

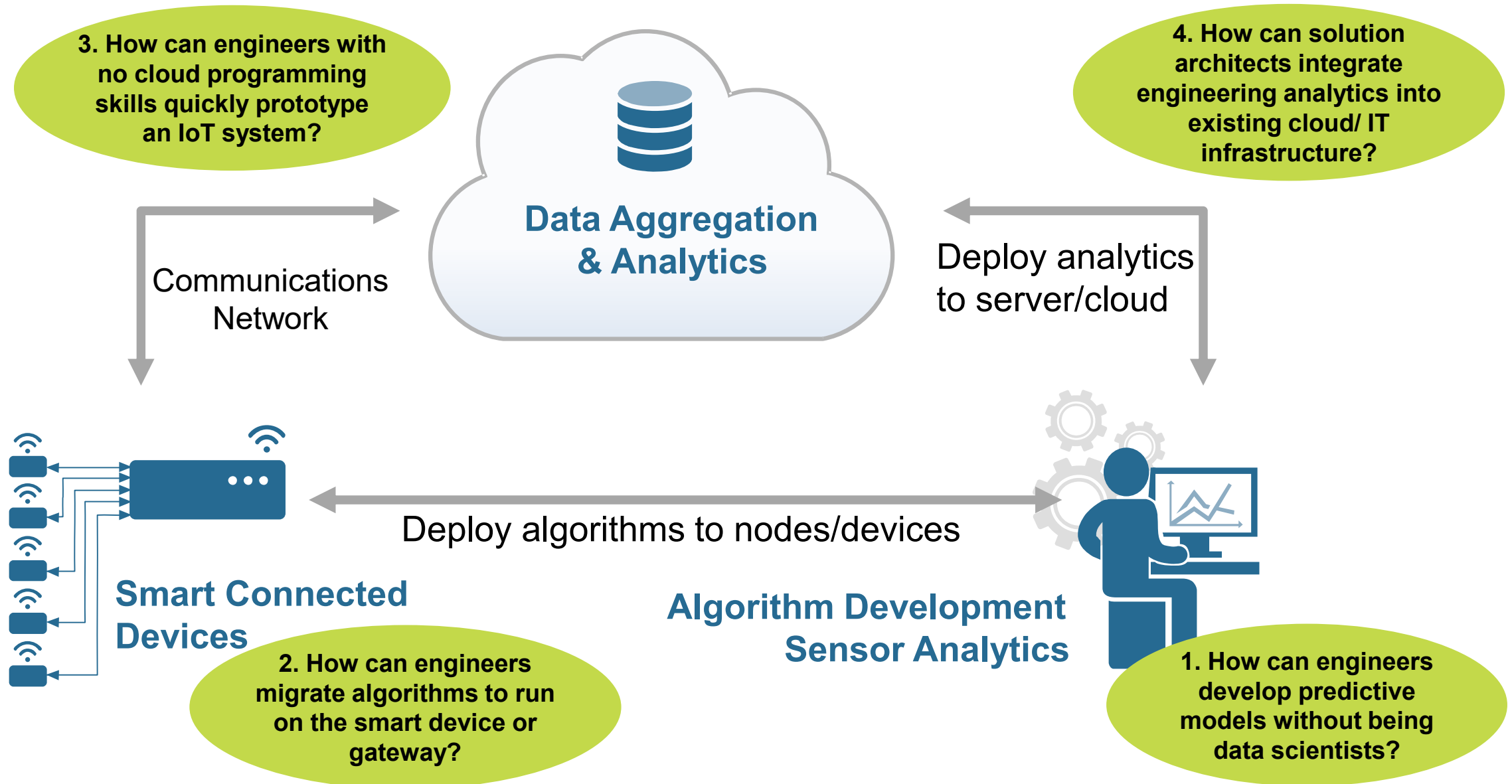
Fast algorithm prototyping with MATLAB for smart IoT systems

