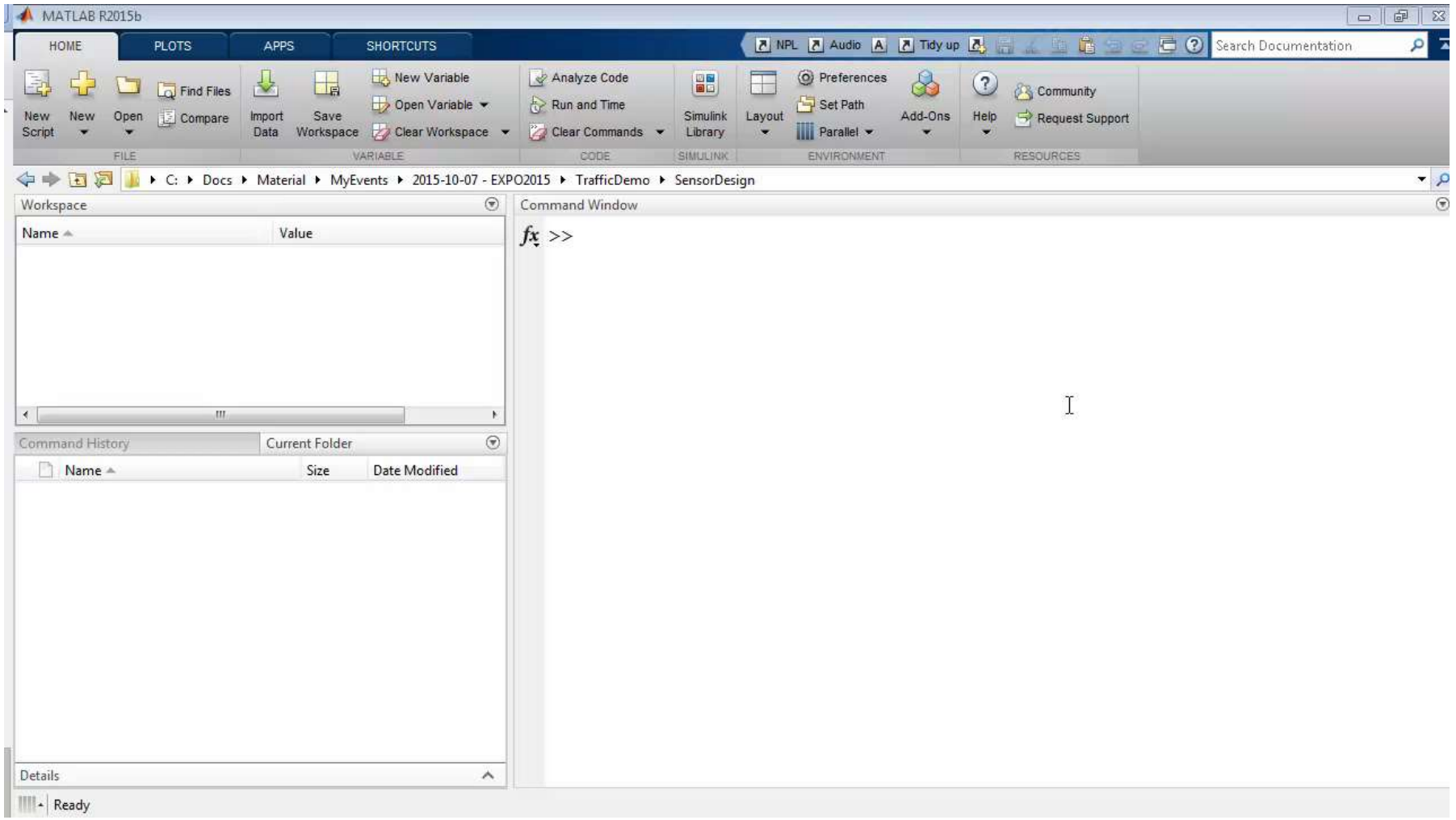


Example 4: Traffic Monitoring - Approach

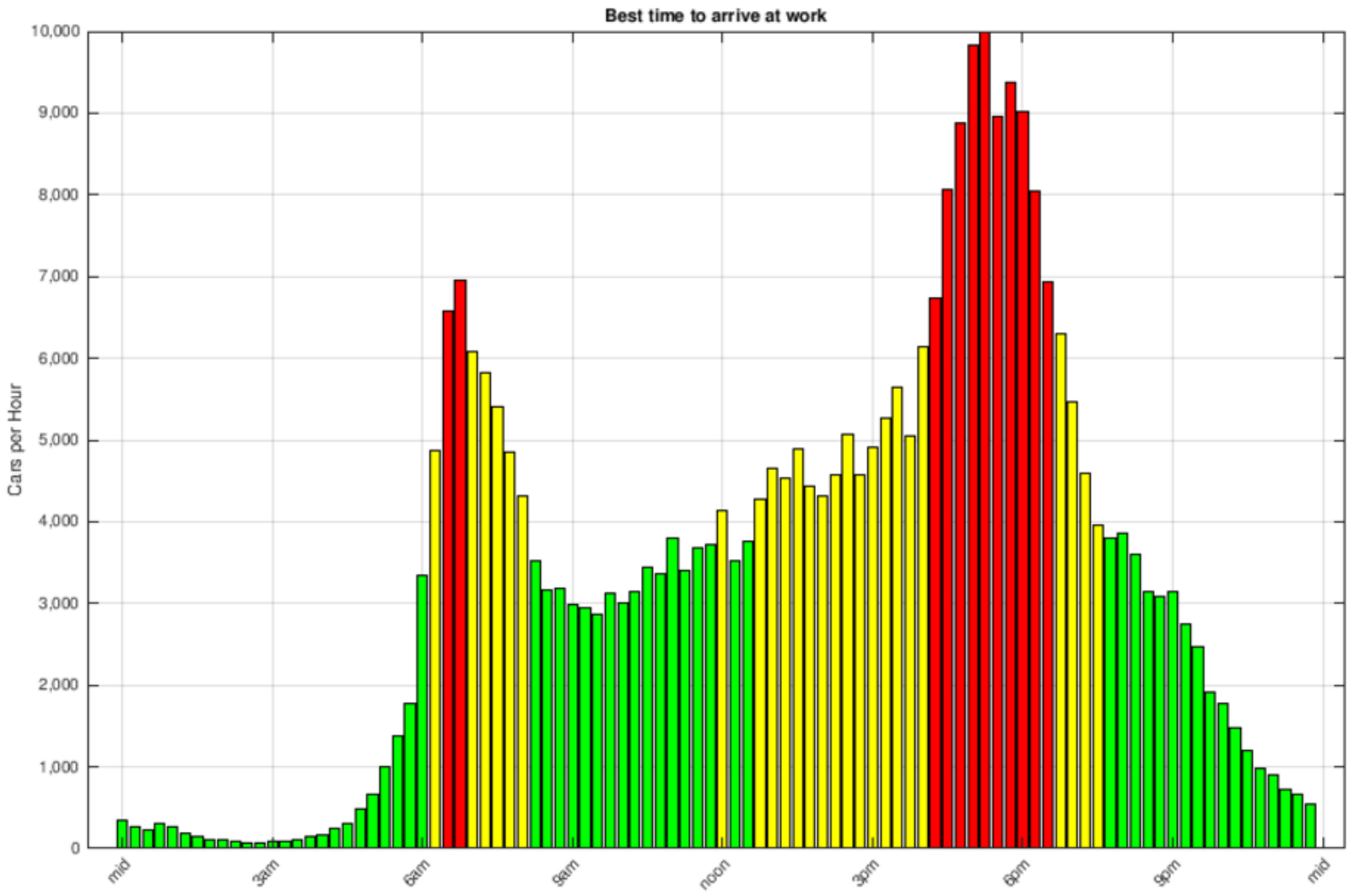
Step 2: Port it to Raspberry Pi

- Use the code generation capabilities of Simulink to deploy this algorithm onto the Raspberry Pi



