

# Edge computing AKA evolution of cloud computing

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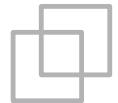
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Productive



Hybrid



Intelligent



Trusted

50 Azure regions





## Core infrastructure

Compute • Networking • Storage • Security • Identity

## Advanced workloads

Web	Media
Mobile	Analytics
Microservices	Databases
Containers	Internet of Things
Integration services	AI + Machine Learning

Azure Stack + Hybrid



# Open source support



Tools



Advanced workloads



Core infrastructure



Azure Stack + Hybrid

DevOps

**Nagios®**

Management



Applications

App frameworks  
and toolsDatabases and  
middleware

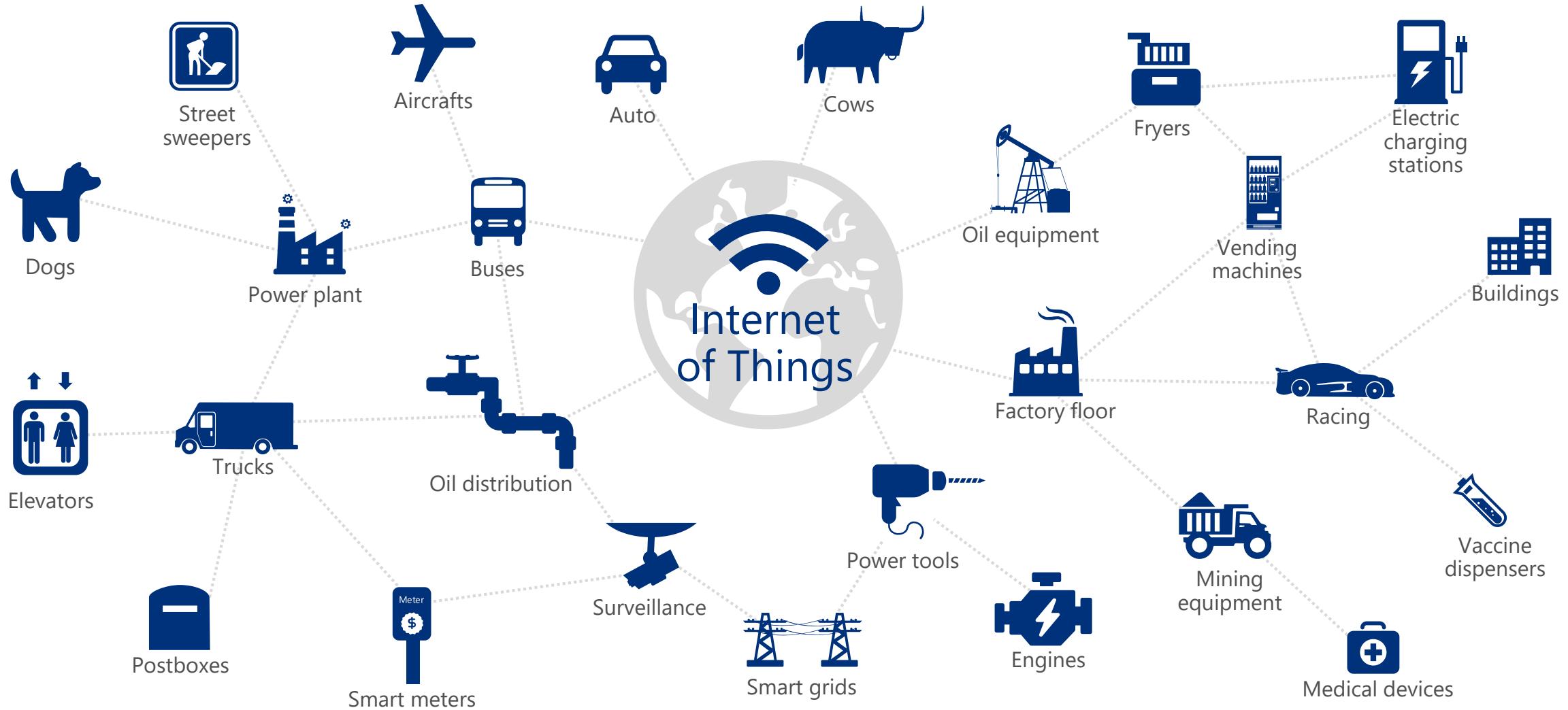
cloudera



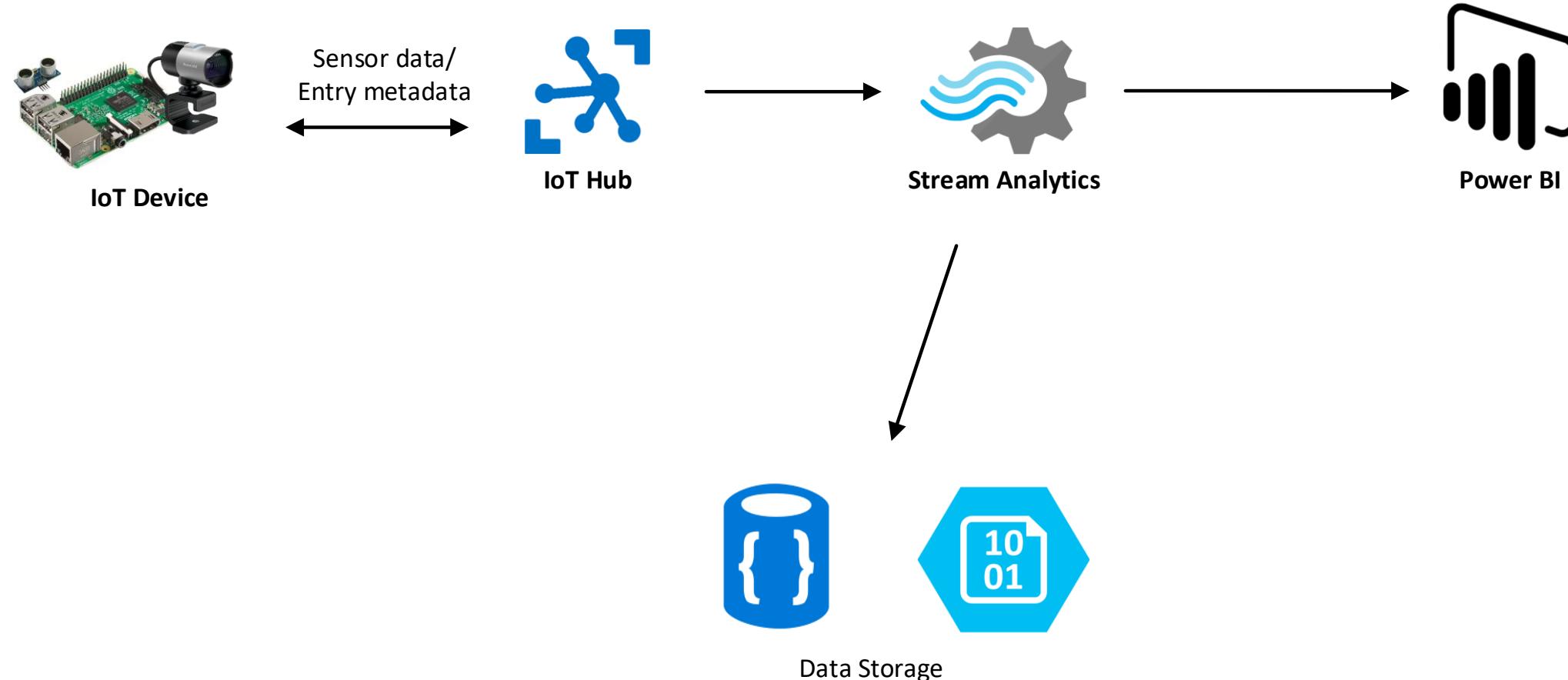
Infrastructure



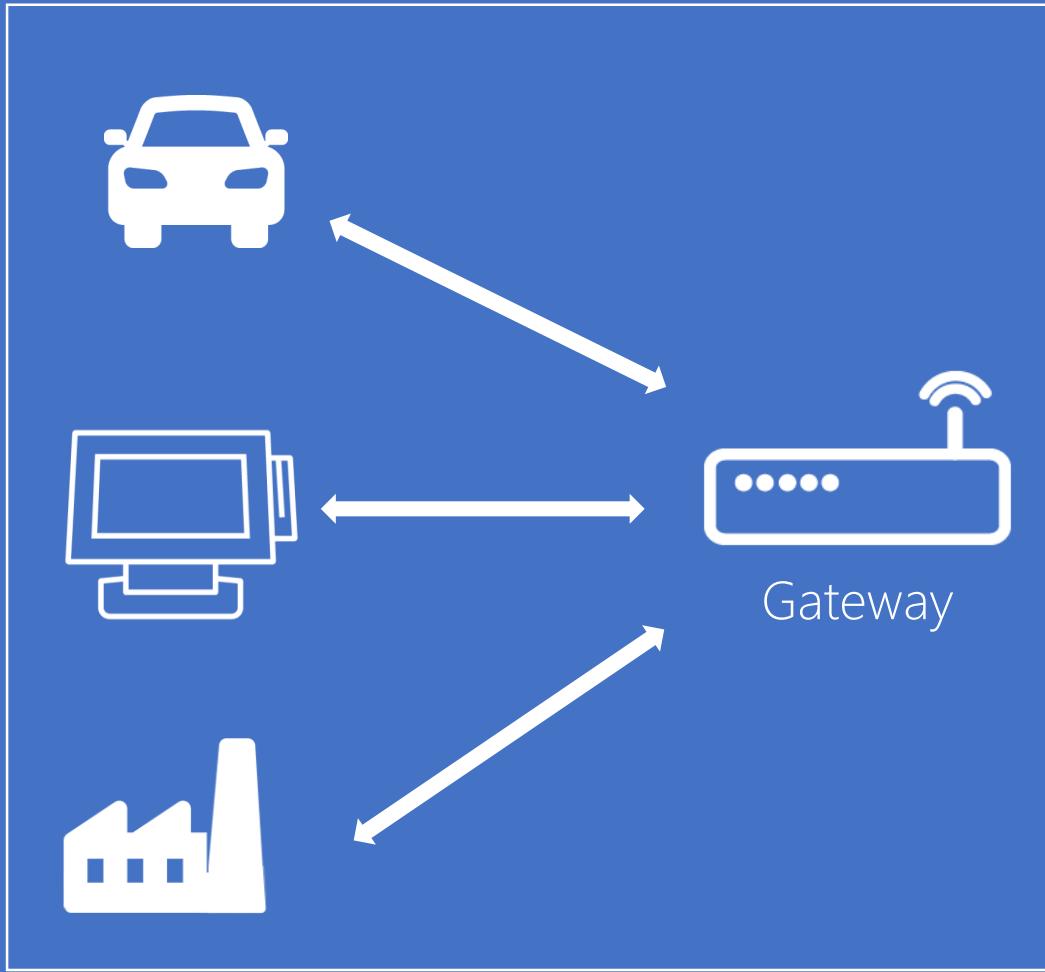
# Innovation at work – real world IoT use cases