Antti Löytynoja, *Senior Application Engineer*

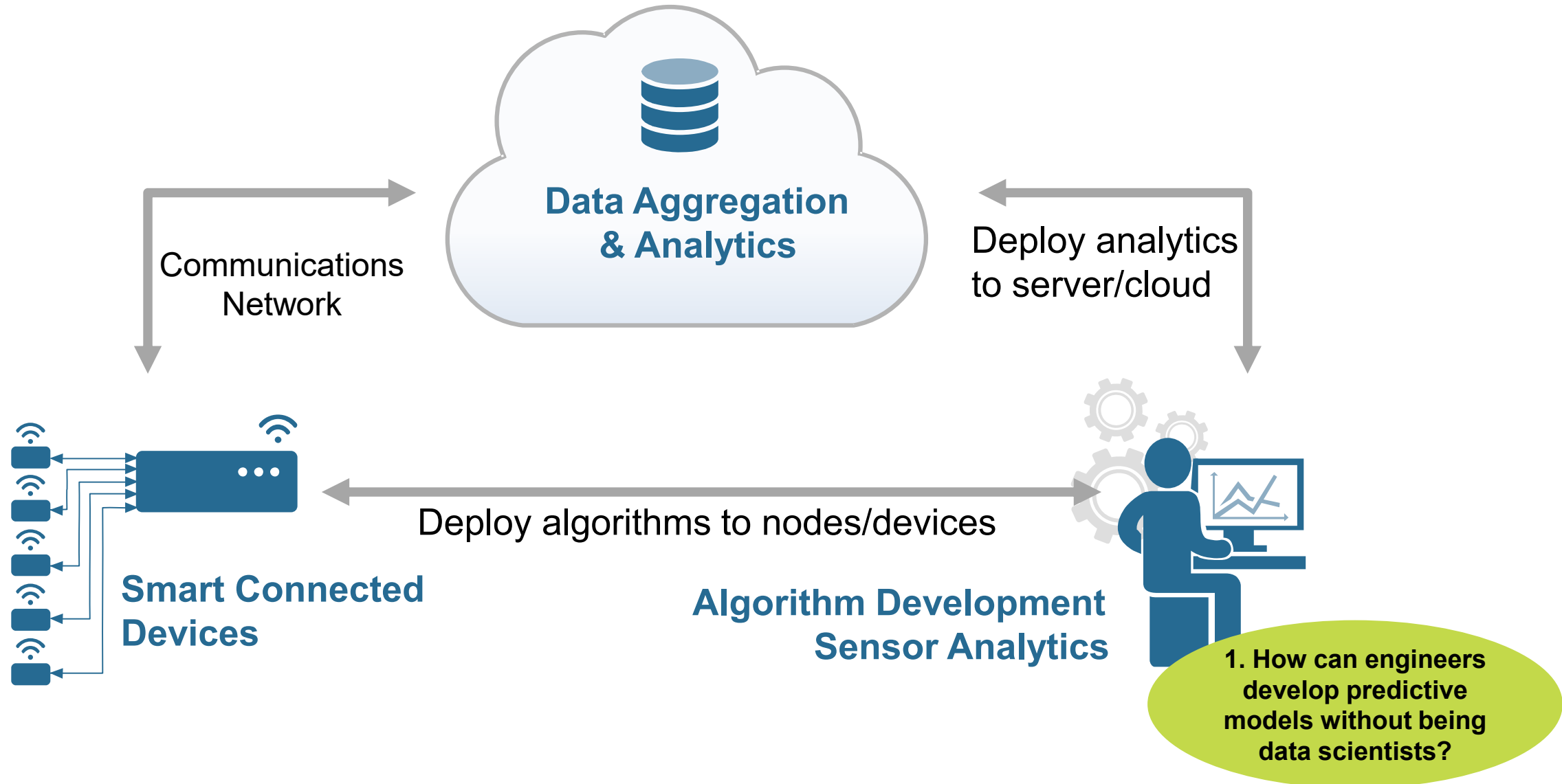
Motivation

- 20-50 billion devices becoming connected in a few years
- We can expect *a lot* of data
- IoT systems, including edge devices, must become smarter and autonomous to handle some of that data -> ***machine learning on the edge***

Challenges in Building IoT Systems with Analytics



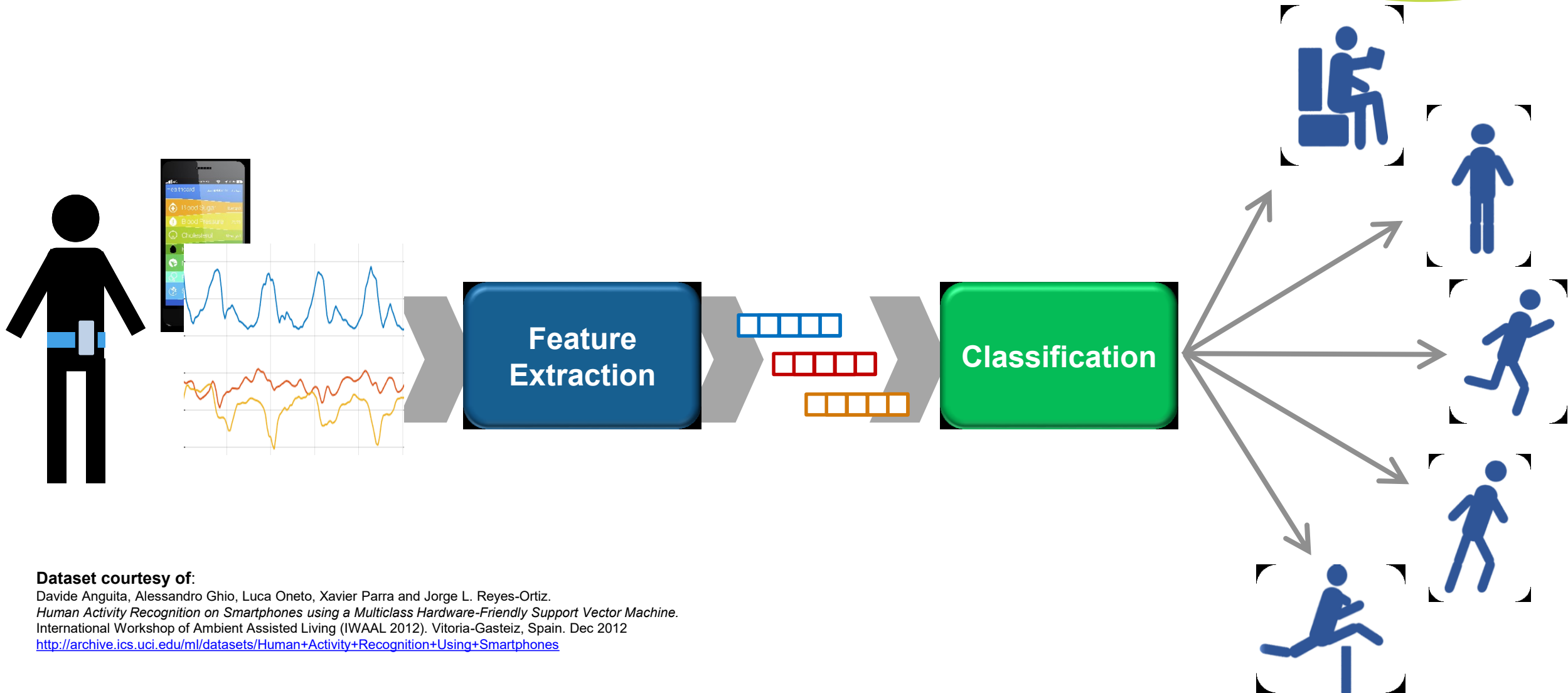
IoT Challenge #1: Developing Predictive Models



