MATLAB EXPO 2016

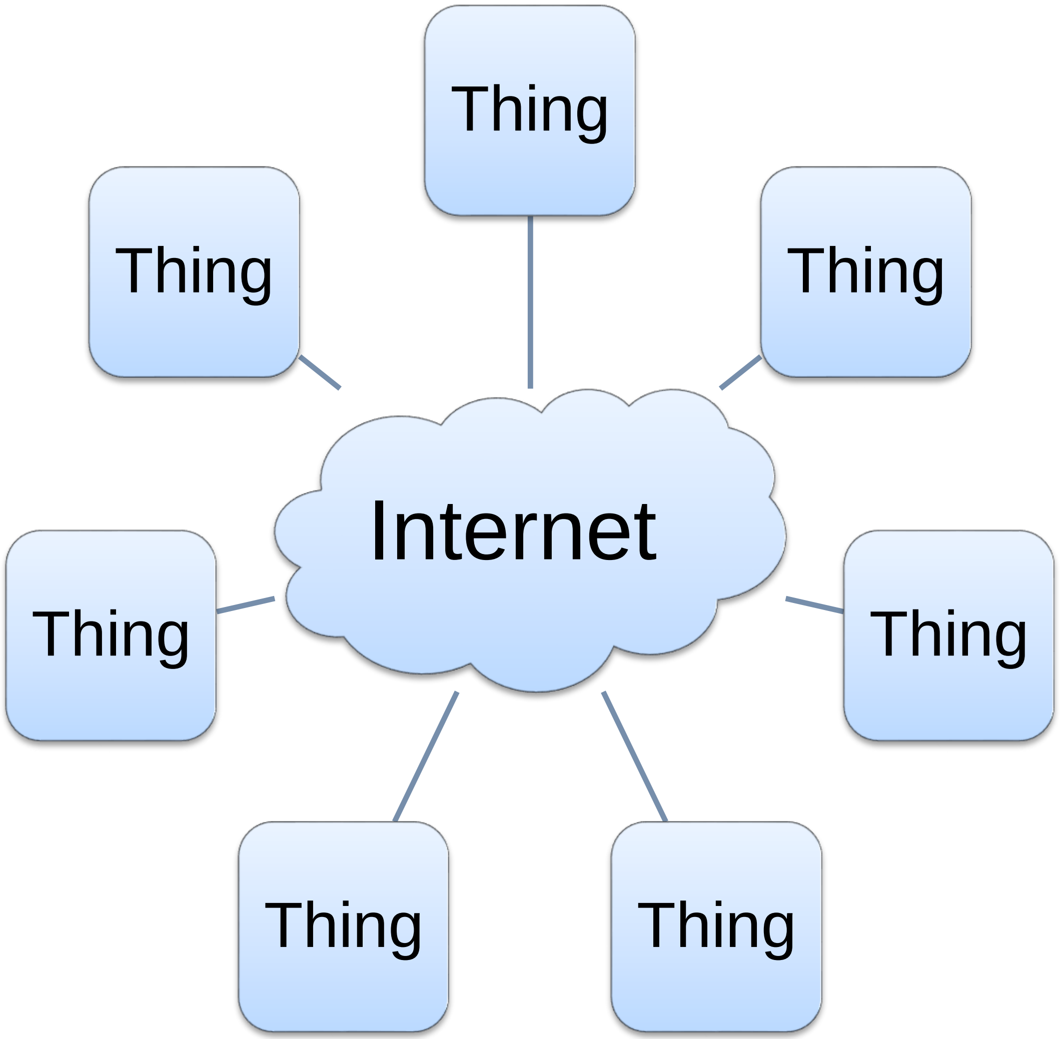
Design Challenges for Sensor Data Analytics in Internet of Things (IoT)

Corey Mathis

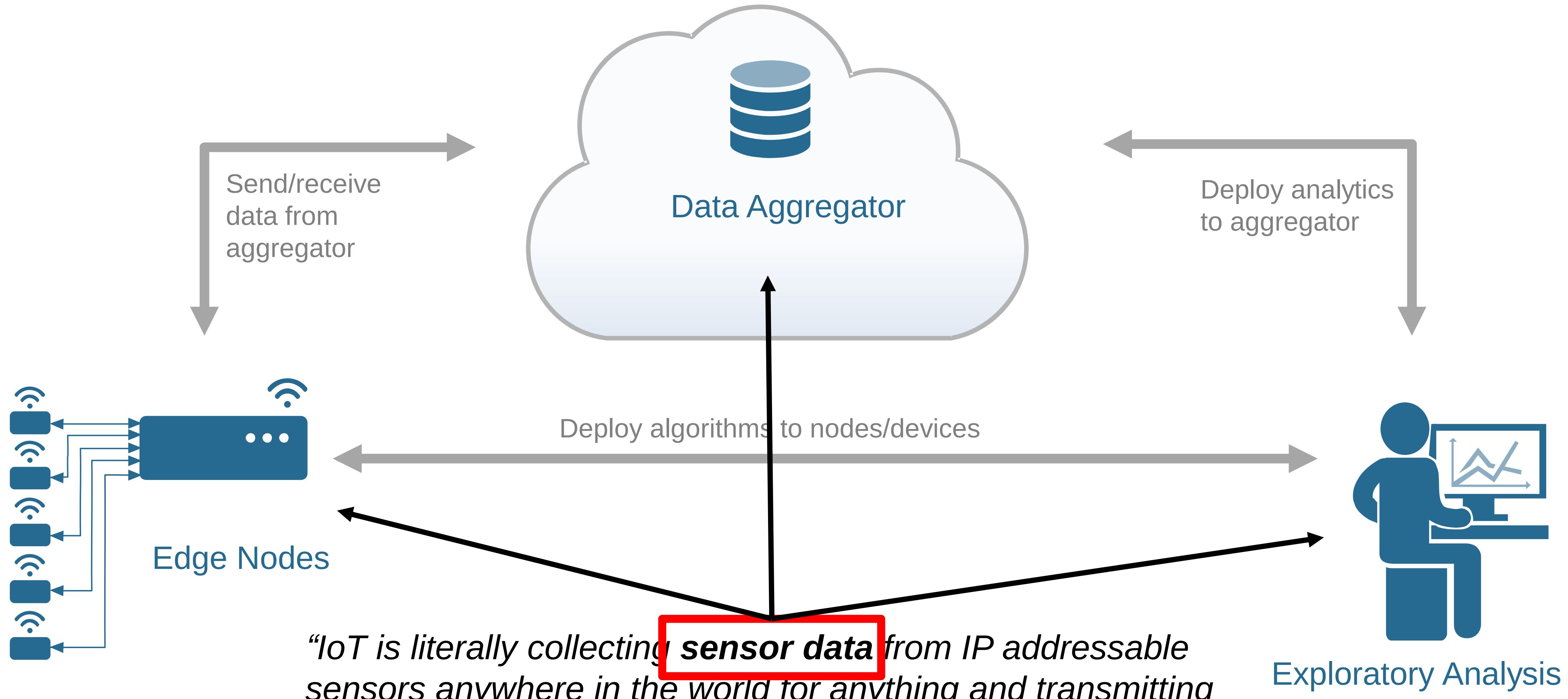
Agenda

- <Brief> IoT Overview
- Design Challenges for Sensor Data Analytics
- Example Solutions

What is the Internet of Things?