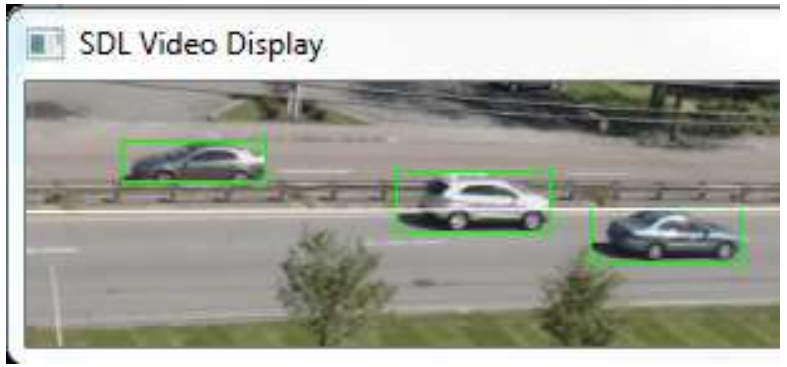


From Data to Insight



When should I start for home?

Well, I better start early from office or stay back late in the office



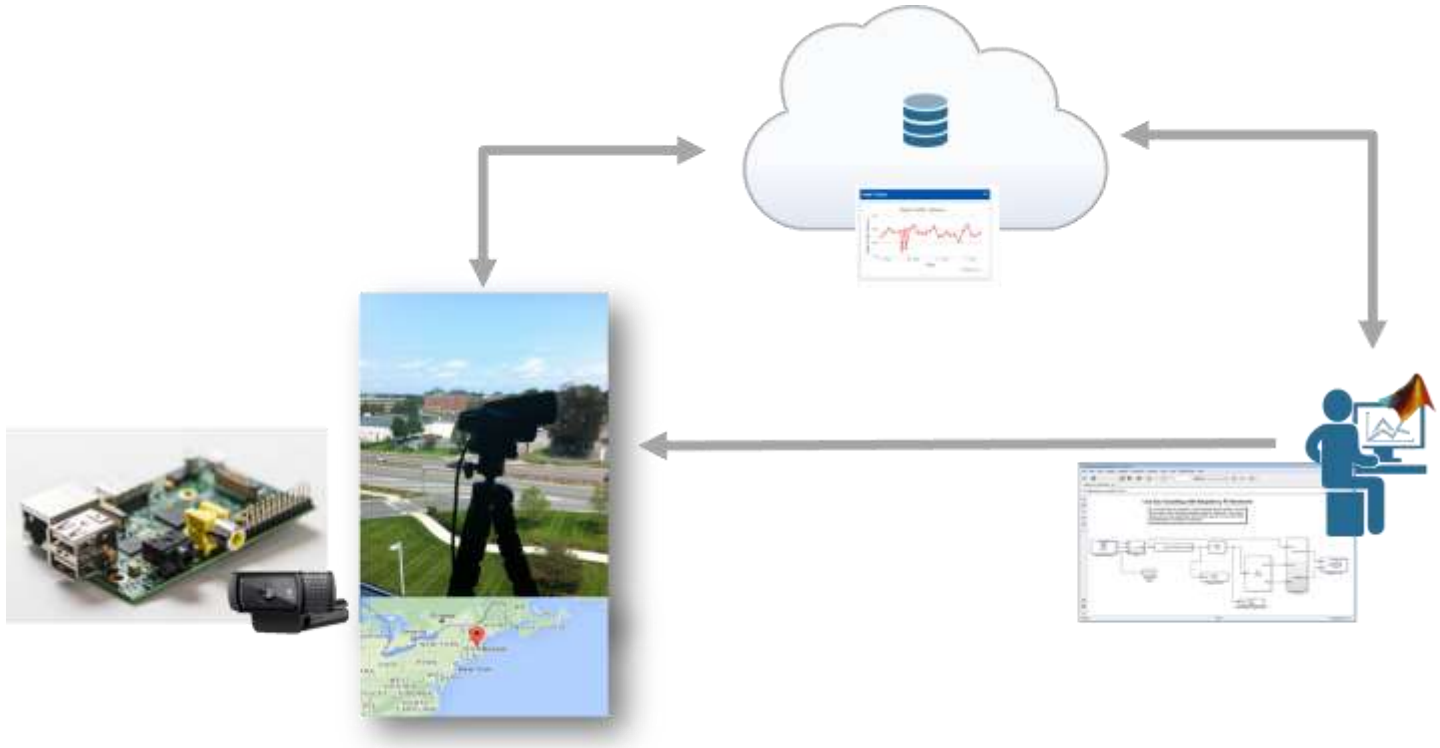
Example 4: Summary – Developing smart devices