Example: Human Activity Recognition and Classification

Supervised Machine Learning

1. How can engineers develop predictive models without being data scientists?



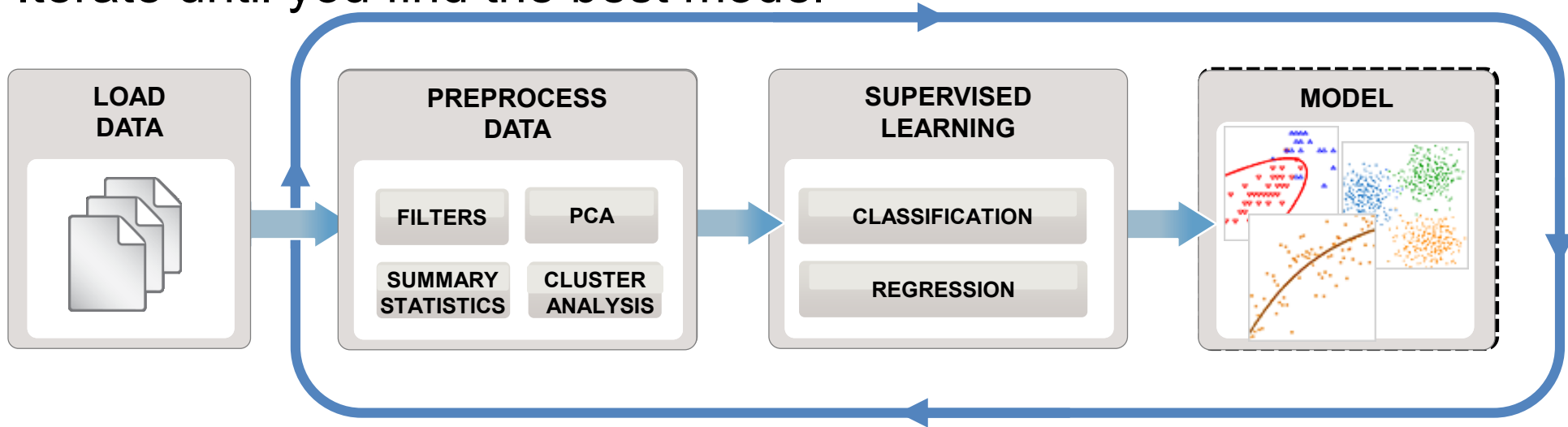
Dataset courtesy of:

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>

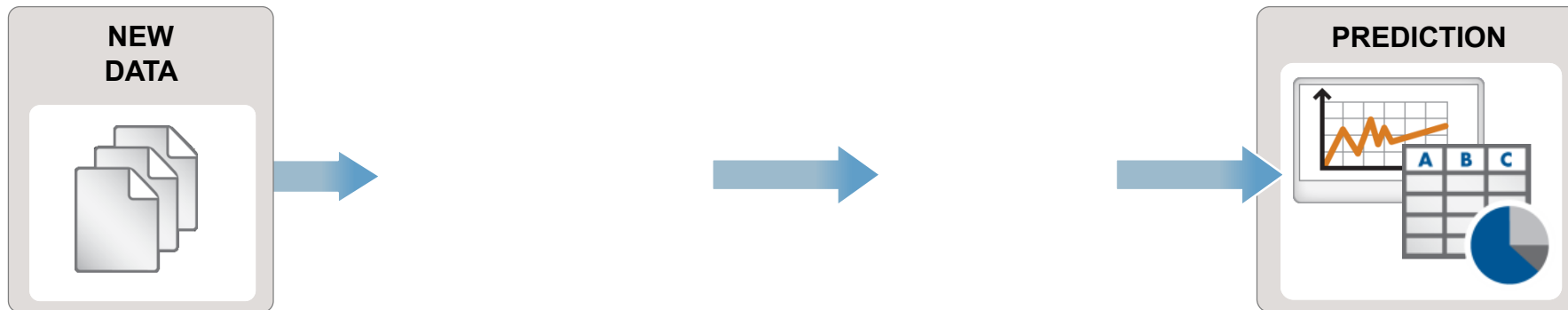
Supervised Machine Learning Workflow

1. How can engineers develop predictive models without being data scientists?

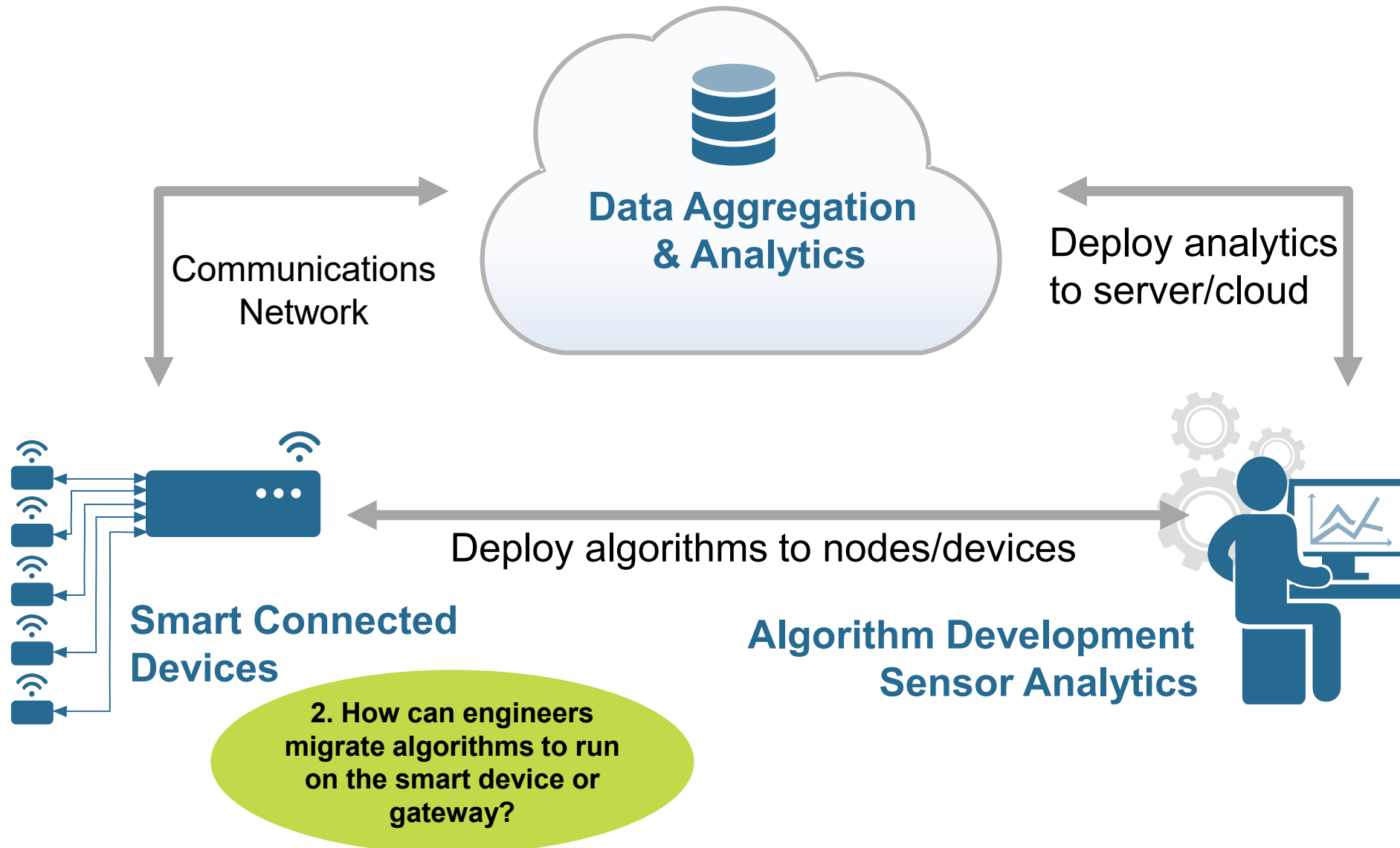
Train: Iterate until you find the best model