# Data Ingress Data Processing Data Visualization

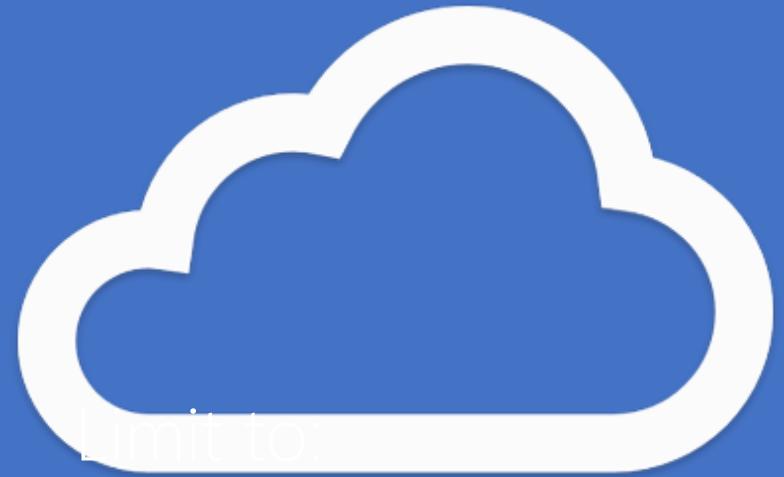


# Future of IoT – Edge Computing



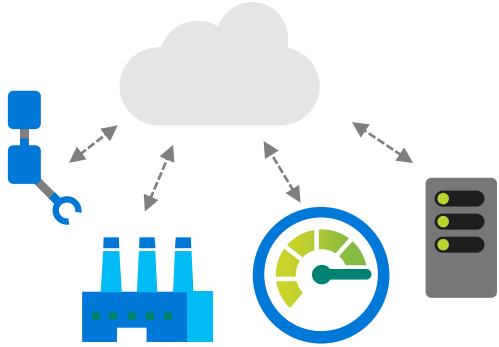
Edge Computing

Latency  
Costs  
Unused compute power  
Offline?



AI Model training  
Heavy data processing

# IoT in the Cloud and on the Edge

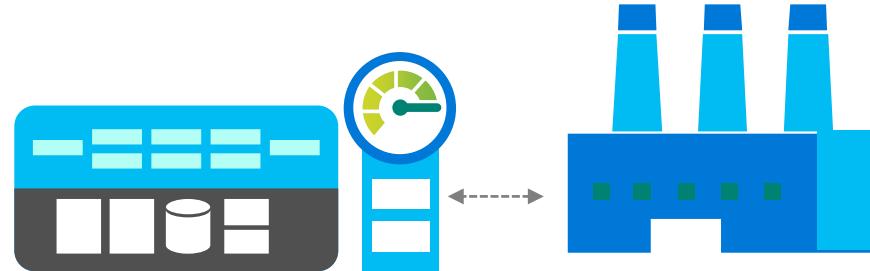


## IoT in the Cloud

Remote monitoring and management

Merging remote data from multiple IoT devices

Infinite compute and storage to train machine learning and other advanced AI tools



## IoT on the Edge

Low latency tight control loops require near real-time response

Protocol translation & data normalization

Privacy of data and protection of IP

Symmetry

# Operational patterns for Azure IoT Edge

- Protocol translation – Collect data using any protocol and translate to IoT friendly protocols (e.g. Modbus -> MQTT)
- On-prem data aggregation and analysis – Aggregate and save on bandwidth, cost, privacy, IP
- Offline – Short or long term
- Deploy intelligence at the edge – Azure Machine Learning and AI, Azure Stream Analytics, Functions, your own code



# Why Azure IoT Edge?

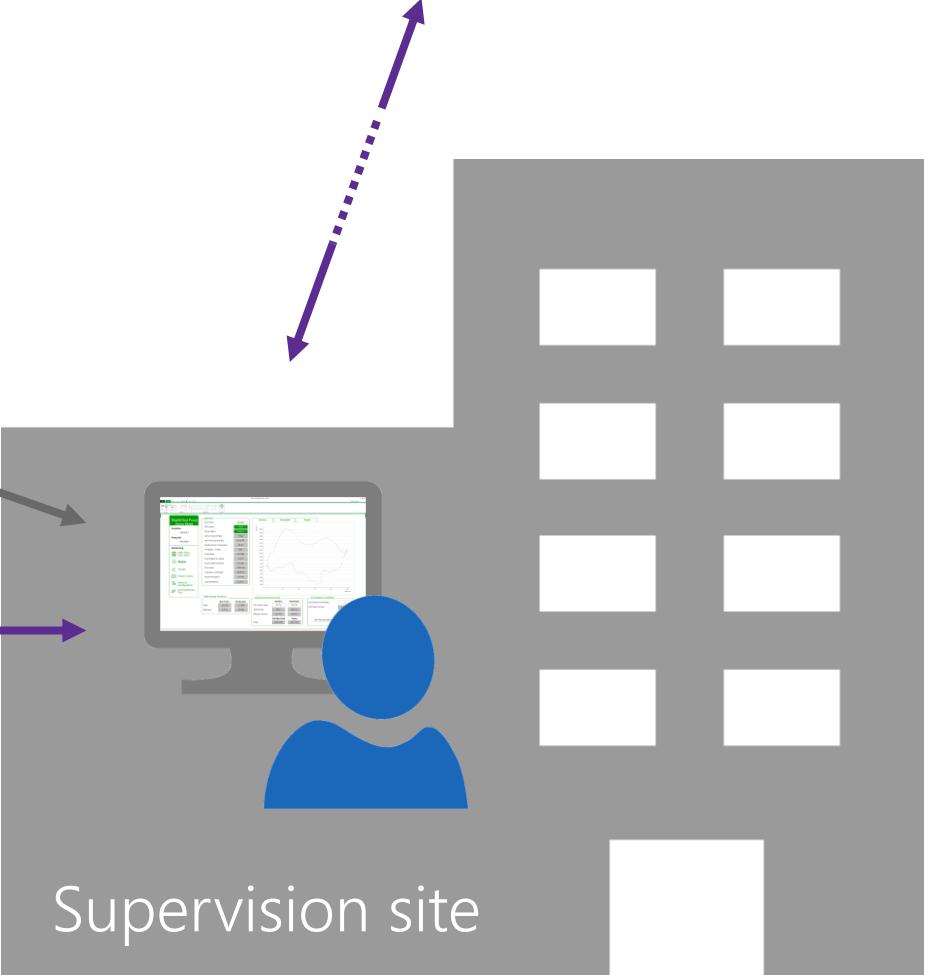


# Today's SCADA solution

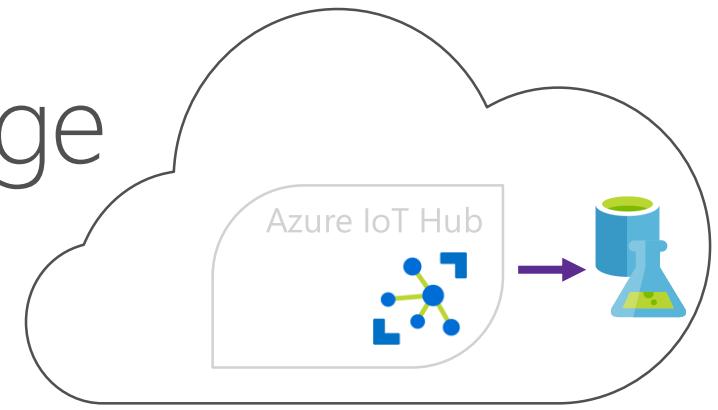
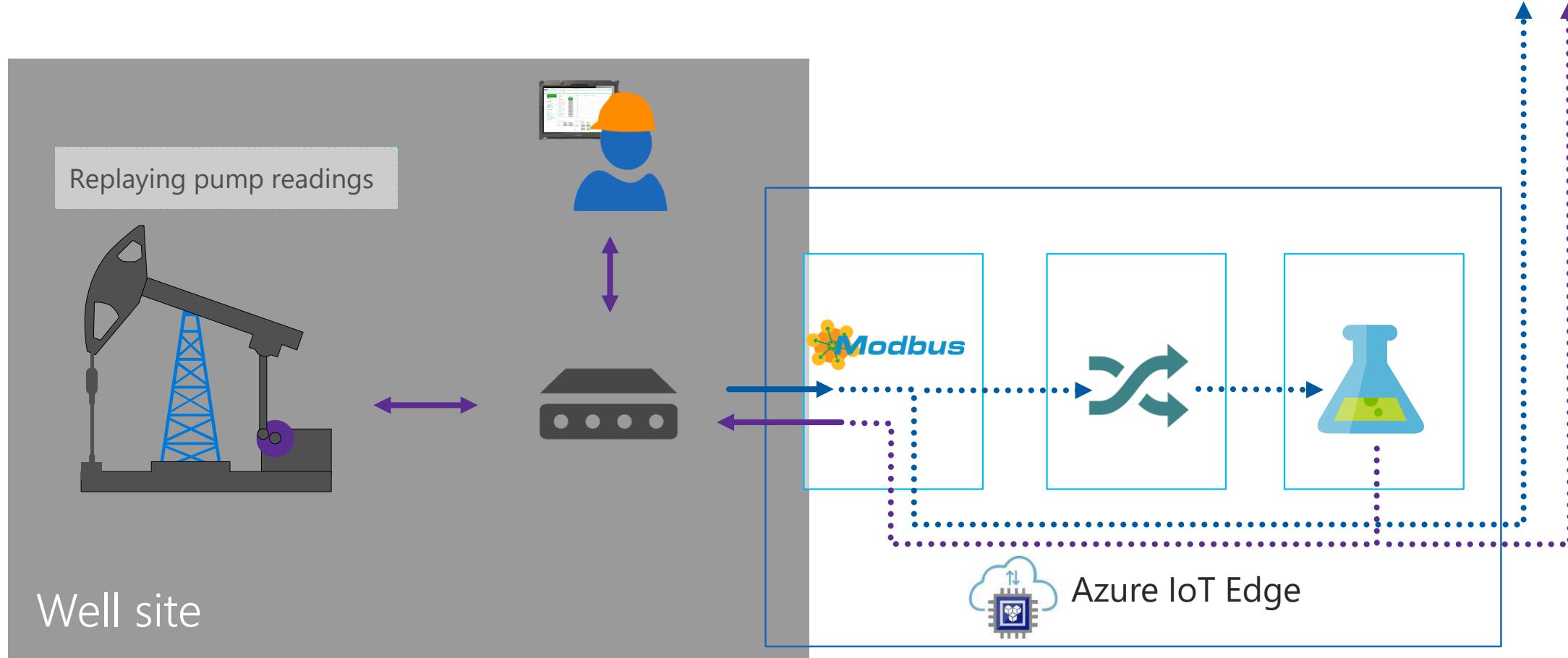