What is the Internet of Things?



"IoT is literally collecting ***sensor data*** *from IP addressable sensors anywhere in the world for anything and transmitting the data."* Tom Moore, IHS Analyst II, Industrial Automation

The Goal of the IoT

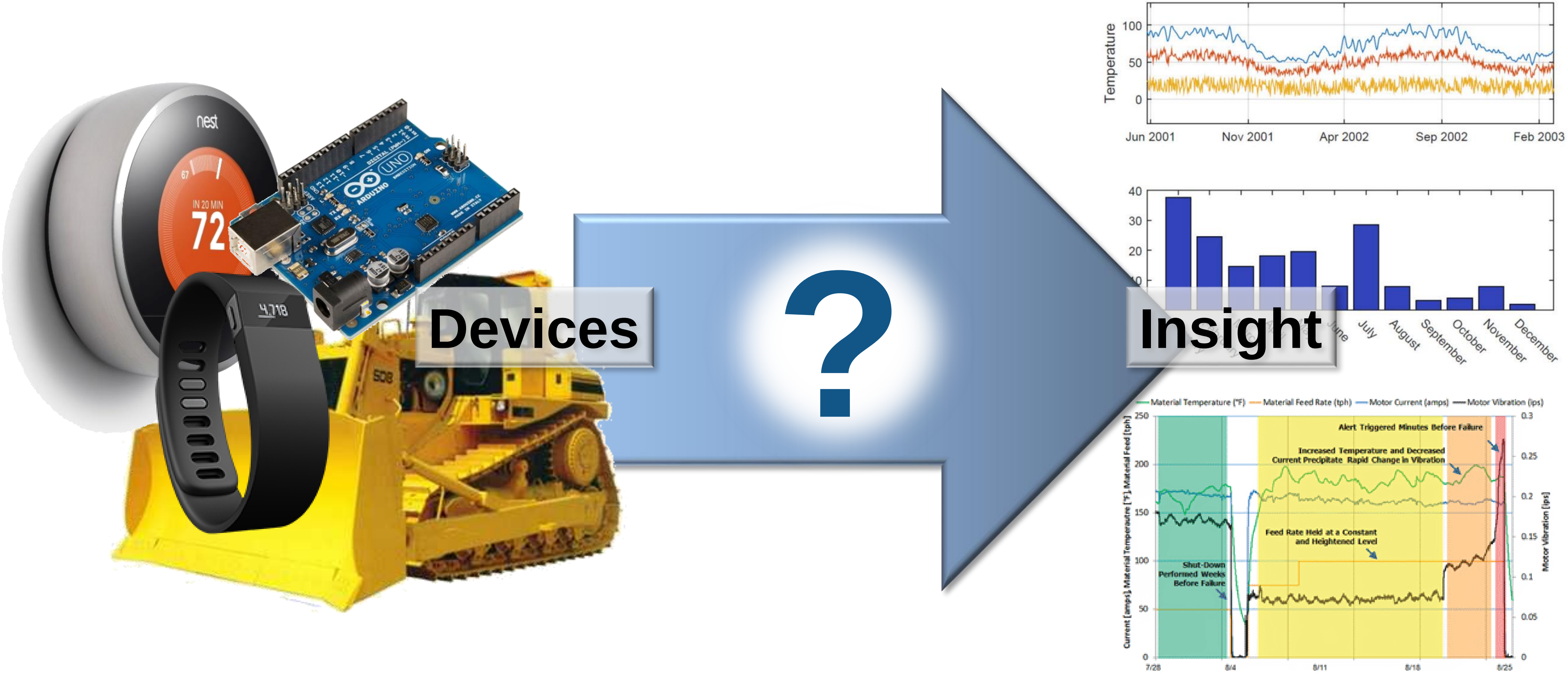


Figure 3. Vibration analysis: Data processed by the company's vibration analysis tool, and leading up to the fan's catastrophic failure, provides an ambiguous indication of the asset's degrading condition.

What is enabled by IoT sensor data?