Step 1: Prototyping

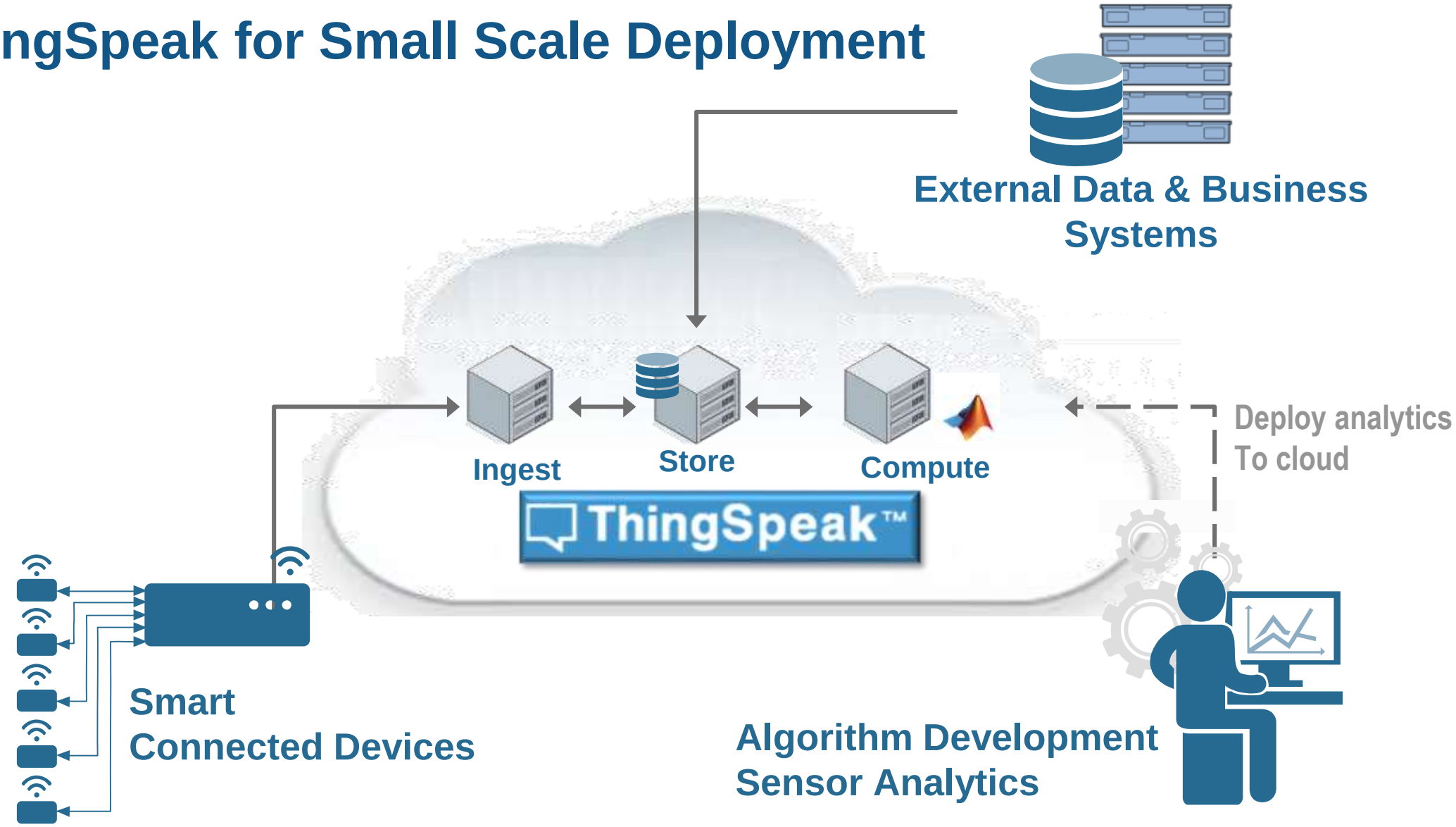
- Create a prototype in Simulink and develop a logic and send count to cloud
- Need only Simulink and a camera feed to start with