SMS/email alert

\$\$\$\$\$



# Example – Machine Learning on the Edge



# Design principles

## Secure

Provides a secure connection to the Azure IoT Edge, update software/firmware/configuration remotely, collect state and telemetry and monitor security of the device

## Cloud managed

Enables rich management of Azure IoT Edge from Azure provide a complete solution instead of just an SDK

## Cross-platform

Enables Azure IoT Edge to target the most popular edge operating systems, such as Windows and Linux

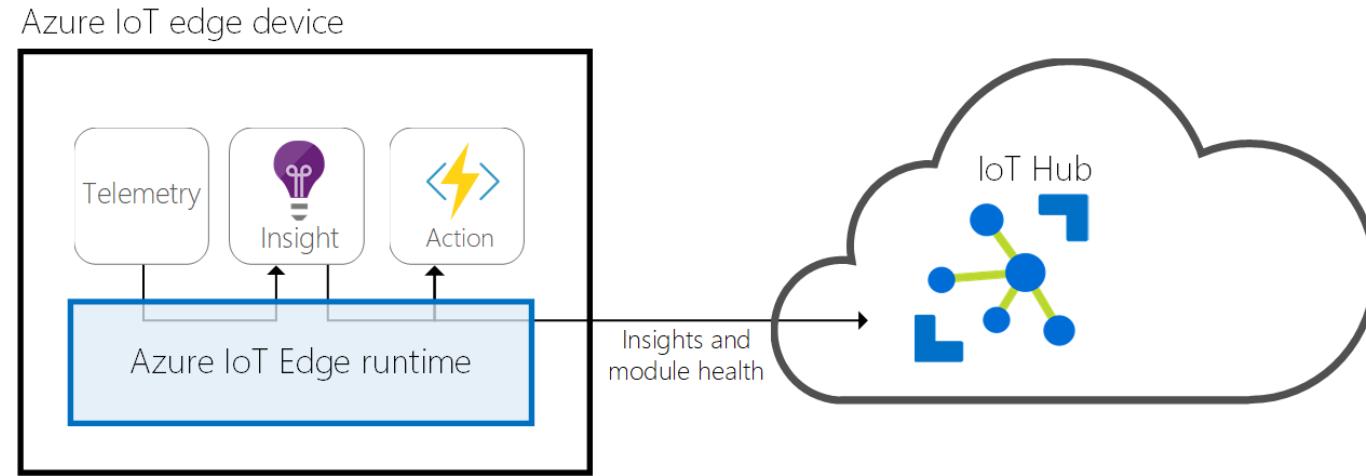
## Portable

Enables Dev/Test of edge workloads in the cloud with later deployment to the edge as part of a continuous integration / continuous deployment pipeline

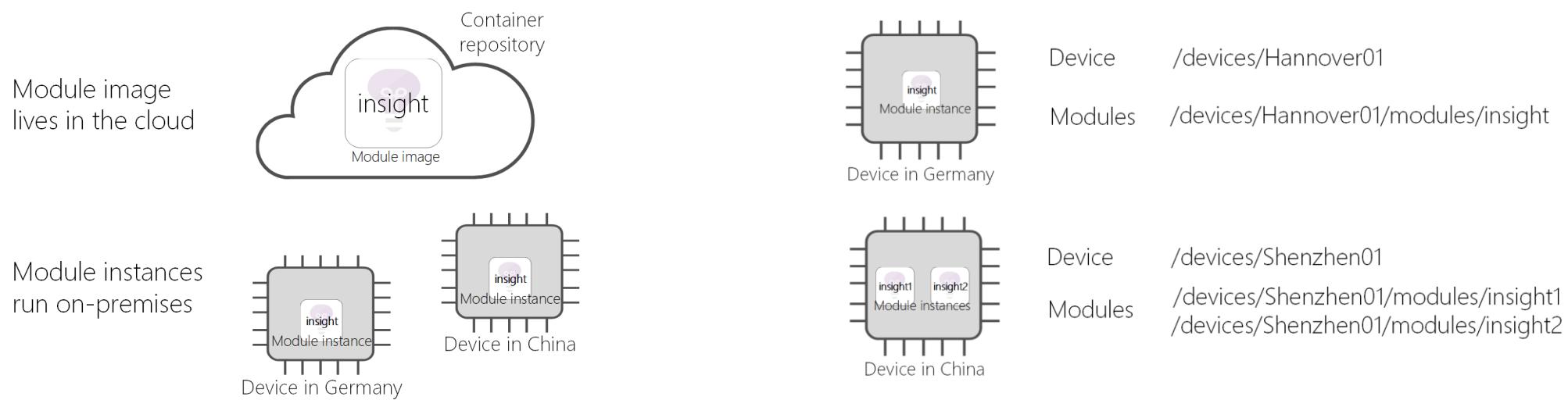
## Extensible

Enables seamless deployment of advanced capabilities such as AI from Microsoft, and any third party, today and tomorrow

# Azure IoT Edge Concepts

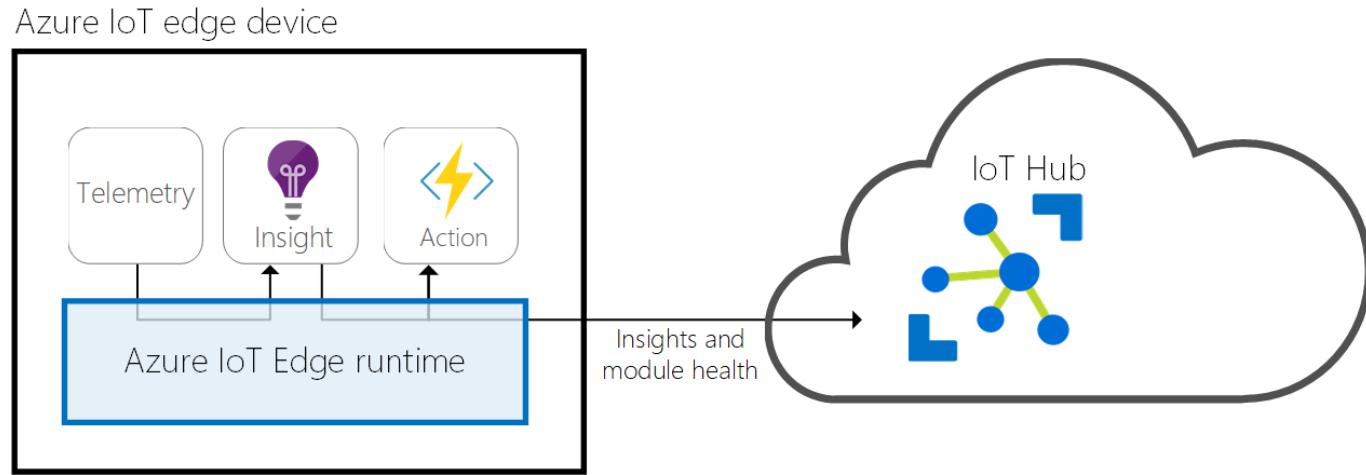


# Concept – Module



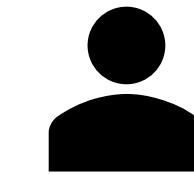
- A **module image** is a package containing the software that defines a module.
- A **module instance** is the specific unit of computation running the module image on an IoT Edge device. The module instance is started by the IoT Edge runtime.
- A **module identity** is a piece of information (including security credentials) stored in IoT Hub, that is associated to each module instance.
- A **module twin** is a JSON document stored in IoT Hub, that contains state information for a module instance, including metadata, configurations, and conditions.