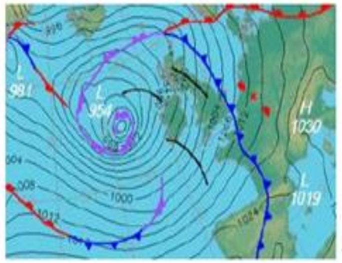
Wearable /Healthcare

- Vital-sign monitor
- Home/Remote healthcare

Infra/Plant equipment

- Health monitoring
- Process monitoring

Weather Environment

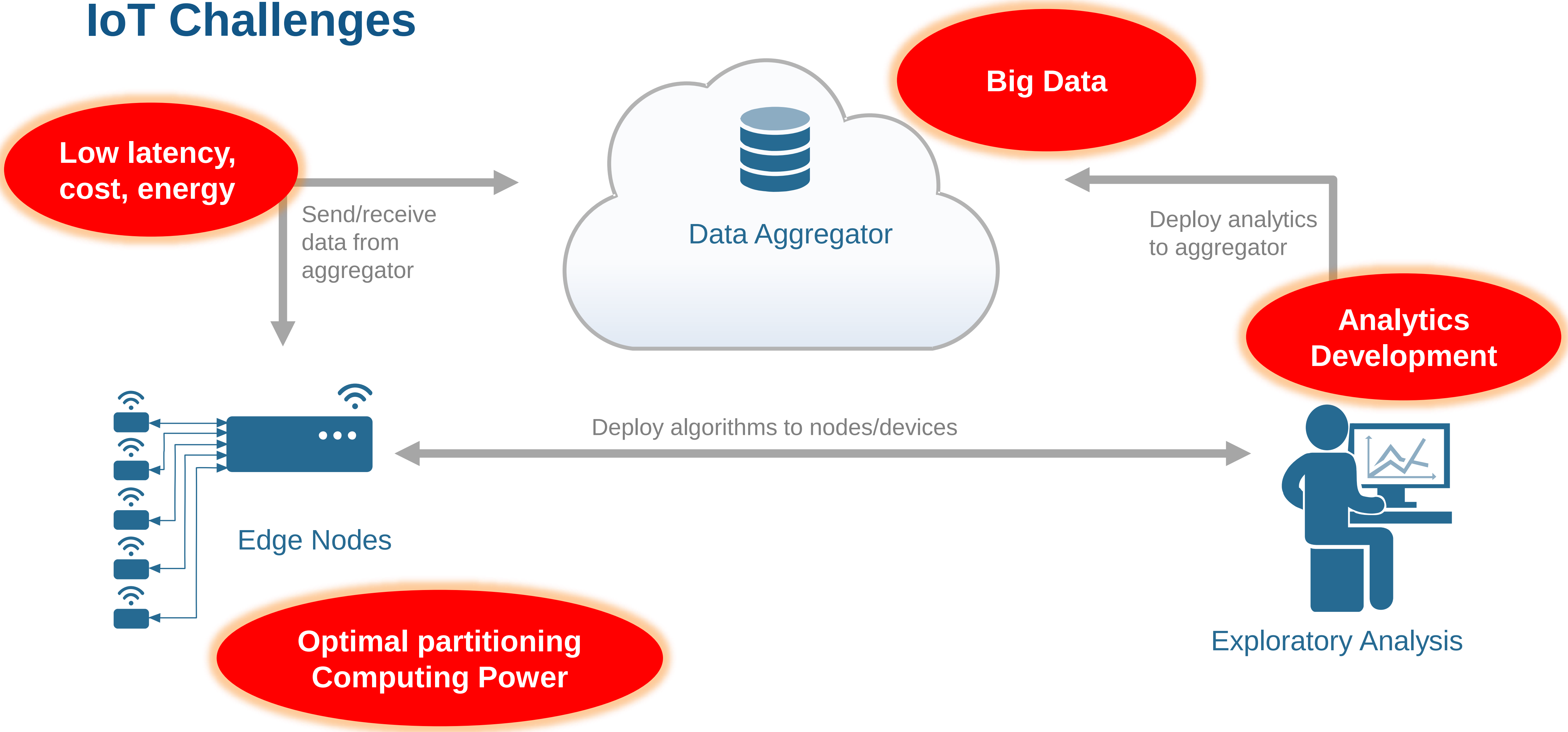


- Weather/ Power/disaster prediction
- Power demand forecast(EMS, Power trading)

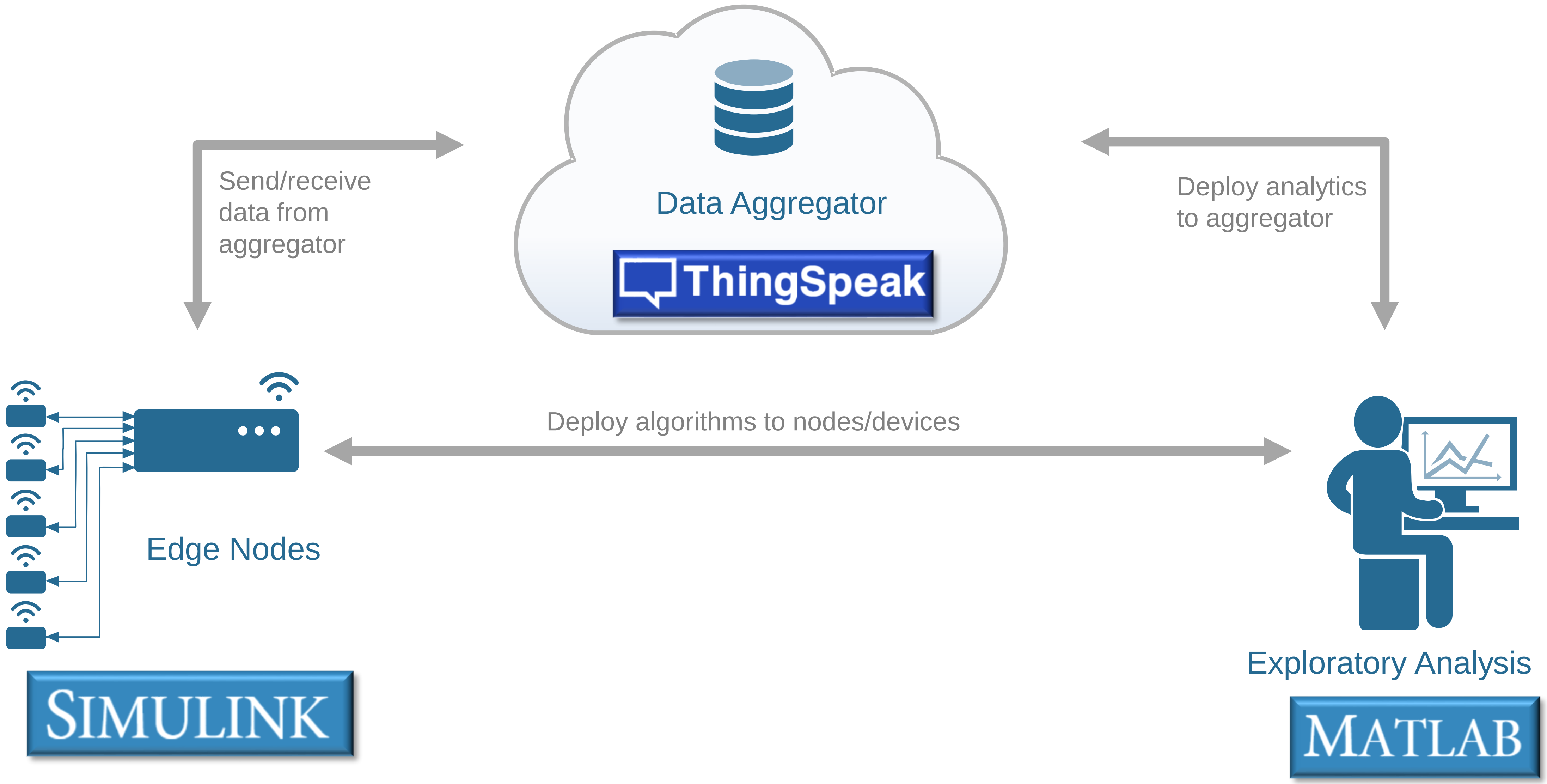
Automotive Aerospace

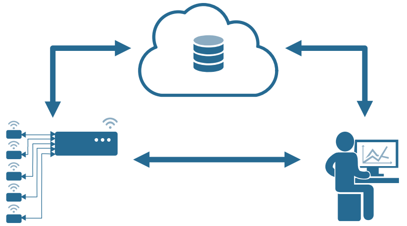
- Telematics, Health monitoring
- Safety driving, ADAS