Step 2: Port it to Raspberry Pi

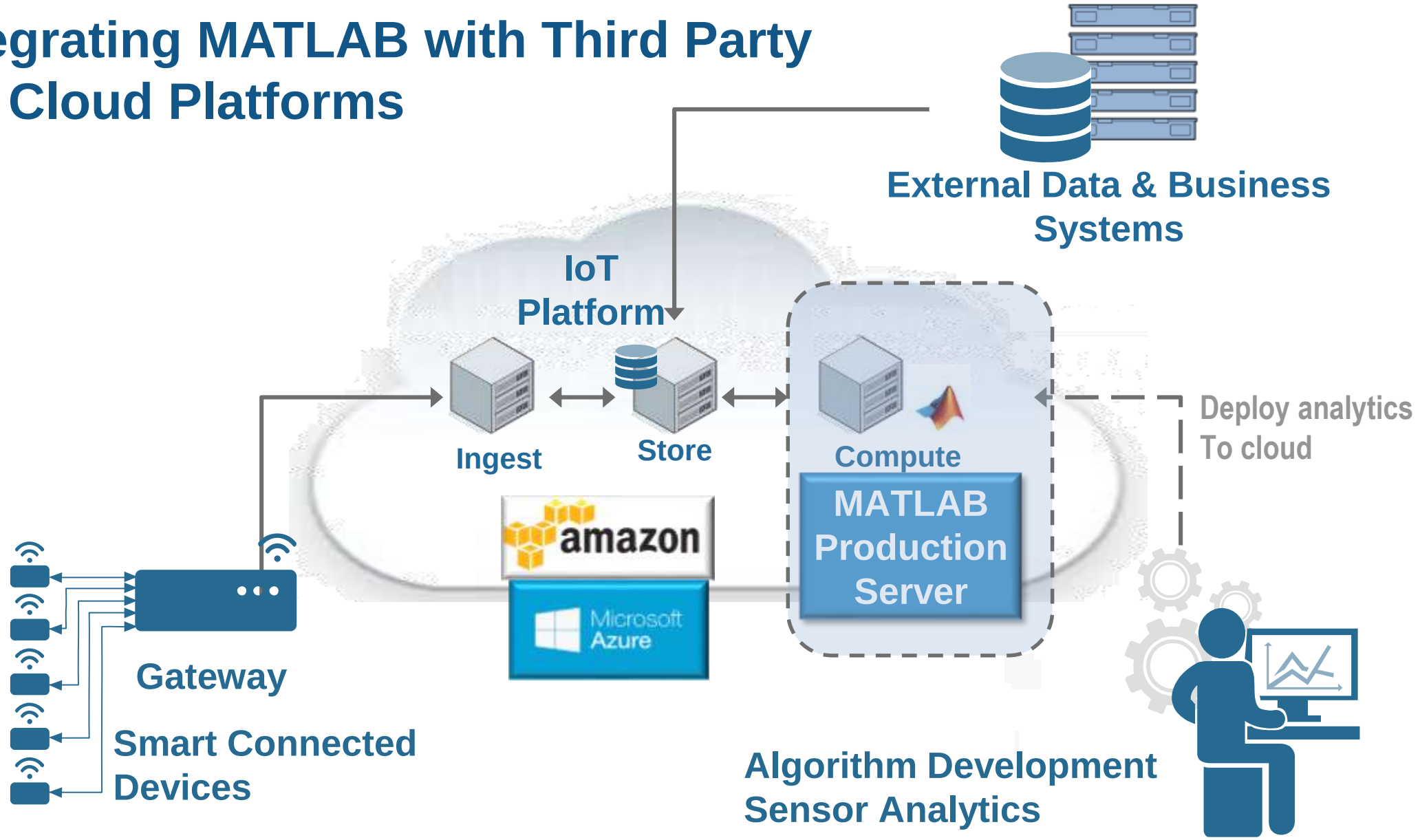
- Use the code generation capabilities of Simulink to deploy this algorithm onto the Raspberry Pi