# Concept – Azure IoT Edge Runtime

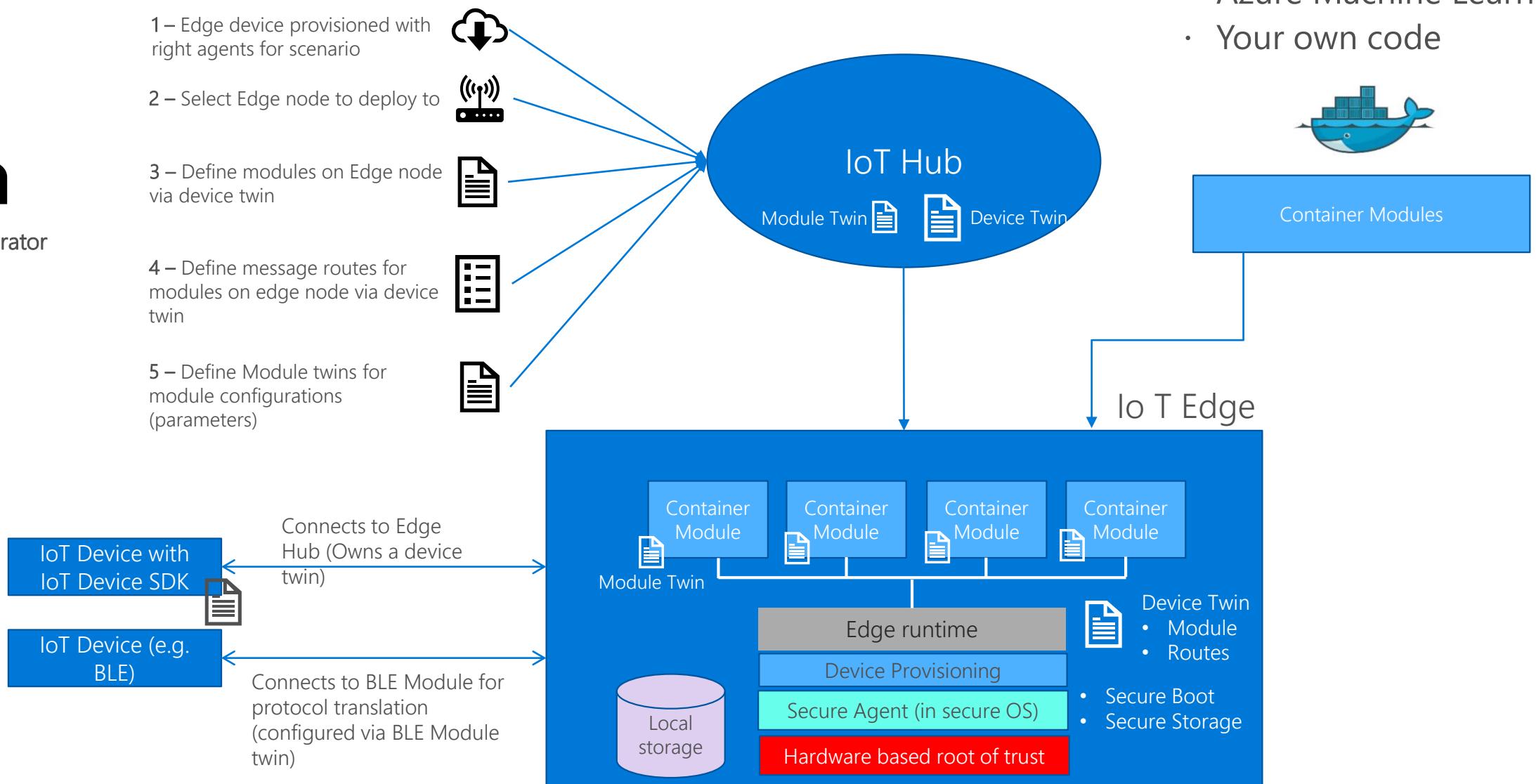


- Installs and updates workloads on the device.
- Maintains Azure IoT Edge security standards on the device.
- Ensures that IoT Edge modules are always running.
- Reports module health to the cloud for remote monitoring.
- Facilitates communication between downstream leaf devices and the IoT Edge device.
- Facilitates communication between modules on the IoT Edge device.
- Facilitates communication between the IoT Edge device and the cloud

# IoT Edge in action

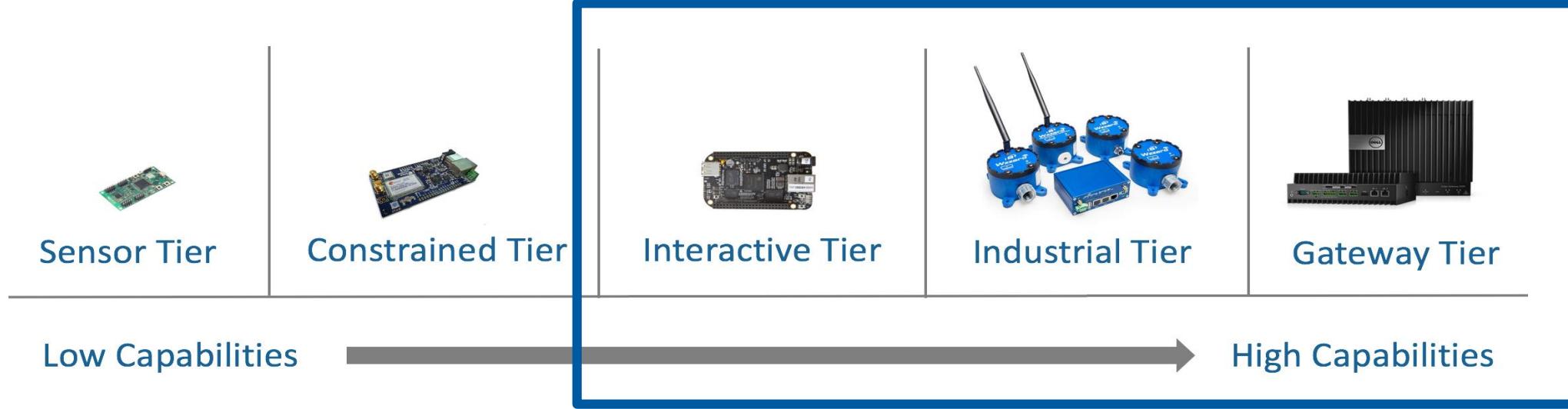


IoT Edge operator



- Container based workloads
- Azure Functions
- Azure Stream Analytics
- Azure Machine Learning
- Your own code

# Hardware for Azure IoT Edge



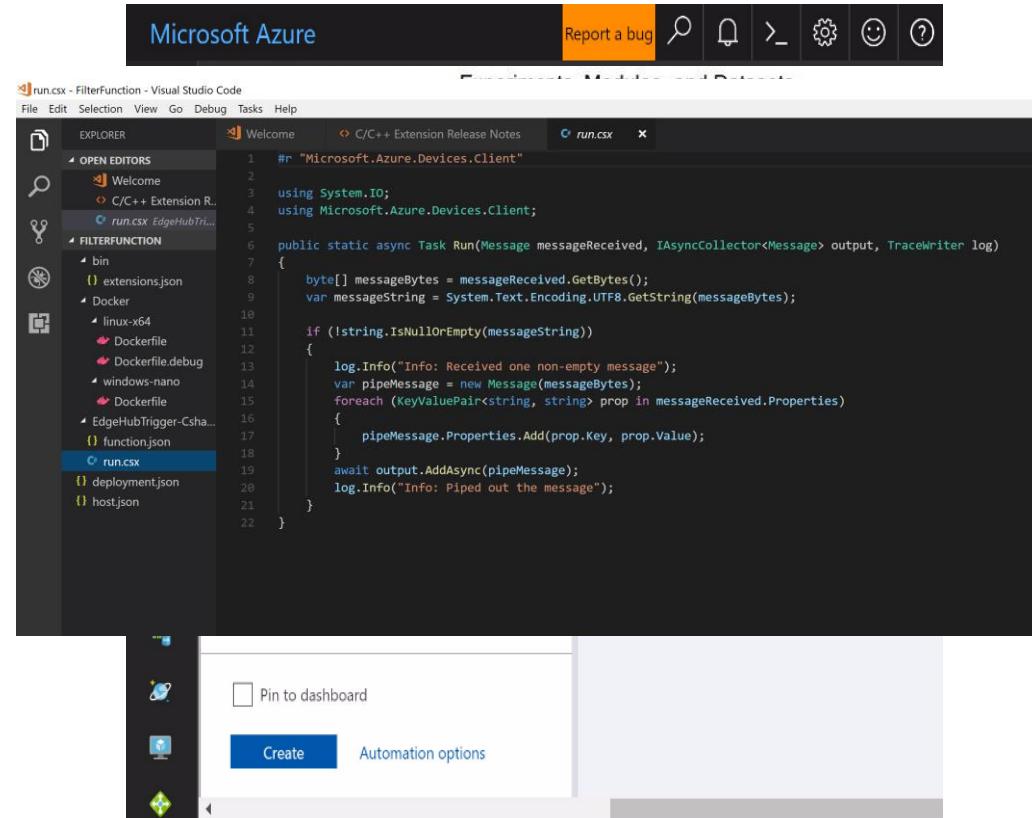
Linux and Windows supported on x64 and ARM (support for containers required)

Hardware sizing dependent on workloads

Internal tests on devices as small as Raspberry Pi 3 with four containers (on Linux)

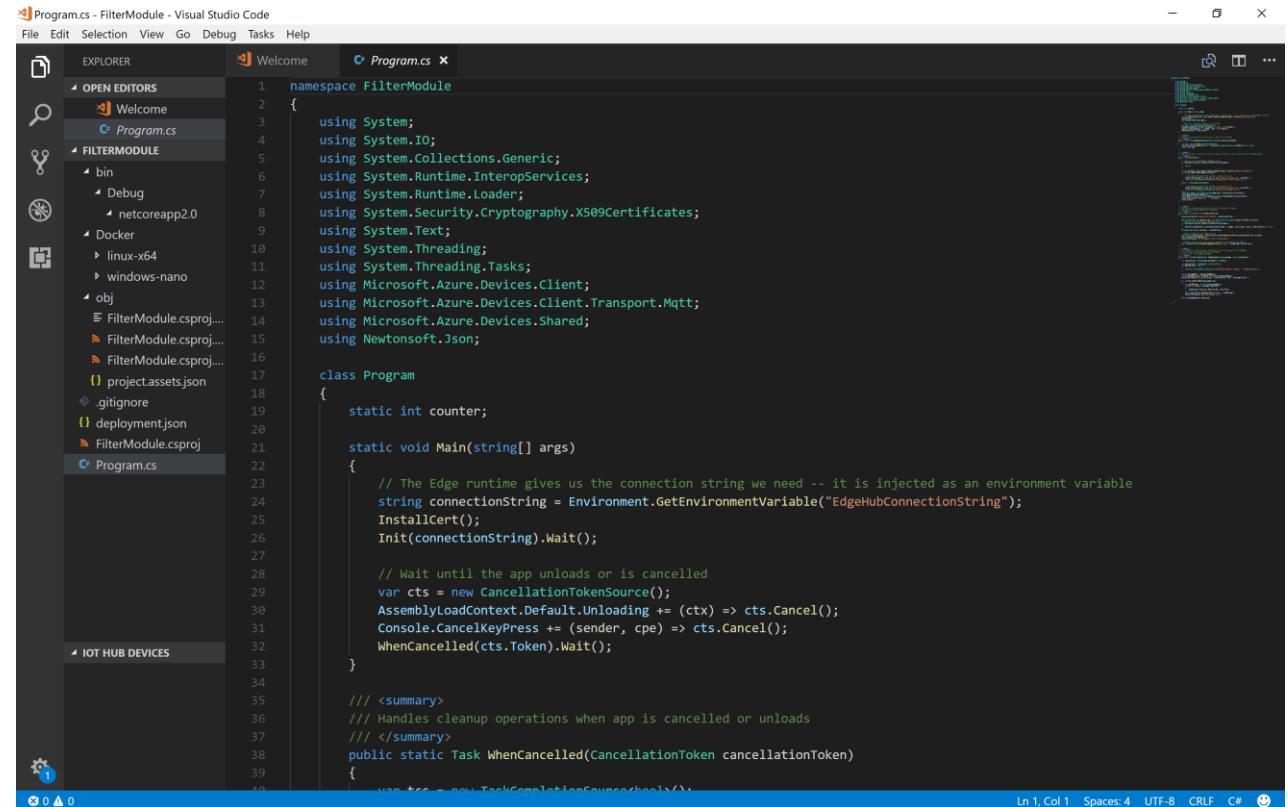
# Azure IoT Edge – Package services in containers