IoT Challenges



MathWorks IoT Solutions





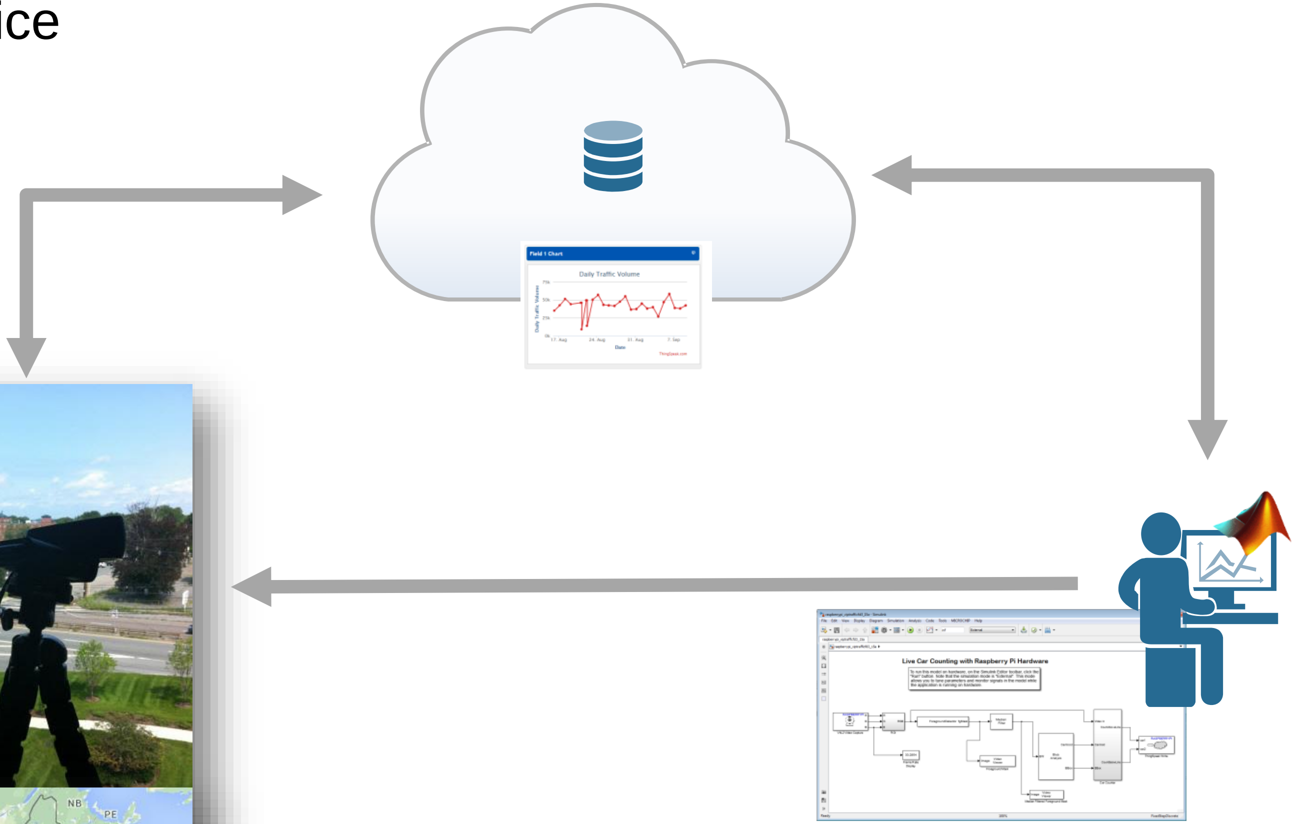
Example 1: Monitoring Traffic

Objectives

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

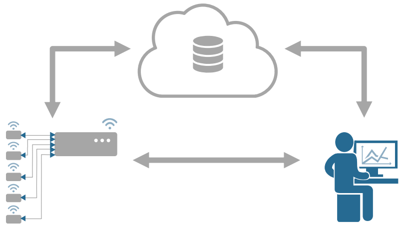
Solution

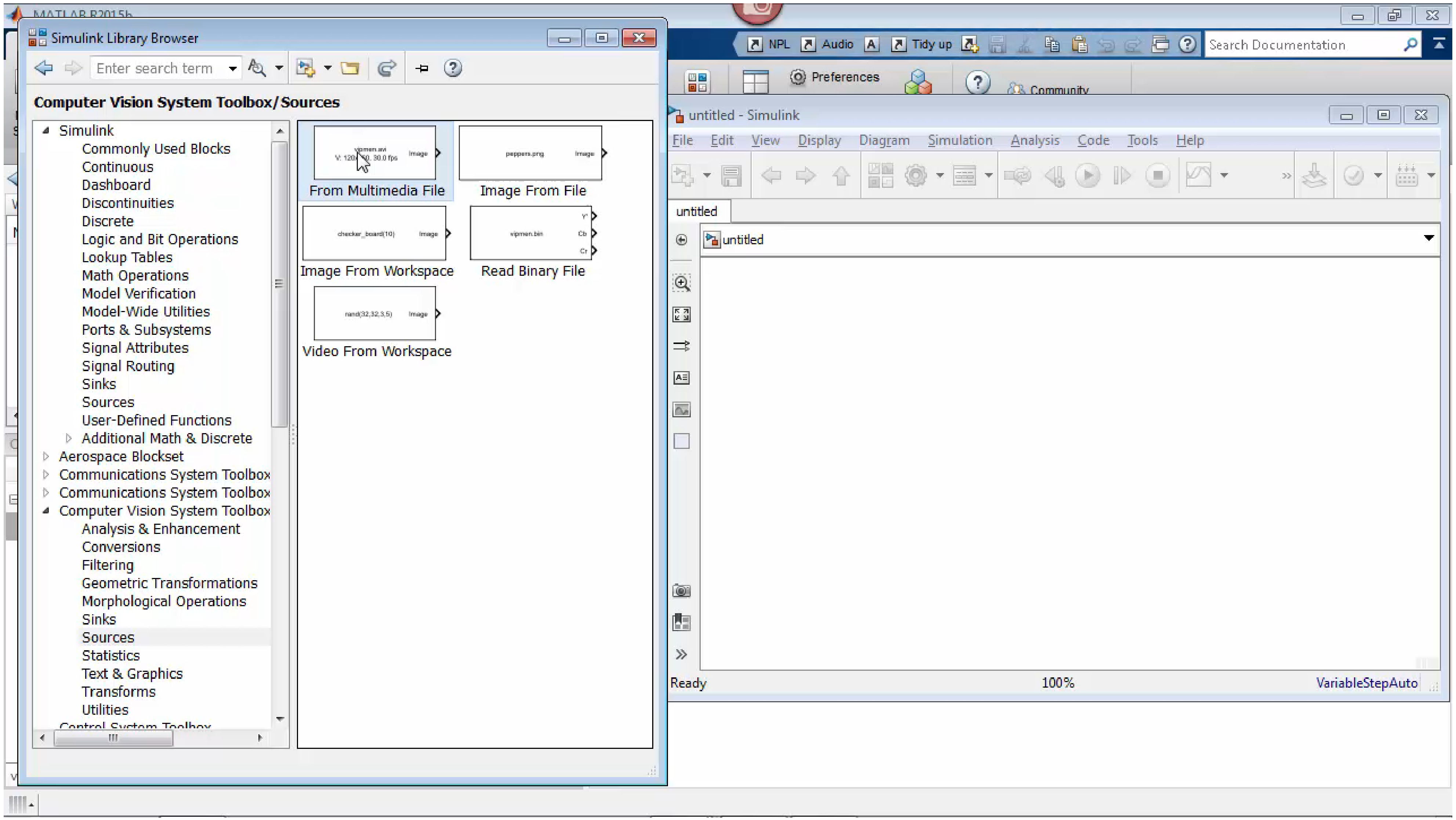
- RaspberryPi + webcam
- **Automated deployment of vision algorithms on embedded sensor**
- Full example available at makerzone.mathworks.com



