Key Takeaways

- MATLAB helps you **develop IoT algorithms**
- MATLAB and ThingSpeak helps you **collect and analyse IoT data, quickly and easily**
- MATLAB and Simulink help you **develop smart connected devices**
- MATLAB **supports cloud deployment** for small to medium scale IoT systems, up to large enterprise systems.
What is IoT?
Do hamsters run a marathon every day?
Commercial Example from Cadmus

Challenge
Measure and evaluate the energy efficiency of residential homes and businesses based on data from onsite sensors

Solution
- Used ThingSpeak to collect up-to-the-minute temperature, humidity, and power usage data
- Used MATLAB to analyze and visualize the data

Results
- Market opportunity seized
- Development effort cut by two-thirds
- Sensor networks quickly deployed
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Commercial Example from Cadmus
IoT Analytics Framework

- Smart Connected Devices
  - Local embedded algorithms
  - Data reduction

- Communication

- Storage
  - Online analytics
  - Visualization and reporting

- Communication

- Connectivity
  - Deploy analytics to cloud

- Algorithm Development
  - Historical analytics
  - Sensor analytics

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IoT Analytics Challenges

1. How do I develop my algorithms?

2. How do I collect enough data to build my algorithm?

3. How do I deploy my algorithms to the cloud?

4. How do I deploy my algorithms on a smart device?
IoT Analytics Challenges

How do I collect enough data to build my algorithm?

Communications Network

Data Aggregation & Analytics

Deploy analytics to server/cloud

Smart Connected Devices

Deploy algorithms to nodes/devices

Algorithm Development Sensor Analytics

How do I develop my algorithms?

MATLAB
MATLAB Helps You Develop IoT Algorithms

- Real data is messy and needs to be cleaned up
- Missing data points need to be handled
- Features need to be extracted
- Predictions need to be made
What Is ThingSpeak?

Web Site For People

Web Service for Devices

```json
{
  - 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",
    fields1: "Number of Westbound Cars",
    fields2: "Number of Eastbound Cars",
    created_at: "2015-05-19T20:14:03Z",
    updated_at: "2016-05-10T10:36:35Z",
    last_entry_id: 1477231
  },
  - feeds: [{
    created_at: "2016-05-19T10:36:20Z",
    entry_id: 1477230,
    fields1: "18.000000",
    fields2: "0.000000"
  },
    { created_at: "2016-05-19T10:36:35Z",
      entry_id: 1477231,
      fields1: "18.000000",
      fields2: "14.000000"
  }
}
```
**ThingSpeak Collects, Analyzes and Acts on Data**

- A new MathWorks web service hosted on AWS
- Lets you collect, analyze and act on data from “things”
- Evaluates **MATLAB** code in the cloud
- Over 130,000 users worldwide
- It’s **free** to get started

https://thingspeak.com
MATLAB Toolbox Access from ThingSpeak

- When you are logged into ThingSpeak™ using your MathWorks® Account, you can use functions from the following toolboxes if you are licensed to use them:
  - Statistics and Machine Learning Toolbox™ (Statistics and Machine Learning Toolbox)
  - Curve Fitting Toolbox™ (Curve Fitting Toolbox)
  - Control System Toolbox™ (Control System Toolbox)
  - Signal Processing Toolbox™ (Signal Processing Toolbox)
  - Mapping Toolbox™ (Mapping Toolbox)
  - System Identification Toolbox™ (System Identification Toolbox)
  - Neural Network Toolbox™ (Neural Network Toolbox)
  - DSP System Toolbox™ (DSP System Toolbox)
  - Datafeed Toolbox™ (Datafeed Toolbox)
  - Financial Toolbox™ (Financial Toolbox)

- Up to date info: https://au.mathworks.com/help/thingspeak/matlab-toolbox-access.html
Custom Visualizations with ThingSpeak - Weather Station Example
Custom Visualizations with ThingSpeak - Weather Station Example
Predictive Analytics Example with ThingSpeak

**Problem:** Common for boats to get stuck due to unusually low tides caused by certain winds

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Predictive Analytics Example with ThingSpeak

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**MATLAB CONFERENCE 2017**
Problem: Common for boats to get stuck due to unusually low tides caused by certain winds

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Predictive Analytics Example with ThingSpeak

- Analytics on the cloud
- Visualisation accessible from ThingSpeak website
- No infrastructure setup or custom web development
MATLAB and ThingSpeak: Customer Testimonial

“In just a few months, we implemented a new service that measures and analyzes temperature and humidity changes in dozens—and soon hundreds—of homes.