- Azure Stream Analytics – In line experience in the ASA web portal
- Azure Functions – Use VSCode to develop Function for your scenario and package as a container
- AI and Azure Machine Learning – Package AI and ML model as a module in a container after training using ML Studio. Deploy packaged ML modules to the IoT Edge



# Azure IoT Edge – Developer experience

- Azure IoT SDK for developing modules, which provide:
  - Protocol and messaging support
  - Security for module (identification and authentication)
  - Module twin support
- Develop and debug in your favorite language (C# released, C, Python, Java and Node.JS coming soon)
- Build container with your code and host in a container repo (e.g. Docker Hub or Azure Container Registry)



The screenshot shows the Visual Studio Code interface with the following details:

- Title Bar:** Program.cs - FilterModule - Visual Studio Code
- File Menu:** File Edit Selection View Go Debug Tasks Help
- Explorer View:** Shows the project structure under FILTERMODULE:
  - bin
  - Debug
  - Docker
    - linux-x64
    - windows-nano
  - obj
  - FilterModule.csproj...
  - FilterModule.csproj...
  - FilterModule.csproj...
  - project.json
  - .gitignore
  - deployment.json
  - FilterModule.csproj
- Program.cs View:** Displays the C# code for the module.

```
namespace FilterModule
{
    using System;
    using System.IO;
    using System.Collections.Generic;
    using System.Runtime.InteropServices;
    using System.Security.Cryptography.X509Certificates;
    using System.Text;
    using System.Threading;
    using System.Threading.Tasks;
    using Microsoft.Azure.Devices.Client;
    using Microsoft.Azure.Devices.Client.Transport.Mqtt;
    using Microsoft.Azure.Devices.Shared;
    using Newtonsoft.Json;

    class Program
    {
        static int counter;

        static void Main(string[] args)
        {
            // The Edge runtime gives us the connection string we need -- it is injected as an environment variable
            string connectionString = Environment.GetEnvironmentVariable("EdgeHubConnectionString");
            InstallCert();
            Init(connectionString).Wait();

            // Wait until the app unloads or is cancelled
            var cts = new CancellationTokenSource();
            AssemblyLoadContext.Default.Unloading += (ctx) => cts.Cancel();
            Console.CancelKeyPress += (sender, cpe) => cts.Cancel();
            WhenCancelled(cts.Token).Wait();
        }

        /// <summary>
        /// Handles cleanup operations when app is cancelled or unloads
        /// </summary>
        public static Task WhenCancelled(CancellationToken cancellationToken)
        {
            return Task.CompletedTask;
        }
    }
}
```
- IOT HUB DEVICES View:** Shows a single device entry.

# Health Checkup with IoT Edge

Concept of cognitive health care platform which focuses on monitoring of quality of healthcare services using IoT and advanced data analysis

- Functional also during internet connection outage
- Effective HW utilization for data processing
- Lower costs related do data collection and processing



# EDGE-ENABLED FRAMEWORK PRE MONITOROVANIE KVALITY ZDRAVOTNEJ STAROSTLIVOSTI

Dizertačná práca

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Katedra kybernetiky a umelej inteligencie, FEI, TUKE, Slovenská republika

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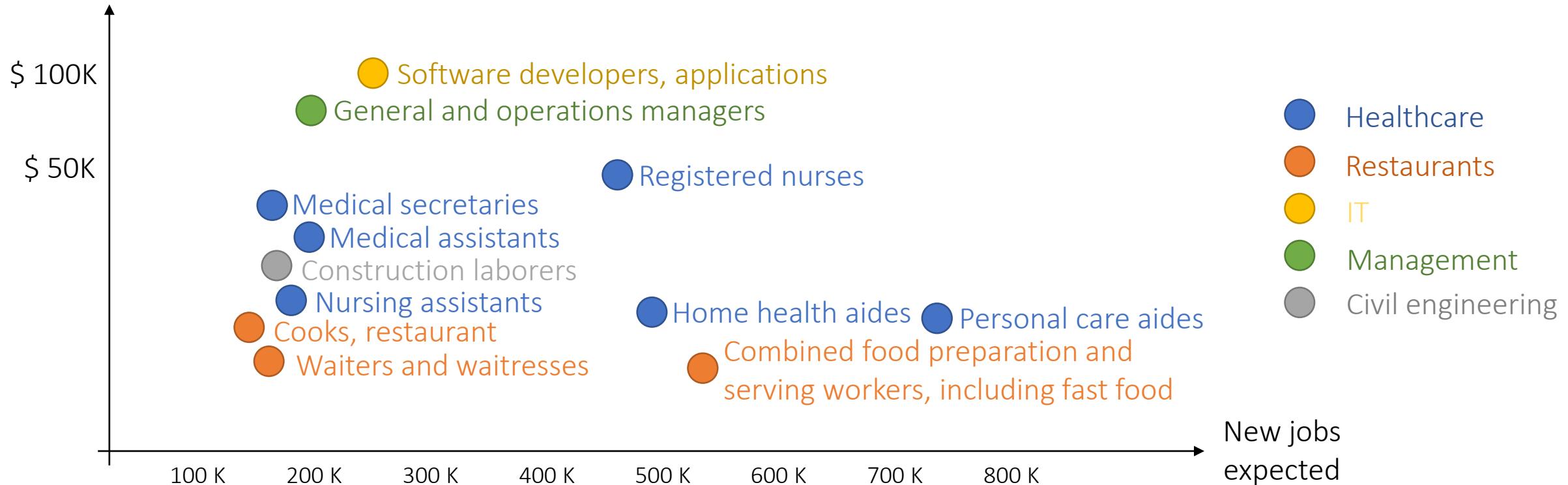
Prezentácia k obhajobe dizertačnej práce



# Motivácia - Zdravotníctvo a IoT technológie

Median wage

Jobs expected in the US in the next 20 years \*Bureau of Labor Statistics, USA



Chance of being automated in the next 20 years \*Oxford University, UK



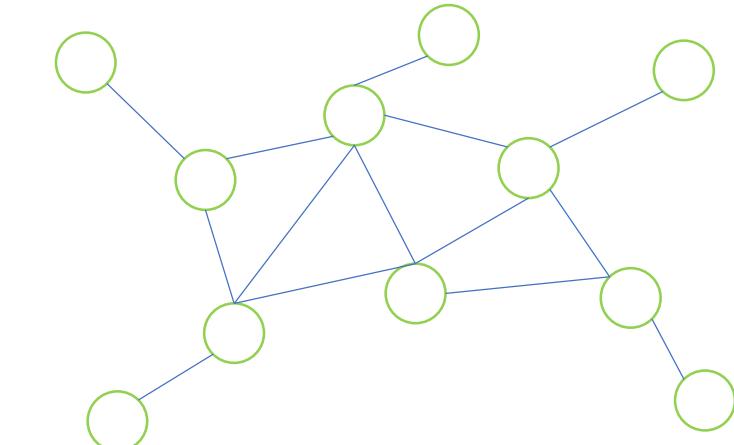
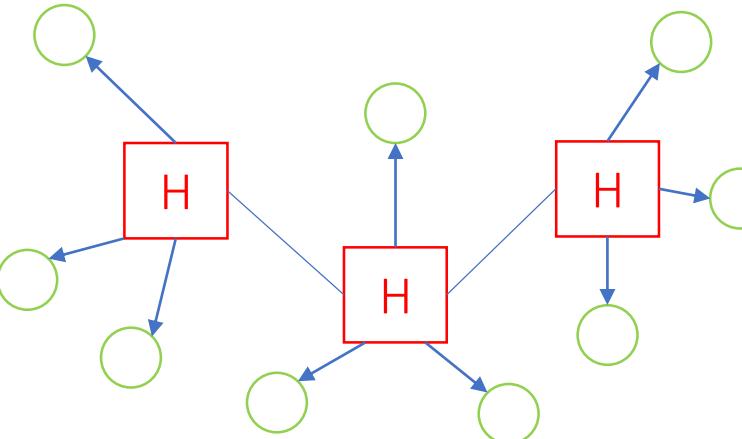
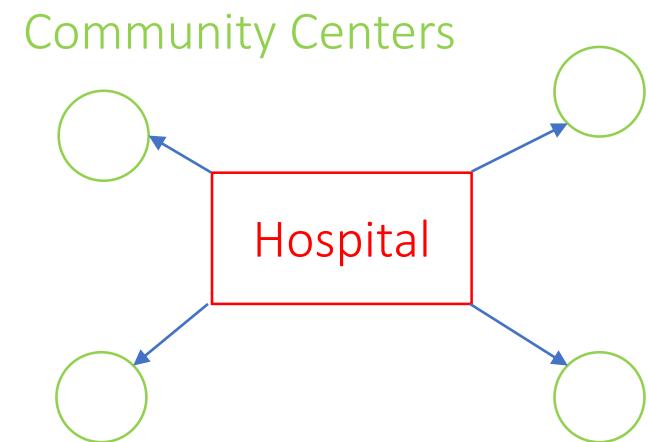
Surgeons  
0.4%  
Healthcare  
Social  
Workers  
0.5%  
Nurses  
0.9%  
Composers  
1.5%

Real estate  
brokers  
98%  
Telemarketers  
99%

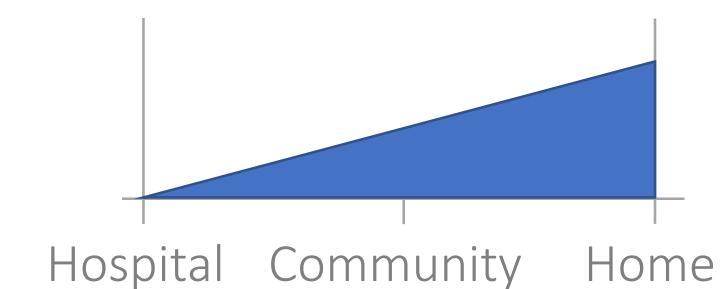
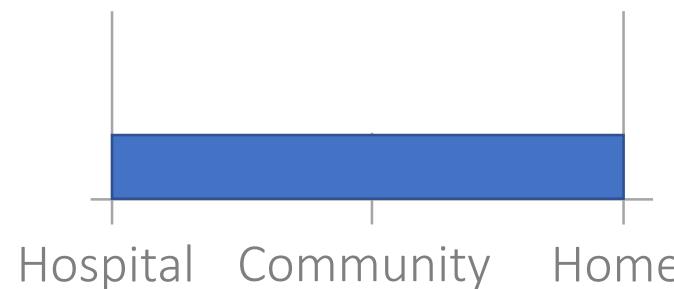
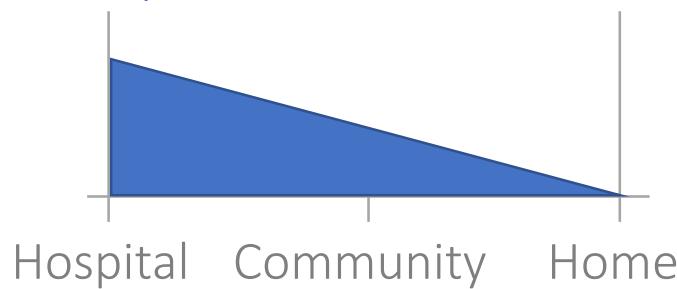