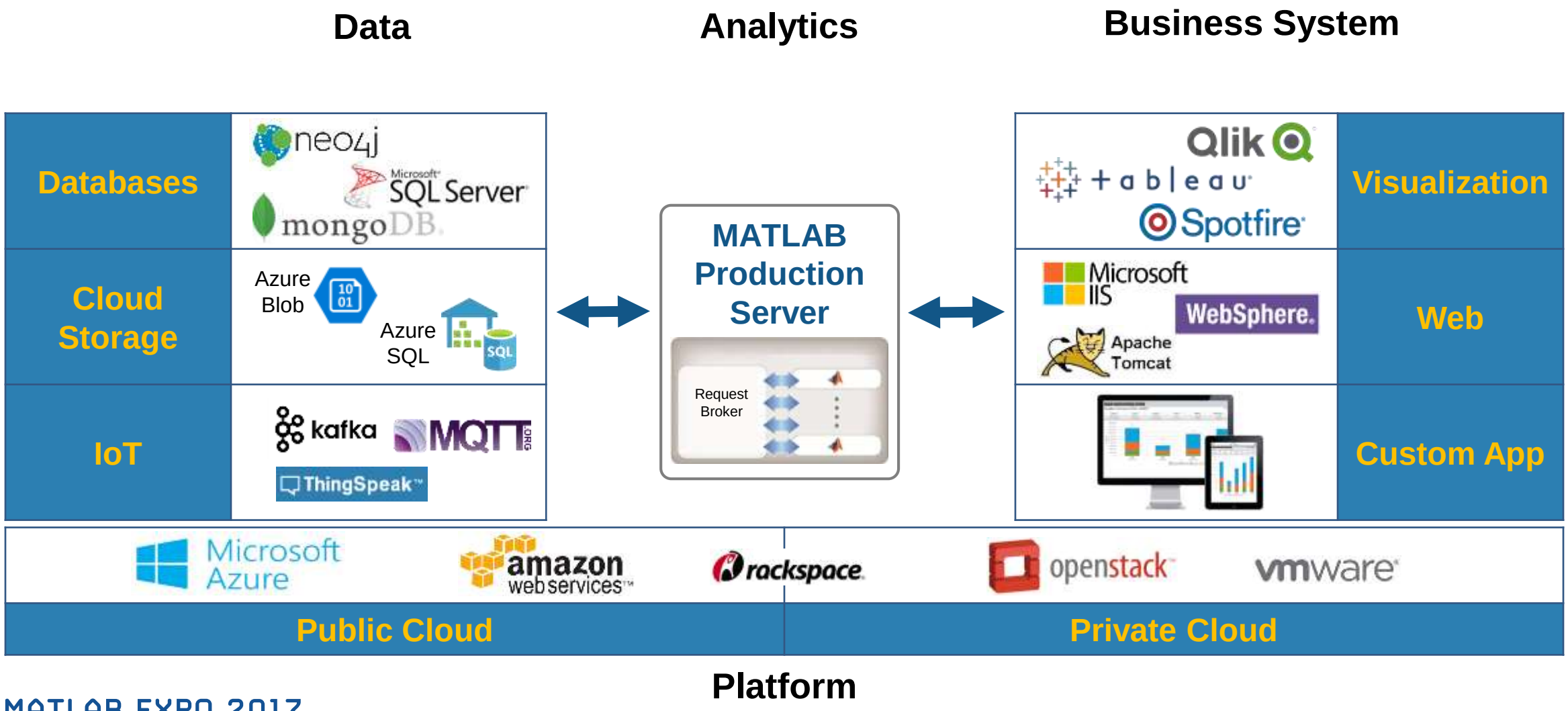
ThingSpeak for Small Scale Deployment



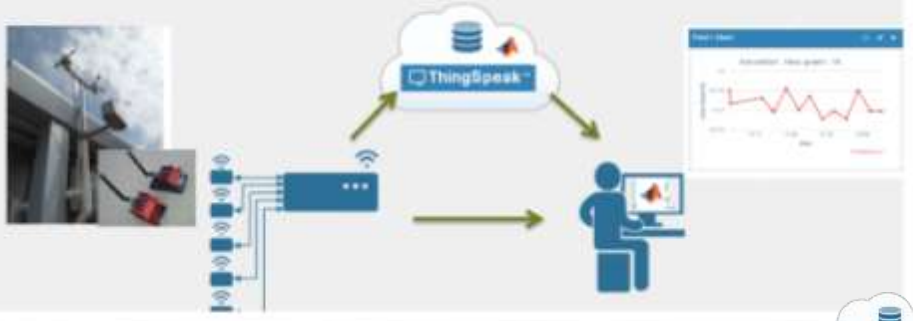
Integrating MATLAB with Third Party IoT Cloud Platforms

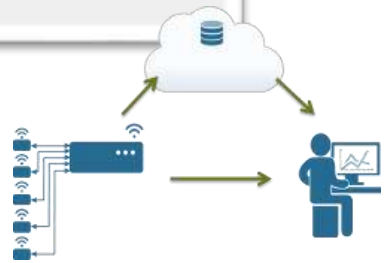


Integrating MATLAB in Large Scale Production Systems



Example 1: Weather monitoring using ThingSpeak and MATLAB



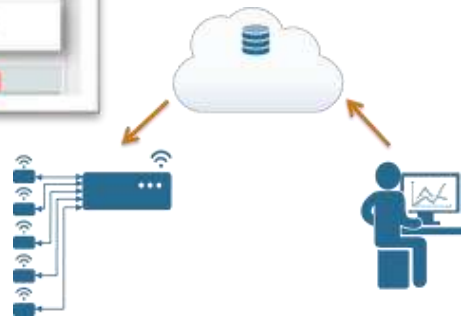


Example 2: Low Tide Prediction Using MATLAB And ThingSpeak

Challenge
Boats get stuck in mud at low tide

Solution
Advance notification of low tide

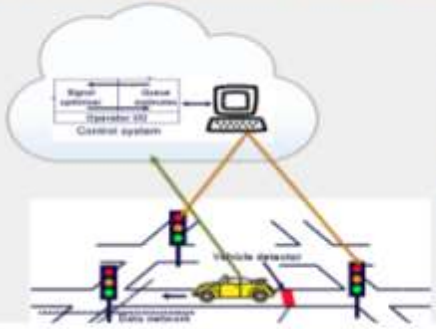
Even cooler...get notifications on mobile