Predict: Use trained model make predictions from new input data

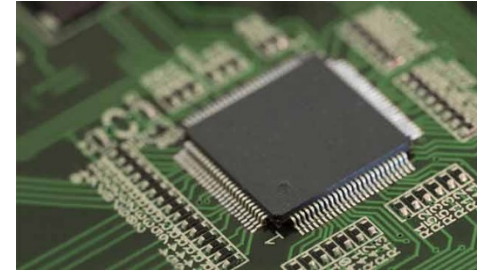
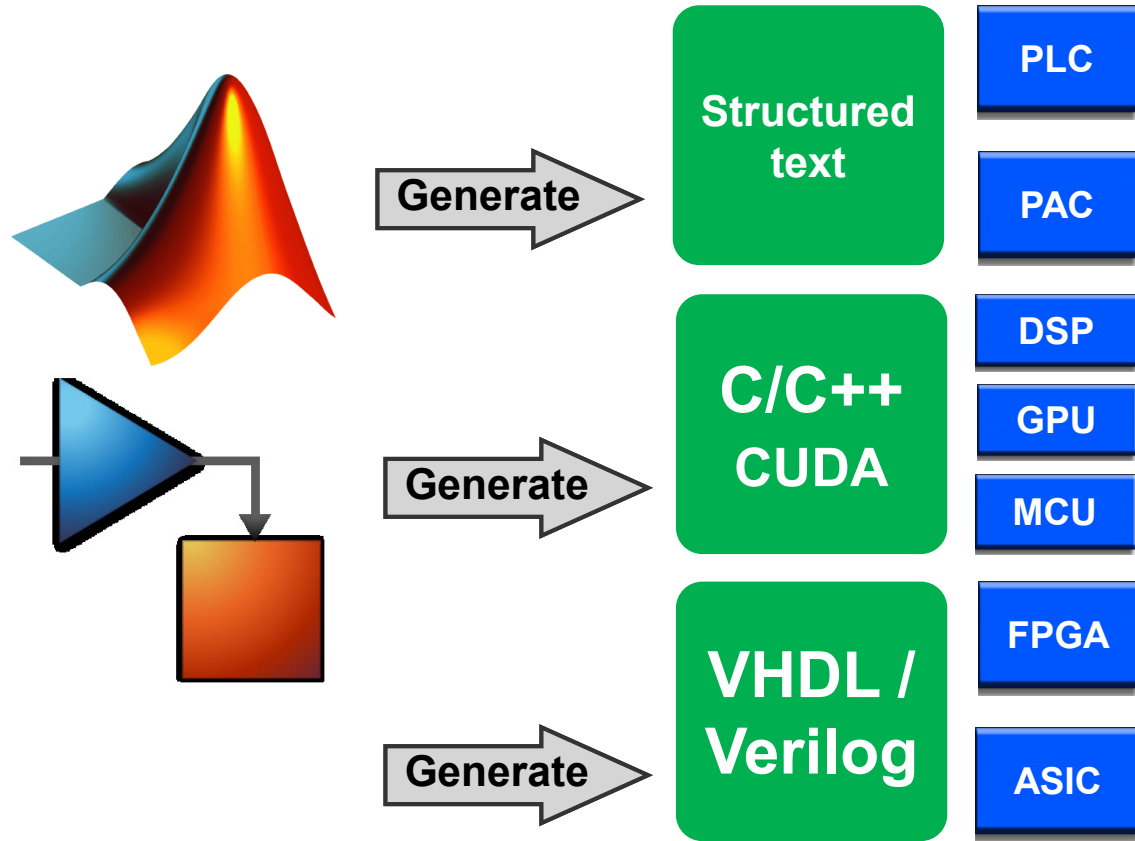


IoT Challenge #2: Migrating Algorithms to Run on a Smart Device



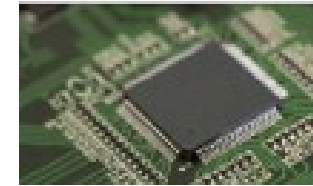
Code Generation removes the gap between algorithm development and implementation

2. How can engineers migrate algorithms to run on the smart device or gateway?



Processor-Optimized Code For

- ARM Cortex-M
- ARM Cortex-R
- ARM Cortex-A
- ST Nucleo Board
- ST Discovery Board
- Intel Curie
- TI microprocessors
- Mobile devices
 - iOS and Android
- Prototyping Hardware
 - Raspberry Pi, BeagleBone Black, Arduino
- Nvidia GPU's