Without MATLAB and ThingSpeak, we would still just be talking about it. Instead, we’re already pitching this service to utilities. That is a huge competitive advantage for our company.”

Dave Korn, VP of engineering at Cadmus
IoT Analytics Challenges

How do I collect enough data to build my algorithm?

Communications
Network

Deploy analytics to server/cloud

Data Aggregation
& Analytics

Deploy algorithms to nodes/devices

Smart Connected Devices

How do I deploy my algorithms on a smart device?

Algorithm Development
Sensor Analytics

How do I develop my algorithms?

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Development of Smart Connected Devices

Connect and Acquire

Signal Pre-Processing

Sensor Signal Analytics

Embedded Implementation

Automatic Code Generation
Reduce Data Transfer with Smart Connected Devices

Objectives
- Measure, explore, discover traffic patterns
- Provide traffic information without sending live video

Solution
- RaspberryPi + webcam
- Automated deployment of vision algorithms on embedded sensor

Full example available at makerzone.mathworks.com
Developing Embeddable Analytics with Simulink
When should I go to work?
MATLAB and Simulink Help Design 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++ and HDL code
- Hardware Support Packages for a wide variety of devices
Ono Sokki Reduce Development Time for Smart Device

Challenge
- Develop a high-precision speedometer (within 0.1 km/h) using inertial measurement unit sensors.
- Very tight deadline

Technology Applied
- Model, simulate and verify complex algorithms in Simulink
- Use automatic C code generation to deploy the algorithm onto an embedded device

Results
- Development time cut significantly
- Project was completed well ahead of schedule
- Easier to maintain, and fewer bugs

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Ono Sokki Reduce Development Time for Smart Device

“With MathWorks tools we have a seamless environment for development, simulation, code generation, and processor-in-the-loop verification. The advantages over hand-coding in C can’t be overestimated.”

Kazuhiro Ichikawa, Ono Sokki

Results

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How do I develop my algorithms?
ThingSpeak for Small Scale Deployment

- A few thousand devices or less
- Quickly build a “Proof of Concept” IoT System
- No need to build/manage web servers and databases

External Data & Business Systems

Deploy analytics To cloud

Algorithm Development Sensor Analytics

Smart Connected Devices

Ingest Store Compute

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Integrating MATLAB with 3\(^{rd}\) Party IoT Platforms

- **MATLAB Production Server** can be used to execute MATLAB analytics on 3\(^{rd}\) party platforms.
Integrating MATLAB in Large Scale Production Systems

Data

- Databases
  - neo4j
  - MongoDB
  - SQL Server

- Cloud Storage
  - Azure Blob
  - Azure SQL

- IoT
  - kafka
  - MQTT

Analytics

- MATLAB Production Server

- Request Broker

Business System

- Visualization
  - Qlik
  - Tableau
  - Spotfire

- Web
  - Microsoft IIS
  - WebSphere
  - Apache Tomcat

- Custom App

Platform

- Public Cloud
  - Microsoft Azure
  - Amazon Web Services
  - Rackspace

- Private Cloud
  - OpenStack
  - VMware

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Big Data and Predictive Analytics at Shell

Shell analyses big data sets to detect events and abnormalities at downstream chemical plants using predictive analytics with MATLAB®.

Multivariate statistical models running on MATLAB Production Server™ are used to do real-time batch and process monitoring, enabling real-time interventions when abnormalities are detected.

MathWorks Addresses IoT Analytics Challenges

- Develop analytics algorithms using MATLAB and toolboxes
- Quickly collect and analyze IoT data with ThingSpeak and MATLAB
- Deploy on smart devices using code generation for embedded hardware
- Deploy on cloud using ThingSpeak and MATLAB Production Server
What You Can Do to Learn More

- Log-in to ThingSpeak with your 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