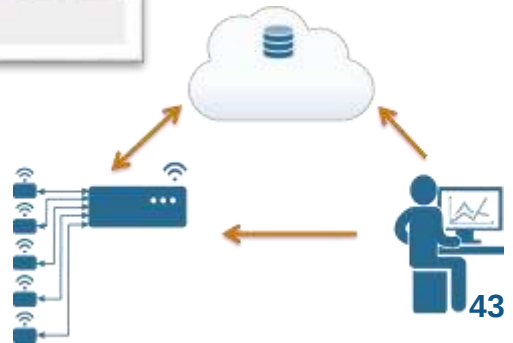


Example 3: Human Activity Analysis and Classification

Example 4: Traffic monitoring

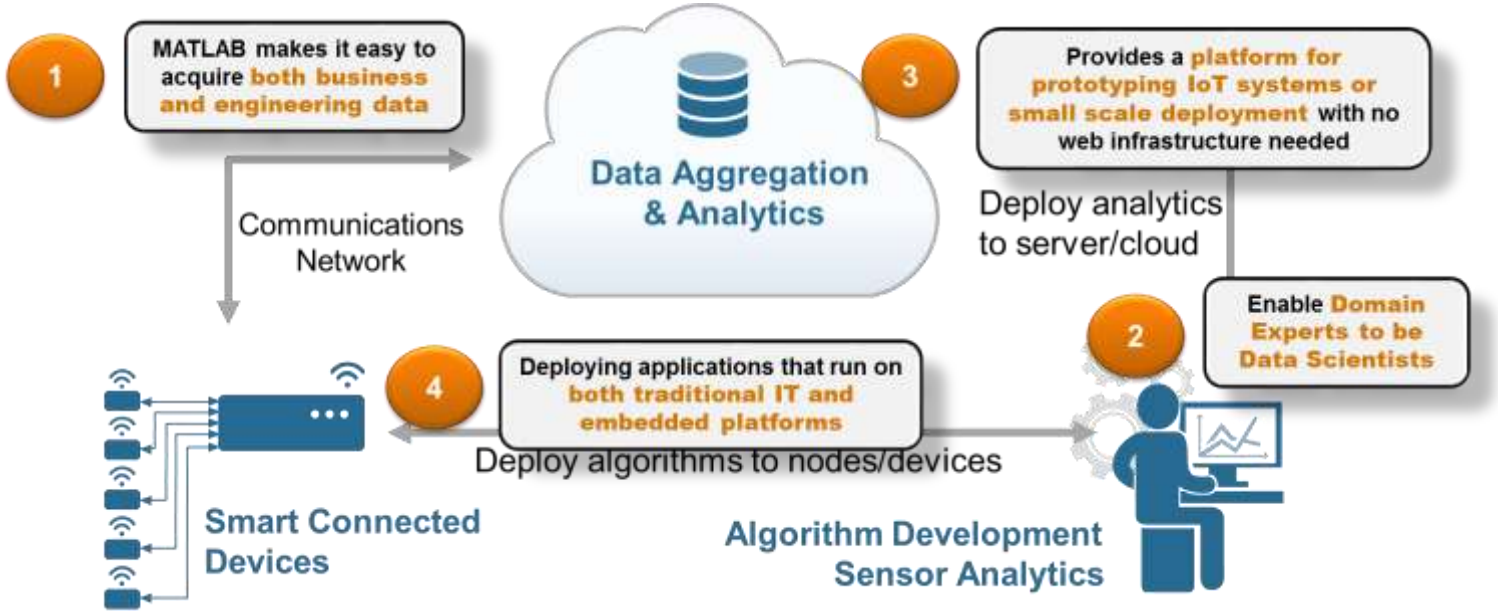
can be used for smart traffic light management





MathWorks Addresses IoT 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



What You Can Do to Learn More

- Log-in to ThingSpeak with you MathWorks account and explore
- View a webinar on Machine Learning with MATLAB
- Read a Technical Article on Forecasting Tides with MATLAB
- Read a tutorial on how to send data to ThingSpeak over MQTT

MathWorks Training Offerings

Machine Learning with MATLAB

INTERMEDIATE

This two-day course focuses on data analytics and machine learning techniques in MATLAB using functionality within Statistics and Machine Learning Toolbox™ and Neural Network Toolbox™. The course demonstrates the use of unsupervised learning to discover features in large data sets and supervised learning to build predictive models. Examples and exercises highlight techniques for visualization and evaluation of results. Topics include:

- Importing and organizing data
- Finding natural patterns in data
- Building predictive models
- Evaluating and improving the model

Prerequisites: *MATLAB Fundamentals*

Interfacing MATLAB with C Code

INTERMEDIATE

This one-day course covers details of interfacing MATLAB with user-written C code. Topics include:

- Source MEX-files
- Data exchange between MATLAB and MEX-files
- The MATLAB engine interface

Prerequisites: *MATLAB Fundamentals* and a basic working knowledge of the C programming language

http://www.mathworks.com/services/training/

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