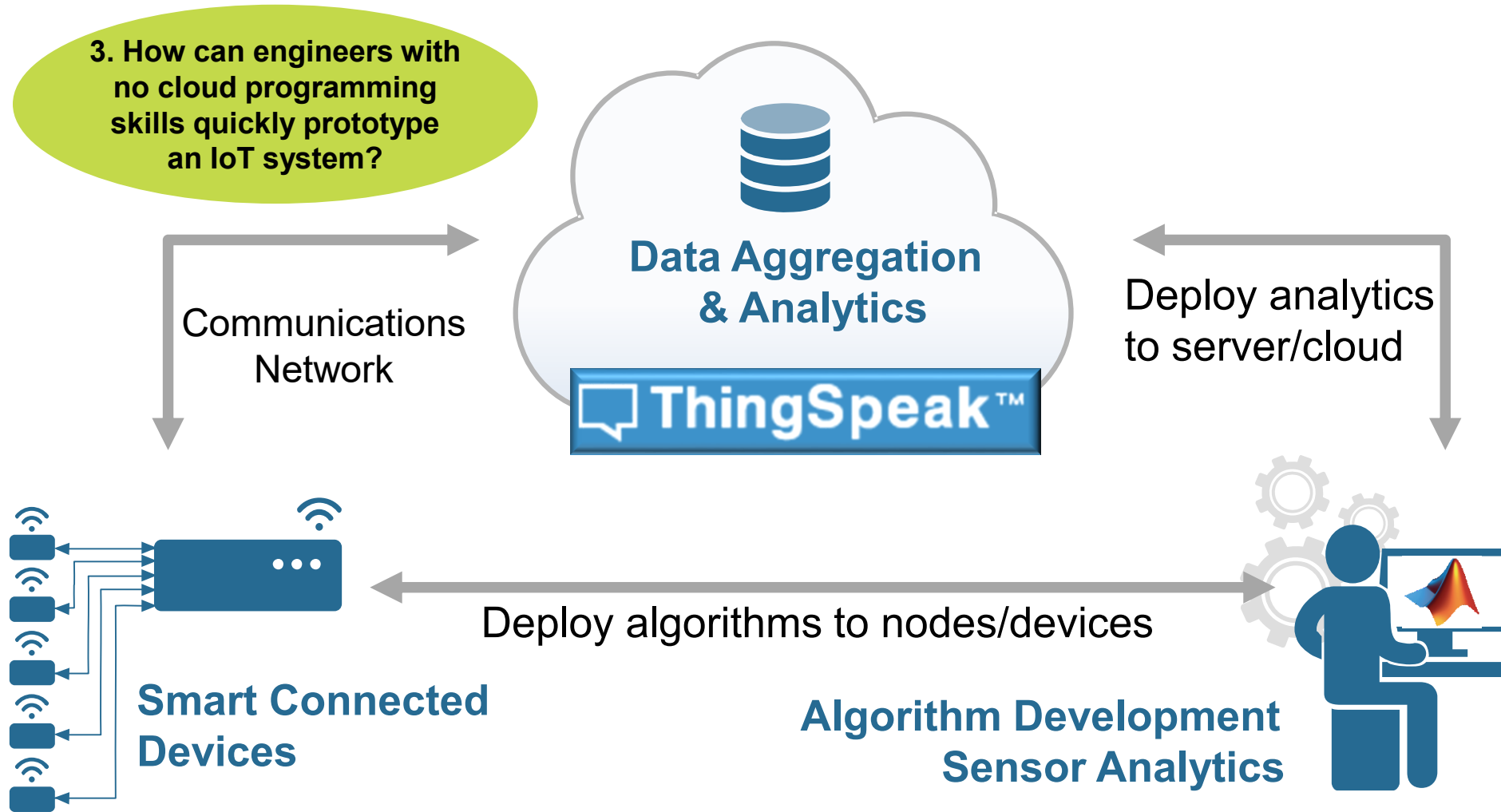


2. How can engineers migrate algorithms to run on the smart device or gateway?

<https://www.mathworks.com/products/embedded-coder.html>

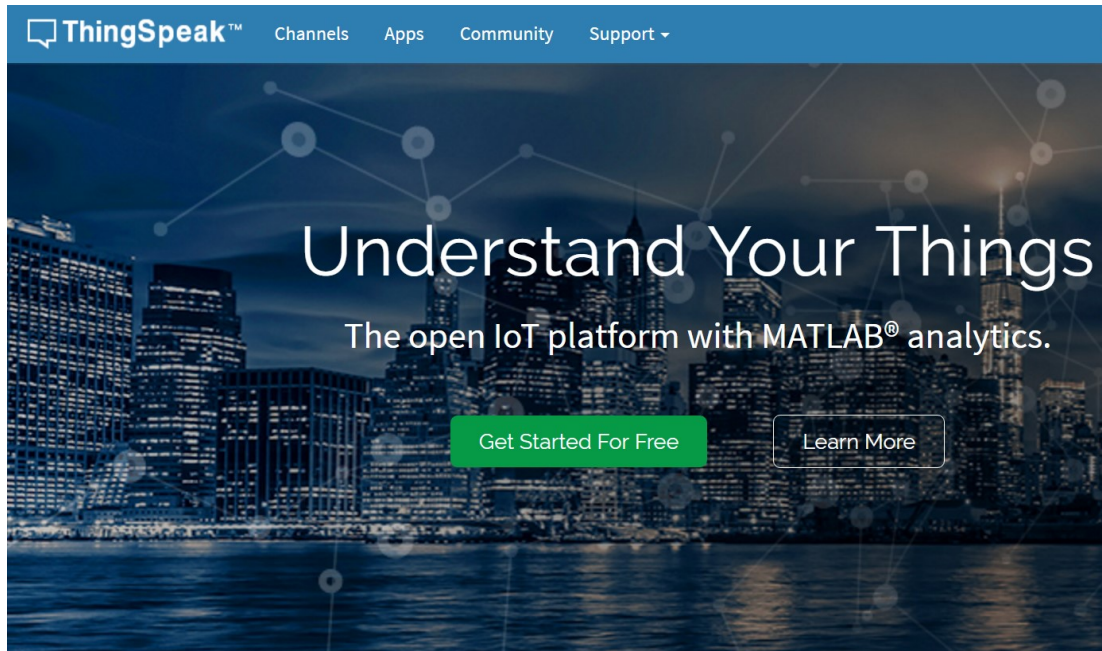
<https://www.mathworks.com/hardware-support.html?q=&fq=product:EC&page=1>