# Motivácia - Zdravotníctvo a IoT technológie

\* Future Delivery of Health Care: Cybercare



Responsibilities



Hospital-Centered

Today

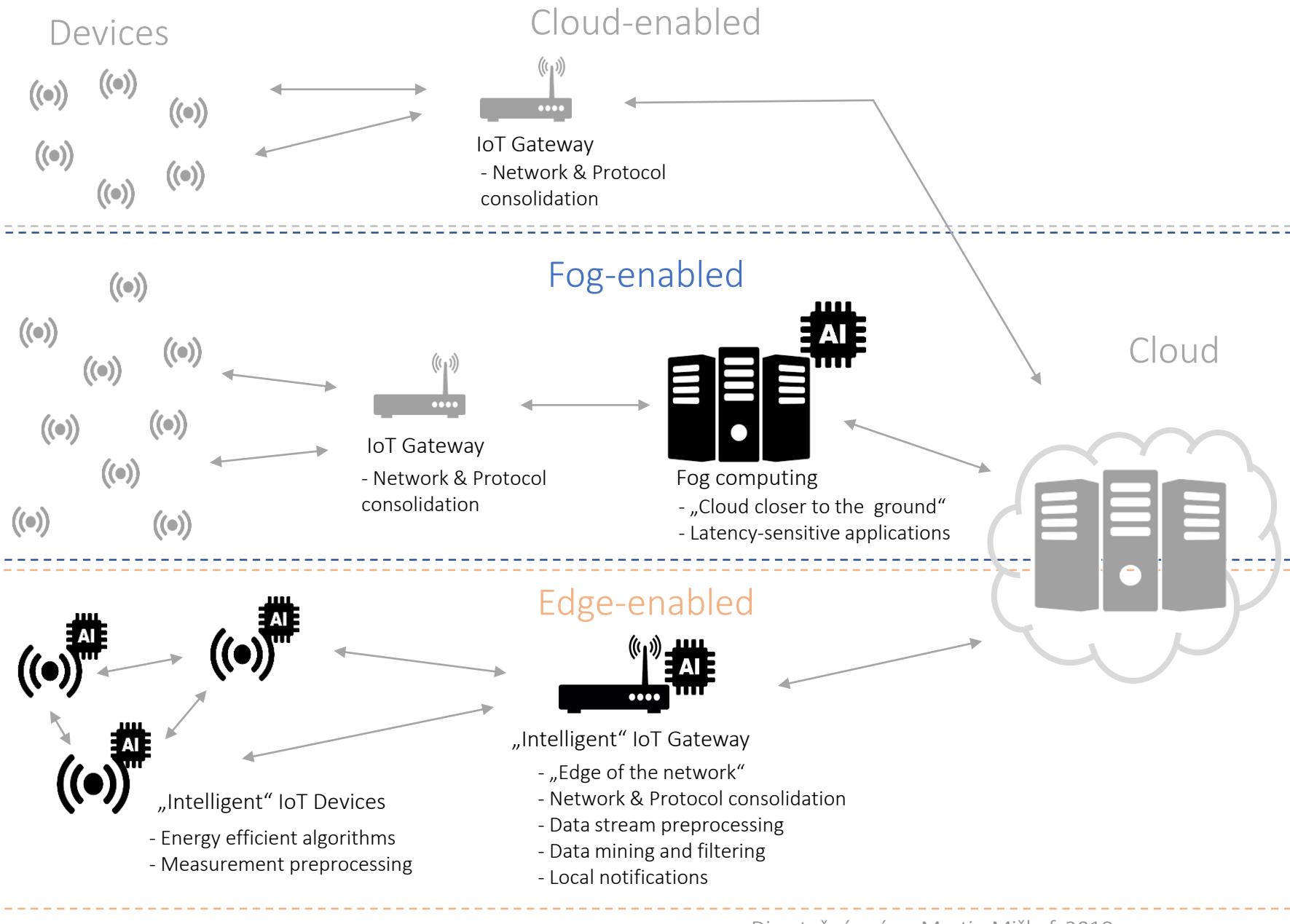
Hospital-Home-Balanced

2020

Home-Centered

2030

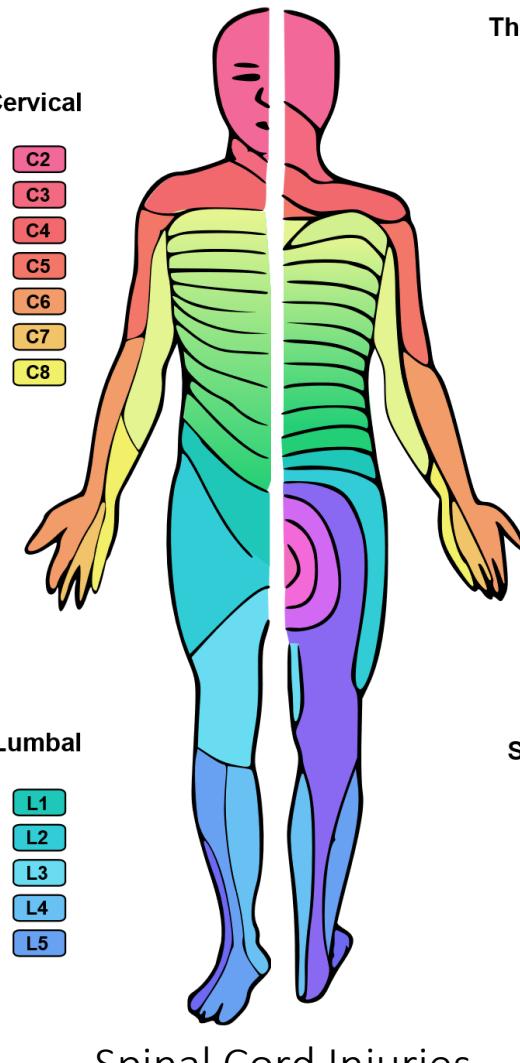
# Moderné spôsoby implementácie IoT riešení



Distribúcia inteligencie v rámci IoT riešenia

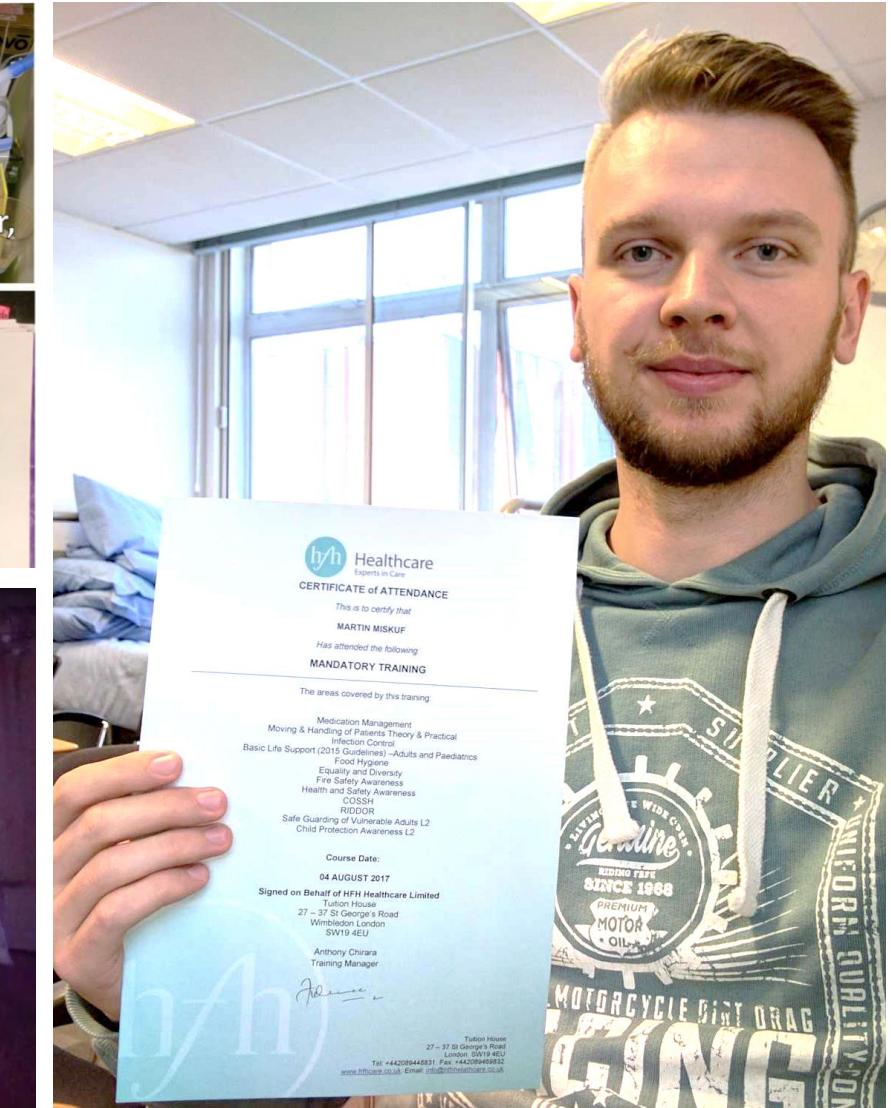
- **Cloud-enabled**
  - Škálovateľnosť
- **Fog-enabled**
  - „Mrak (Cloud) pri zemi“
  - Pojem - Cisco 2015
  - Private / Hybrid cloud
  - Väčšie IoT riešenia
- **Edge-enabled**
  - Koncové zariadenia „hrana siete“
  - Pojem – 90. roky
  - Menšie IoT riešenia