Traffic sensor – step 1

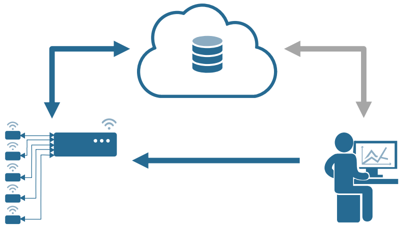
Design a car counter in Simulink

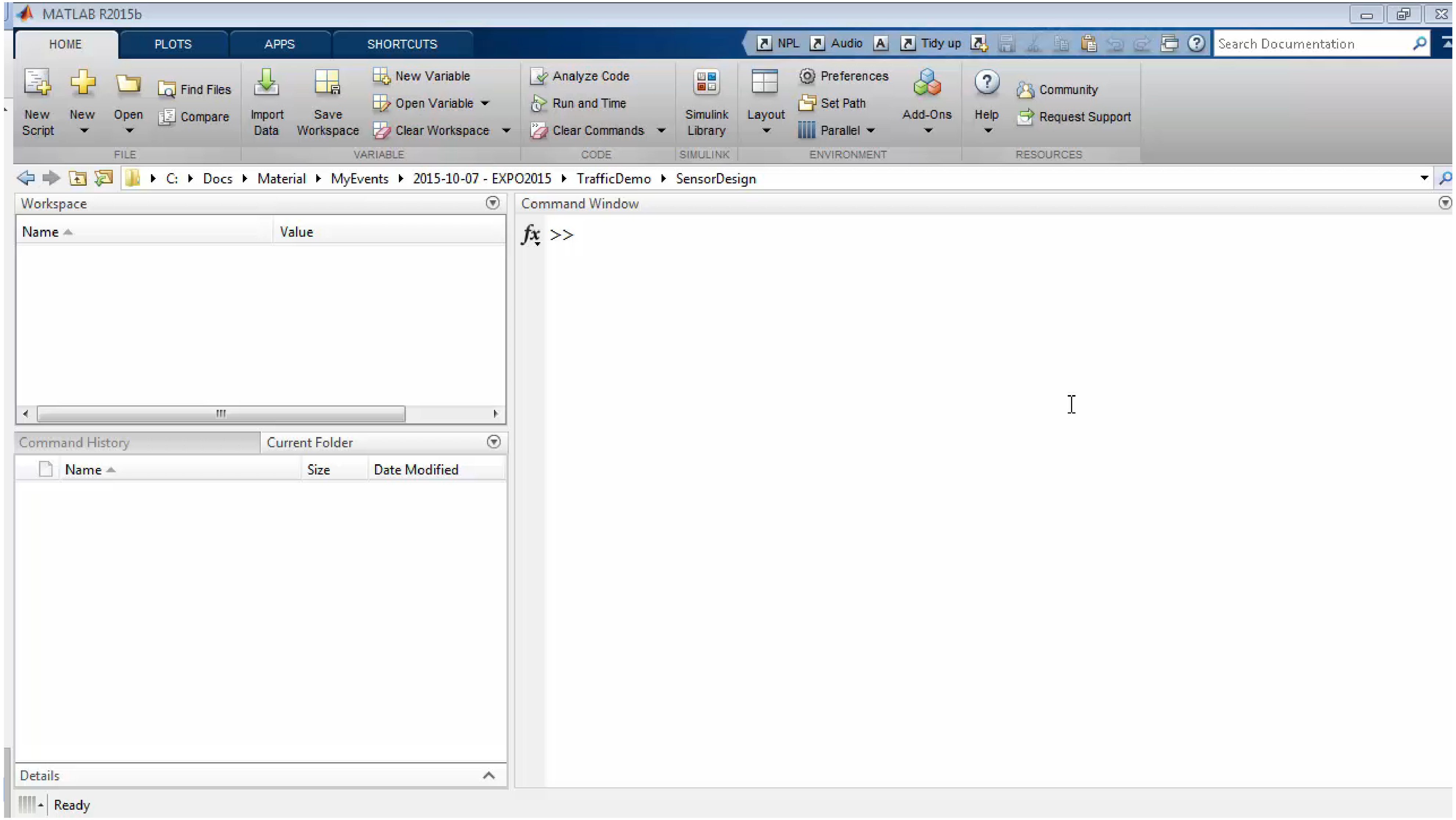




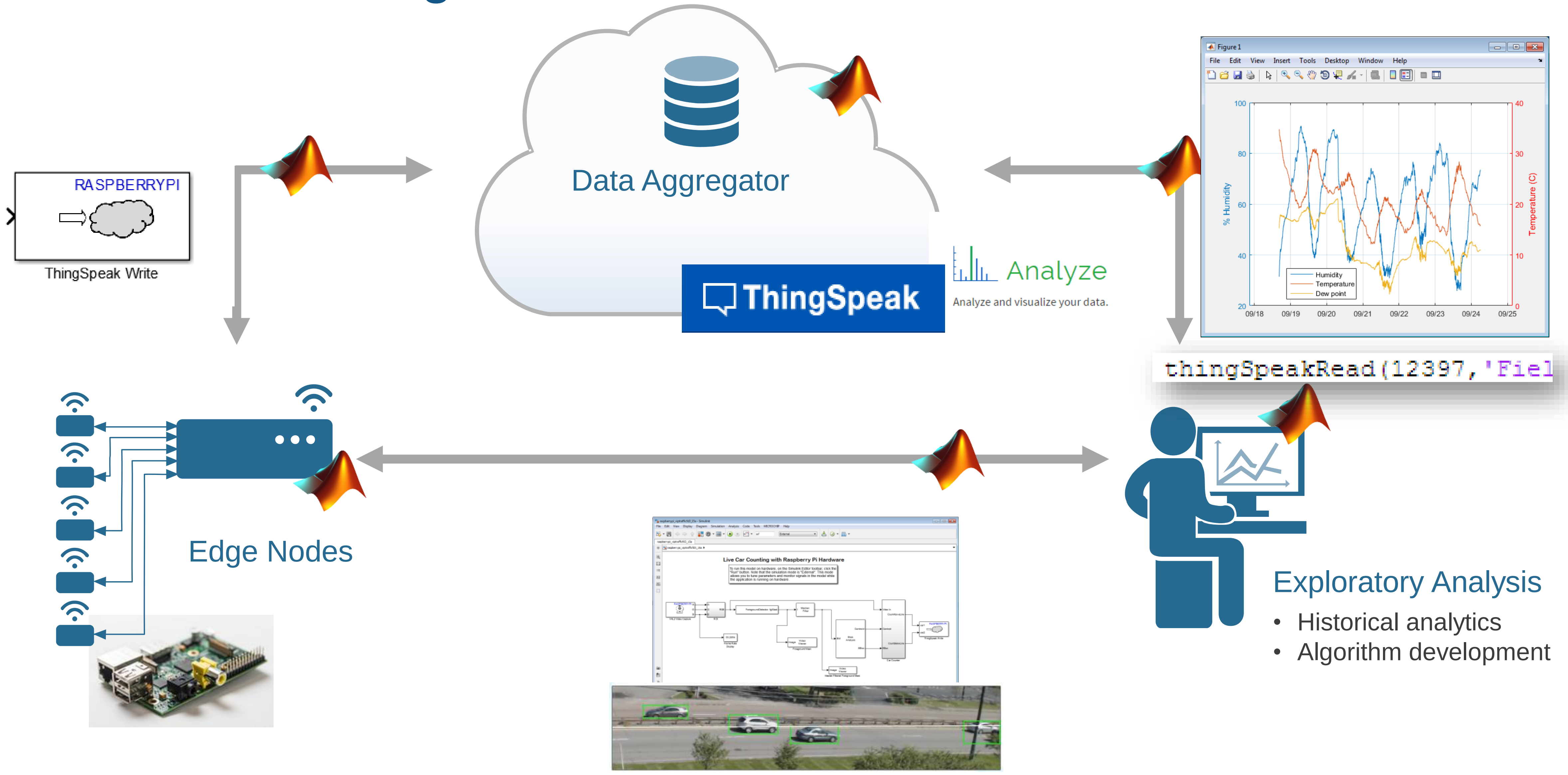
Traffic sensor – step 2

Port it to Raspberry Pi

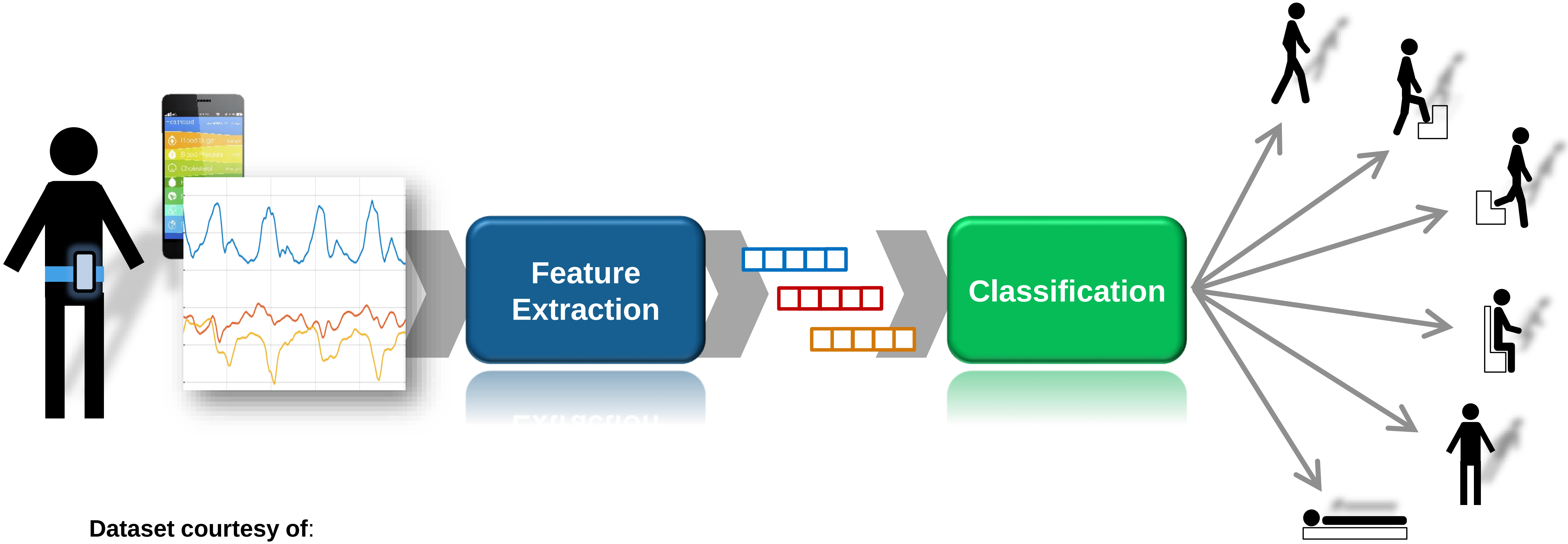




IoT Traffic Monitoring Solution

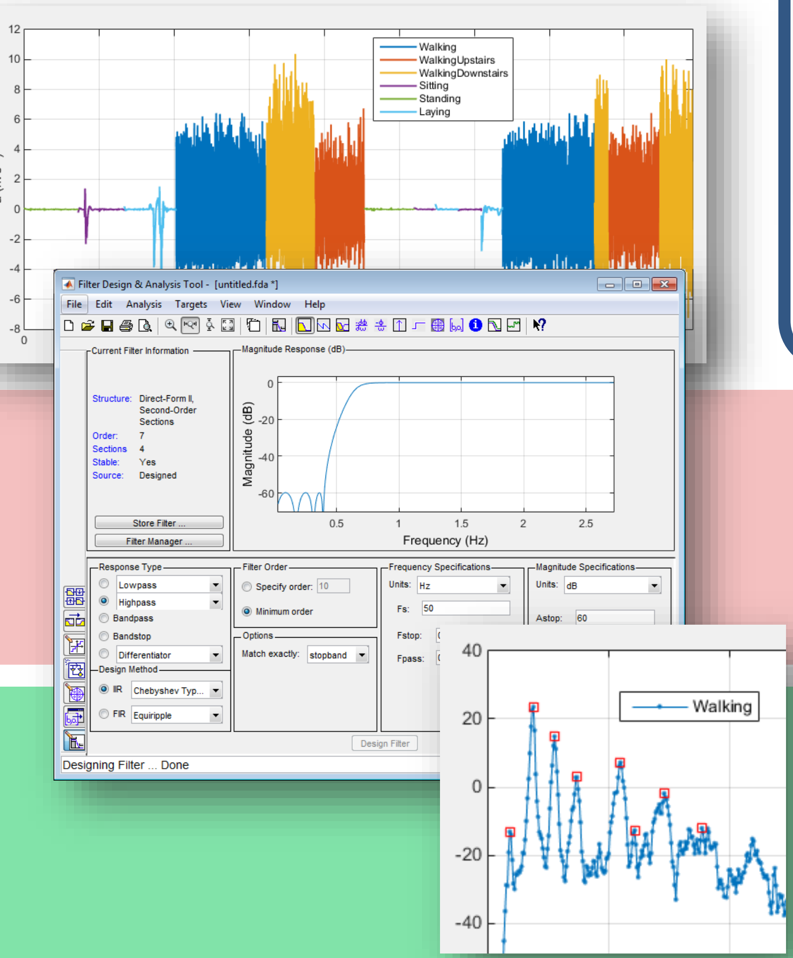


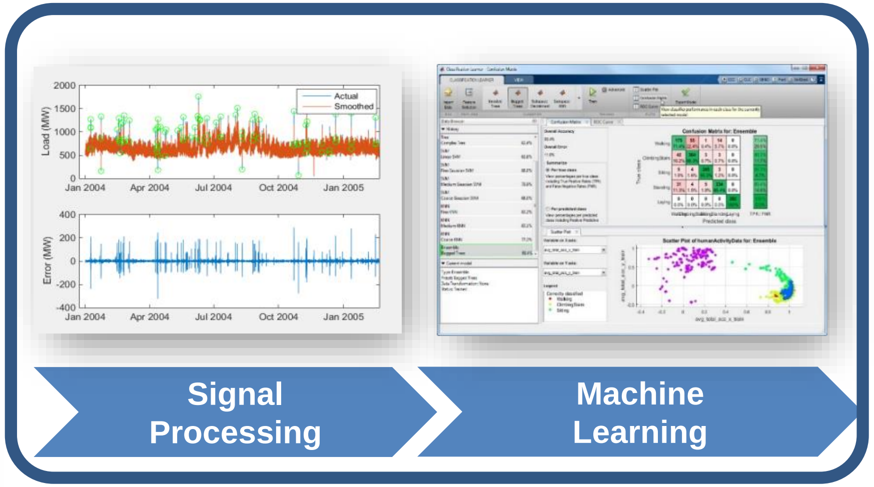
Example 2: Human Activity Analysis and Classification



Dataset courtesy of:
Davide Anguita, Alessandro Ghio, Luca Oneto, Xavier Parra and Jorge L. Reyes-Ortiz.
Human Activity Recognition on Smartphones using a Multiclass Hardware-Friendly Support Vector Machine.
International Workshop of Ambient Assisted Living (IWAAL 2012). Vitoria-Gasteiz, Spain. Dec 2012
http://archive.ics.uci.edu/ml/datasets/Human+Activity+Recognition+Using+Smartphones

Sensor Data Analytics Workflow – the bigger picture

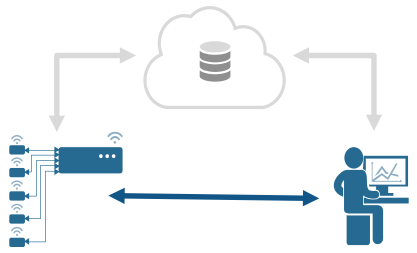


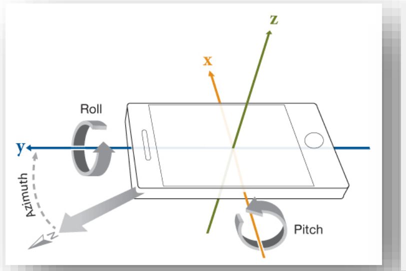


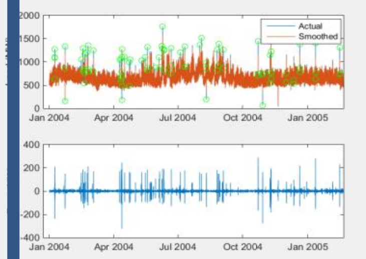
- Domain knowledge
- Open-ended problem
- Long discovery cycles

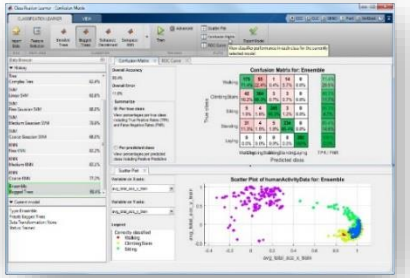
- Built-in algorithms
- Concise code (54 lines for 66 features!)
- Apps and visualisation accelerate insight

Sensor Data Analytics Workflow – the bigger picture





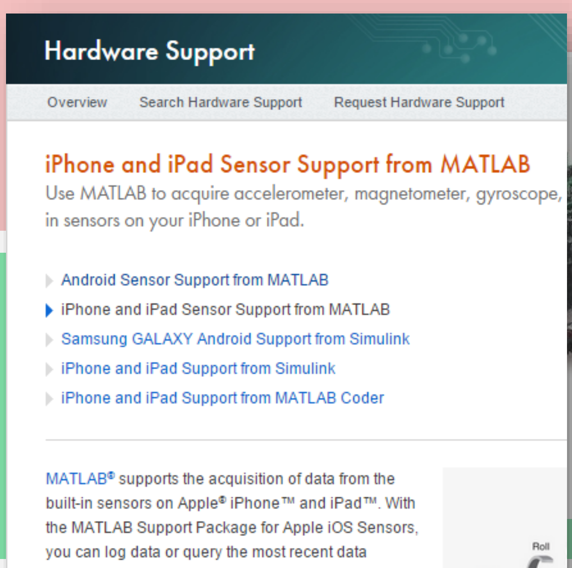




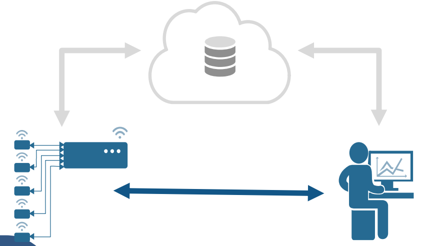
Connect and Acquire → Signal Processing → Machine Learning