IoT Challenge #3: Prototyping IoT Systems



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"
    }
  ]
}
```

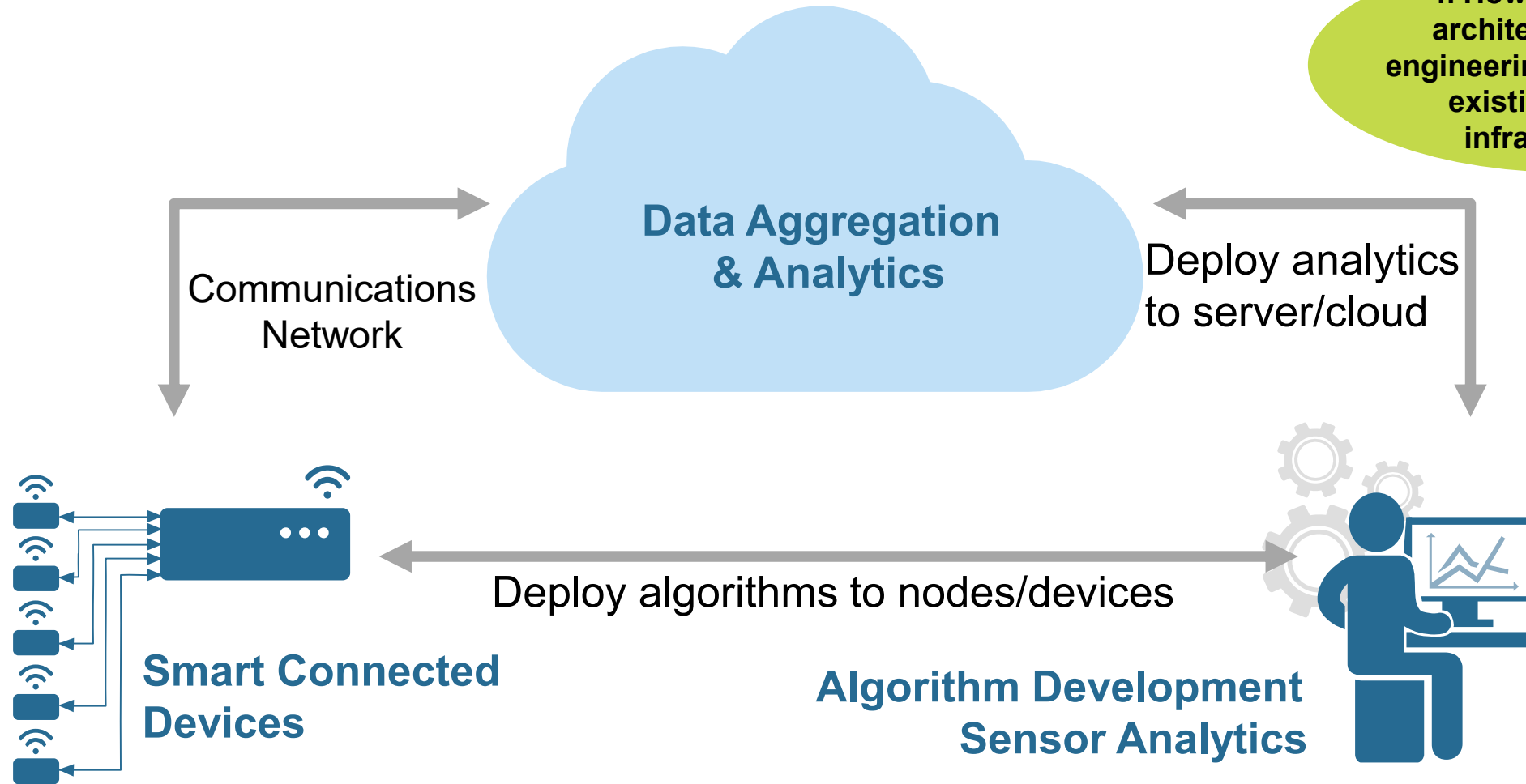
- MathWorks web service hosted on AWS
- Lets you collect, analyze and act on data from “things”
- It has **MATLAB** for IoT Analytics
- It's **free** to get started



3. How can engineers with no cloud programming skills quickly prototype an IoT system?

IoT Challenge #4: Integrating Engineering Analytics into the Cloud

4. How can solution architects integrate engineering analytics into existing cloud/ IT infrastructure?

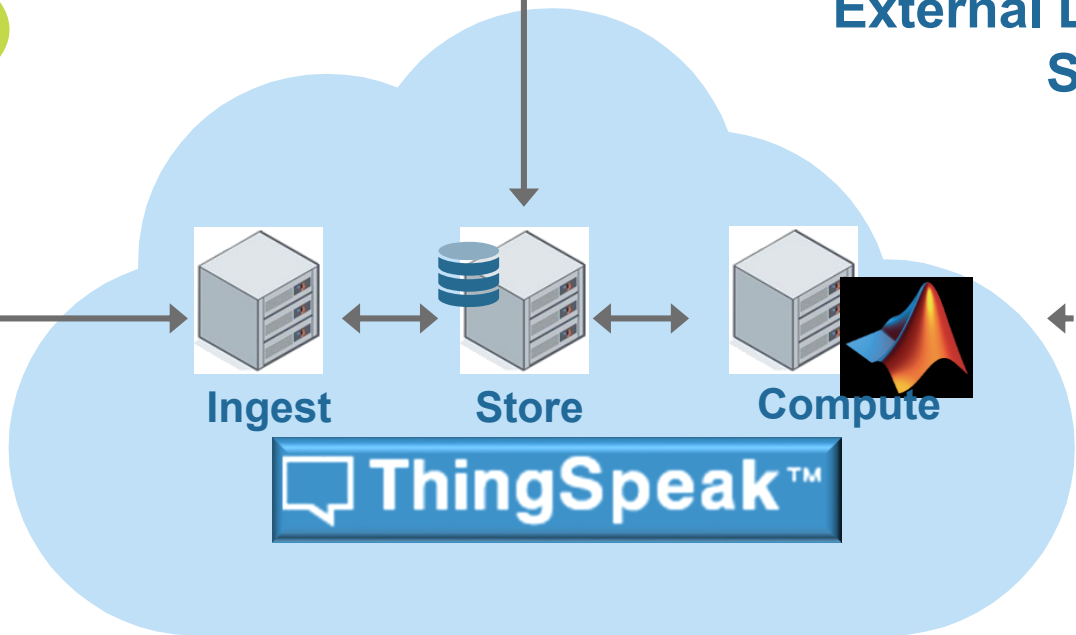


ThingSpeak for Small Scale Deployment

4. How can solution architects integrate engineering analytics into existing cloud/ IT infrastructure?



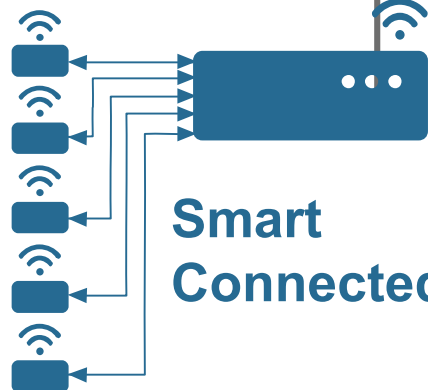
External Data & Business Systems



Deploy analytics To cloud



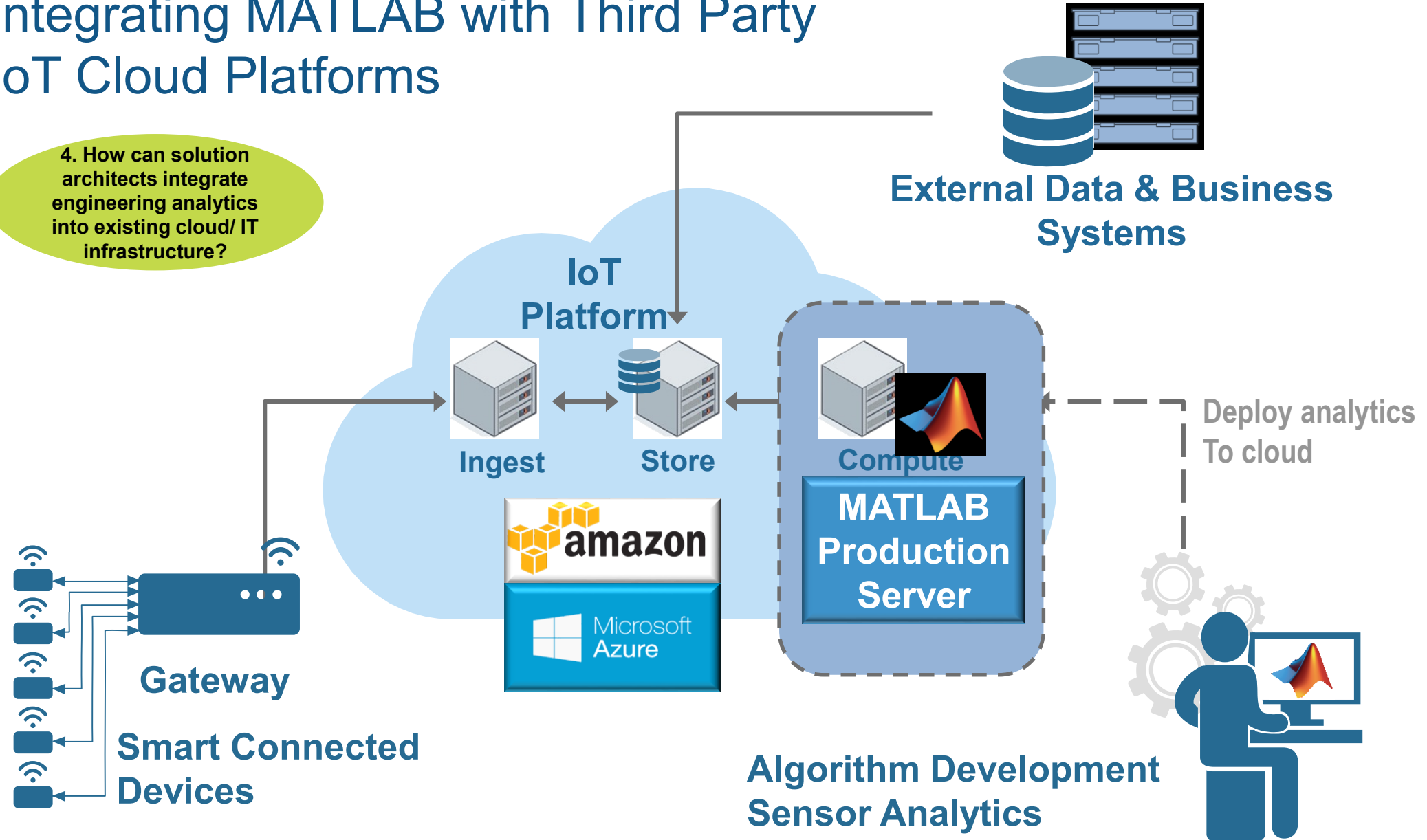
Algorithm Development
Sensor Analytics



Smart
Connected Devices

Integrating MATLAB with Third Party IoT Cloud Platforms

4. How can solution architects integrate engineering analytics into existing cloud/ IT infrastructure?



Summary

1. Use high-level functions and apps to develop AI
 - Enable quicker algorithm/model development
2. Automatically generate code for edge
 - Avoid double-implementation: reduce cost and avoid errors in recoding
 - Power your devices with AI
3. Prototype cloud analytics with ThingSpeak
 - Avoid cloud-architecting, use the same code as on desktop
4. Integrate with existing cloud systems using MATLAB Production Server
 - Avoid recoding, call MATLAB-functions as a service

Close the gaps
Unify workflows
Reduce time-to-market

What next?

- Contact us: antti.loytynoja@mathworks.com
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risto.kause@mathworks.com
- Learn more: <https://www.mathworks.com/solutions/internet-of-things.html>
<https://www.mathworks.com/solutions/machine-learning.html>
<https://bit.ly/2GwAJaJ> (webinar: sensor data analytics)

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Thank You