# Home-centered healthcare system certifikácia, pozorovania a skúsenosti

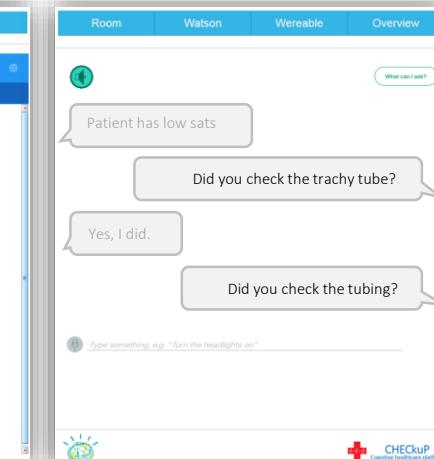
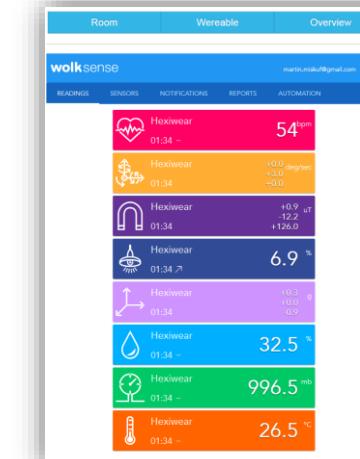
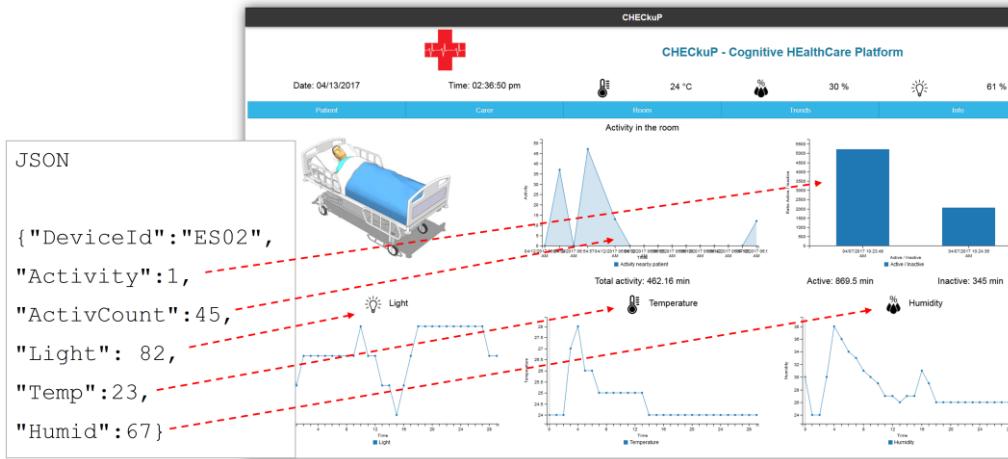


Thoracal

- Th1
- Th2
- Th3
- Th4
- Th5
- Th6
- Th7
- Th8
- Th9
- Th10
- Th11
- Th12



# Prípadová štúdia CHECkuP – Cognitive HHealthCare Platform



Cognitive Expert Advisor

Real-time visualizations & analytics



Edge-enabled  
IoT Gateway

Advanced data analytics  
healthcare data classification  
anomaly detection

EMG & Gyroscope data  
(Patient Fall Simulation)



CHECkuP Devices



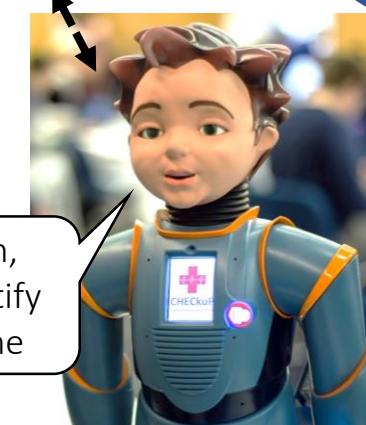
←



Myo Armband



Hold on,  
I will notify  
someone



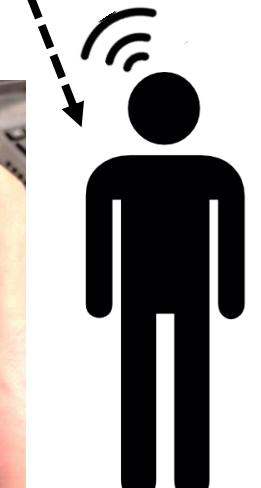
Robokind



Wearables



Cognitive  
services



Caregiver 4.0

# Prípadová štúdia CHECkuP – Cognitive HHealthCare Platform

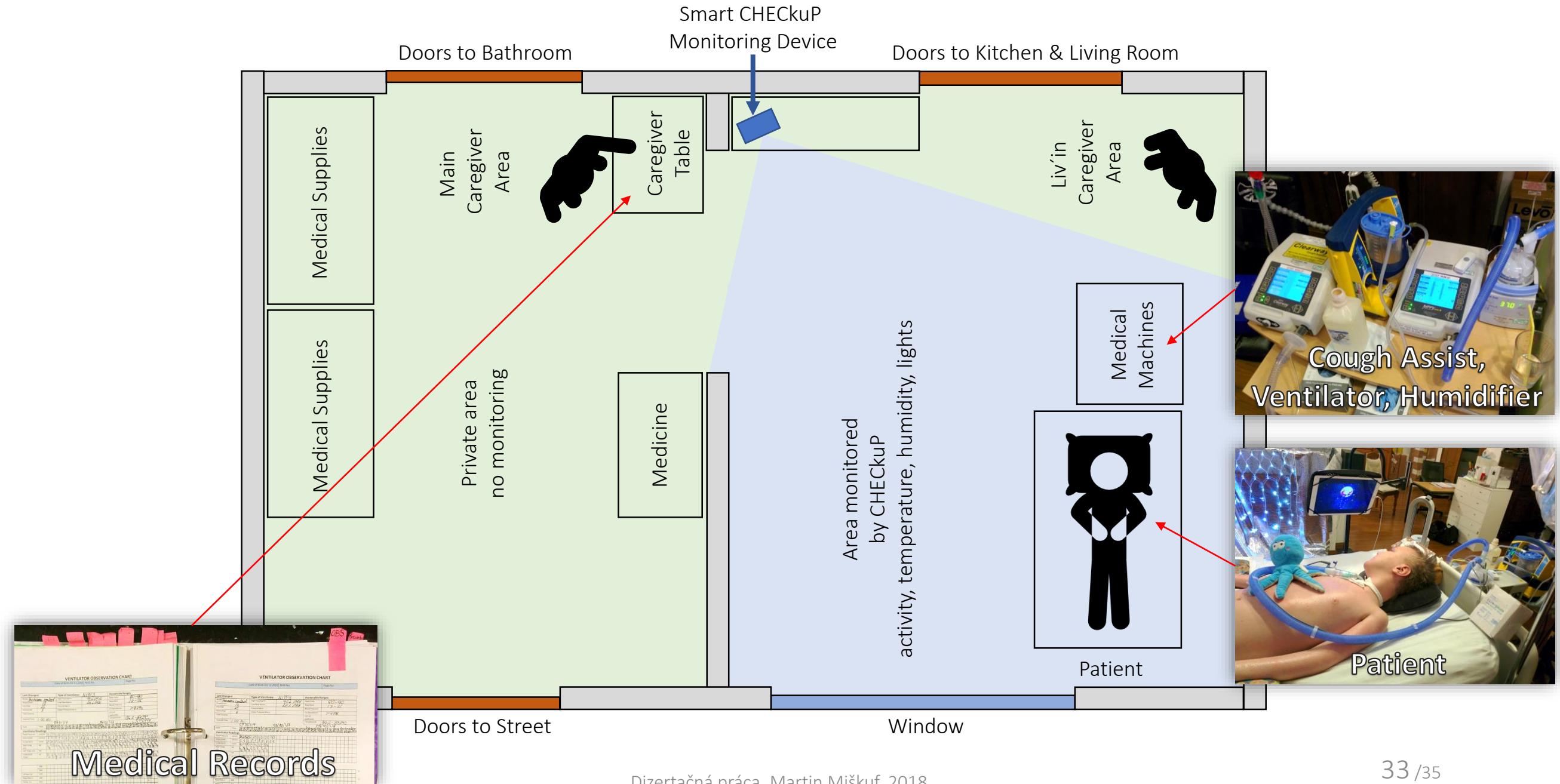


Edge-enabled IoT  
riešenie pre  
monitorovanie  
kvality zdravotnej  
starostlivosti

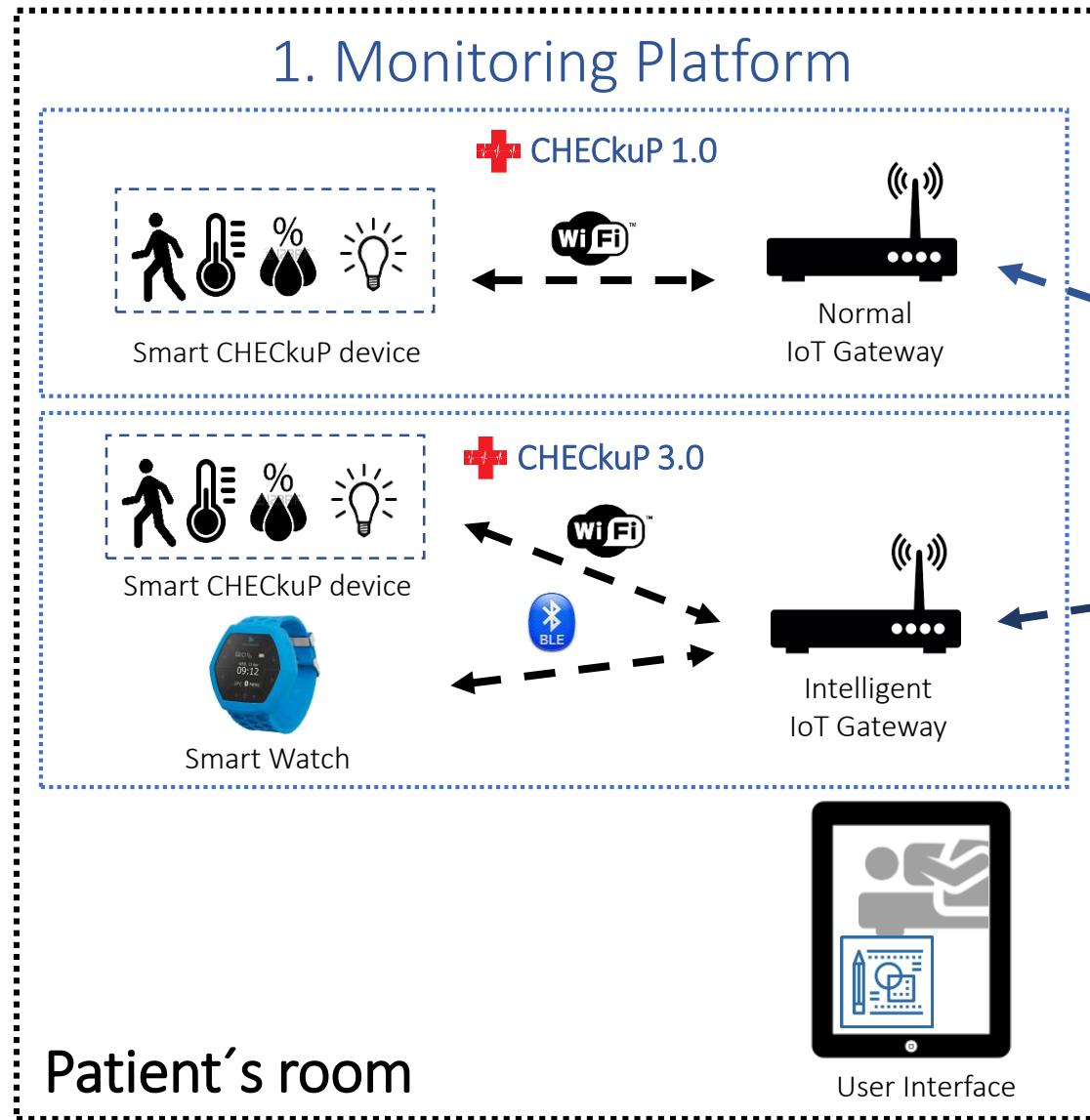
- IoT zariadenia
- Cognitive služby
- Pokročilá dátová analytika