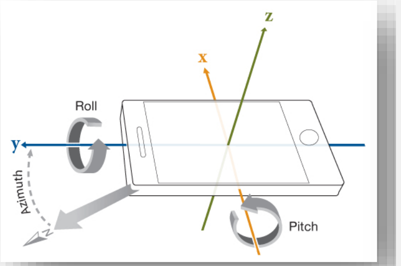
- Different tools and environments
- Disconnect between hardware and analysis
- Inefficiencies in data sharing

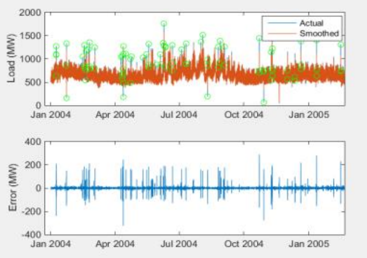
- MATLAB Connects to DAQ interfaces and sensors directly. E.g.
  - [Android Sensor Support]
  - [iPhone and iPad Sensor Support]

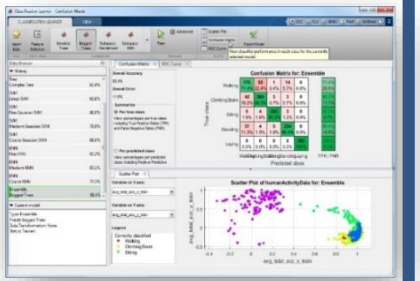


Sensor Data Analytics Workflow – the bigger picture

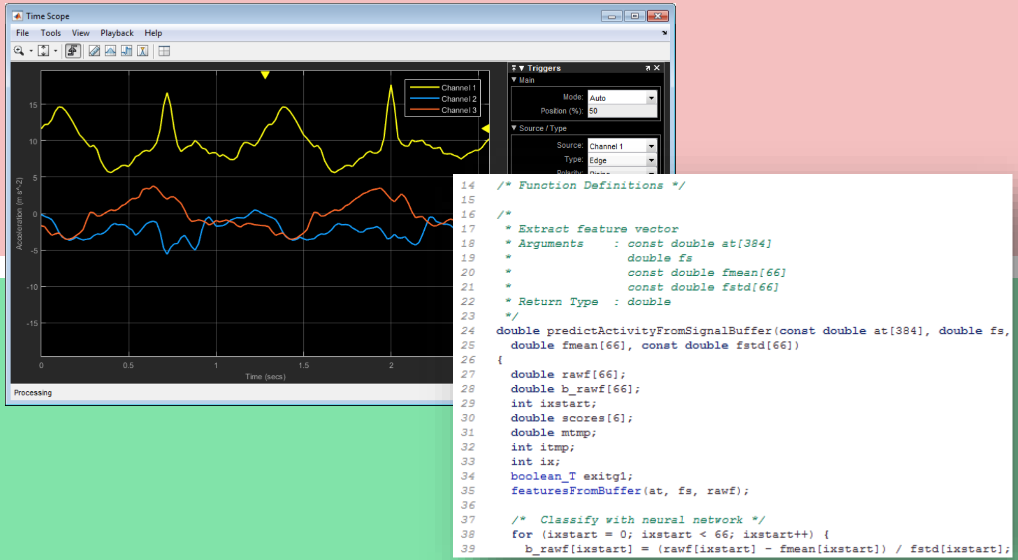








Connect and Acquire → **Signal Processing** → **Machine Learning** → **Implementation**

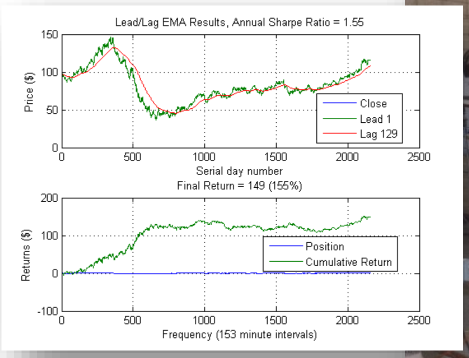


- Signal analysis vs. on-line DSP
- From Machine Learning theory to pre-trained, low-footprint classifiers
- MATLAB vs. C/C++

- Streaming algorithms, data sources and visualization for System modelling and simulation
- Automatic code generation

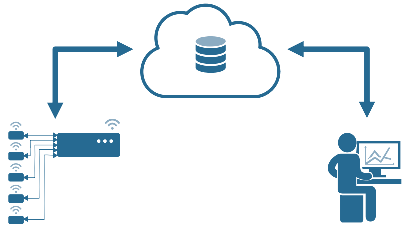
Signal analysis for classification
Application examples

- Mobile sensing
- Structural health monitoring (SHM)
- Fault and event detection
- Automated trading
- Radar post-processing
- Advanced surveillance
- ...



Customer Study: BuildingIQ

Predictive Energy Optimization



BuildingiQ

Opportunity

- **Real-time, cloud-based system** for commercial building owners to reduce energy consumption of HVAC operation

Analytics Use

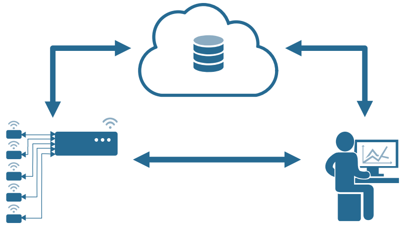
- **Data:** 3 to 12 months of data from power meters, thermometers, and pressure sensors, as well as weather and energy cost, comprising billions of data points
- **Machine learning:** SVM regression, Gaussian mixture models, k-means clustering
- **Optimization:** multi-objective, constrained

Benefit

- Typical energy consumption reduced 15-25%

Customer Study: iSonea

Cloud and Embedded Analytics



Opportunity

- Develop an acoustic respiratory monitoring system for wheeze detection and asthma management

Analytics in cloud and embedded

- Captures 30 seconds of windpipe sound and processes the data locally to clean up and reduce ambient noise
- Invokes spectral processing and pattern-detection analytics for wheeze detection on iSonea server in the cloud
- Provides feedback to the patient on their smartphone

Benefit

- Eliminates error-prone self-reporting and visits to the doctor

Summary

- Develop Lightweight IoT systems entirely in MATLAB
- Integrate MATLAB algorithms within professional IoT systems

Q and A