# Testovanie CHECkuP v reálnych podmienkach

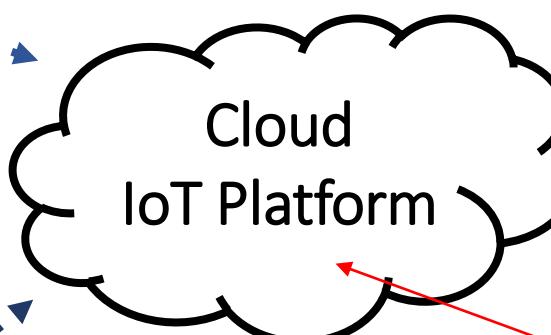


# Architektúra CHECkuP počas testovania



1. Generation of CHECkuP Monitoring  
3. Generation of CHECkuP Monitoring & Cognitive Expert Advisor

2. Web Portal

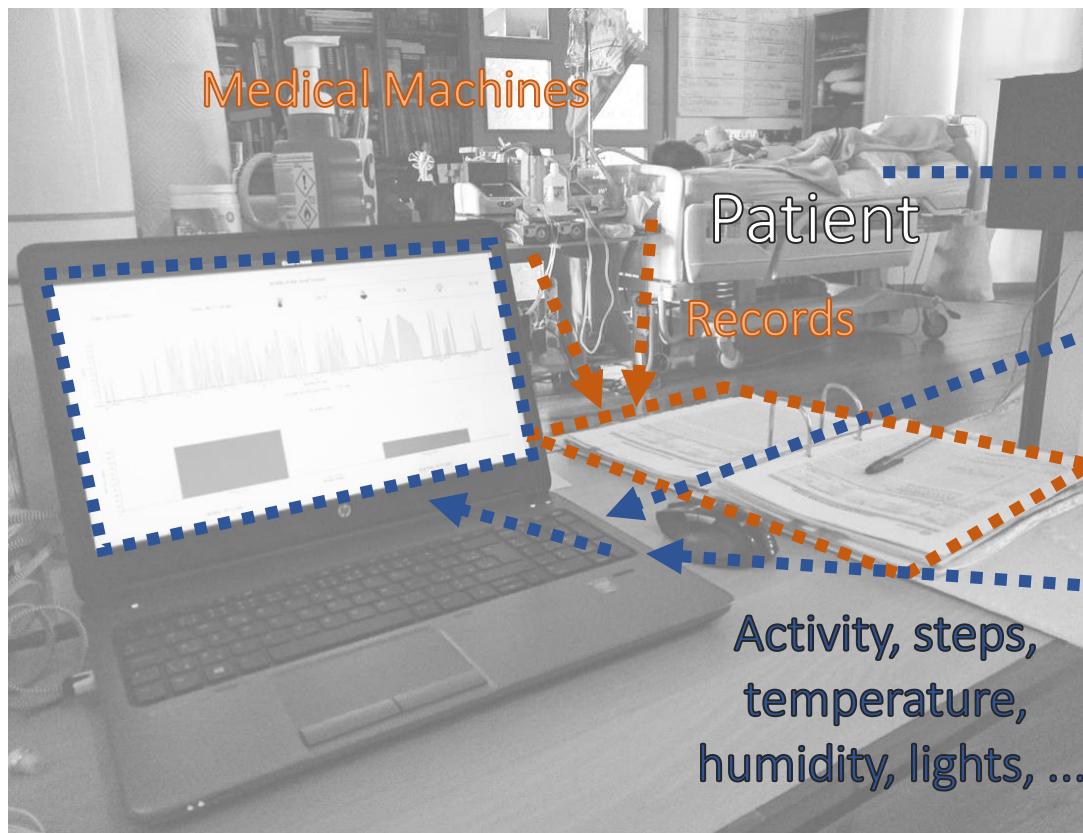


\* AFD: Healthcare Data Classification – Cloud-based Architecture Concept

\* AFD: Edge-enabled Platform for Monitoring Quality of Healthcare in Home Environment

\* ADF: Systematický vývoj Edge-enabled Rámca pre Monitorovanie Kvality Zdravotnej Starostlivosti

# Testovanie CHEKuP v reálnych podmienkach

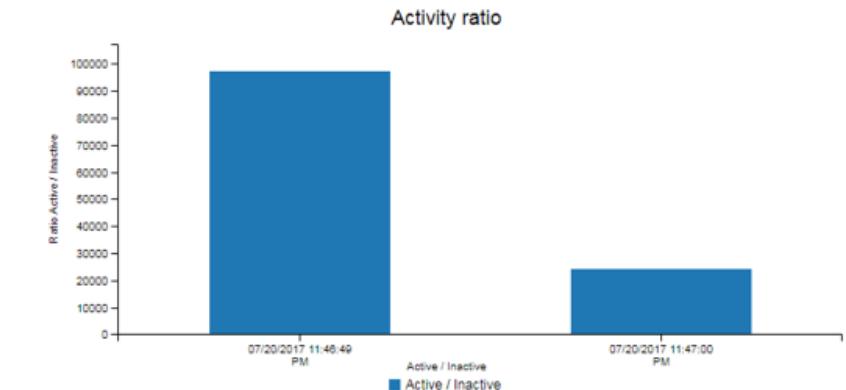


CHEKuP IoT Portal



CHEKuP Devices  
Monitoring activity

Activity ratio after 2 weeks

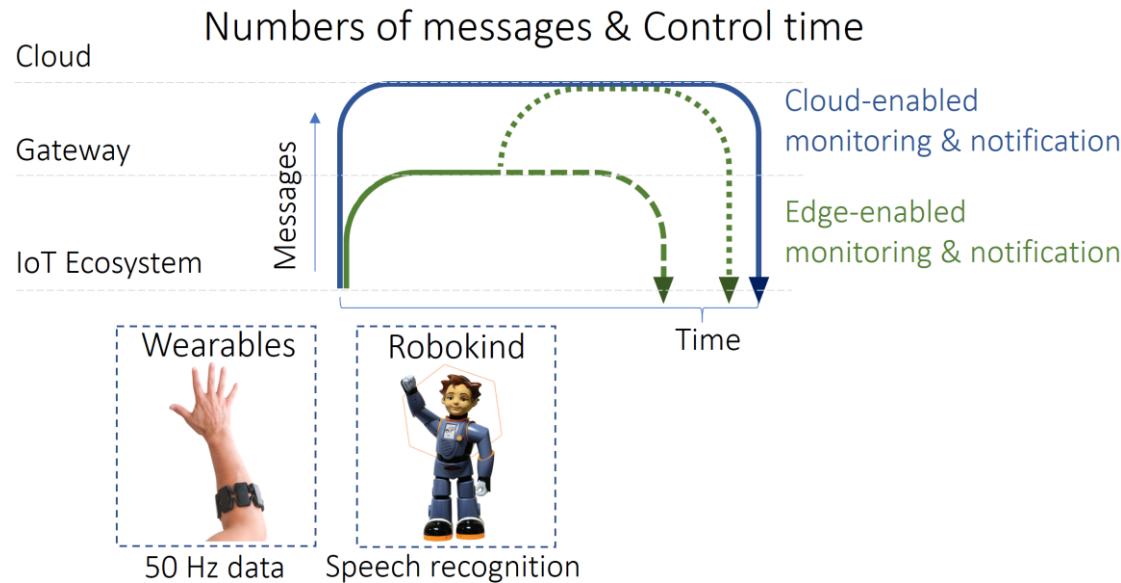


Inactive: 16219.83 min Active: 4052.33 min

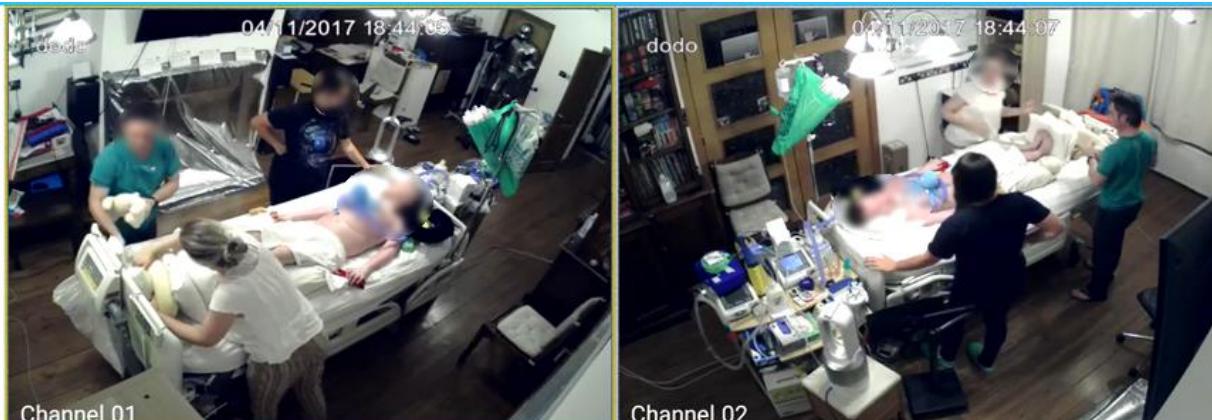


# Vyhodnotenie implementácie princípov Edge-enabled rámca

## Experiments



## Prípadová štúdia



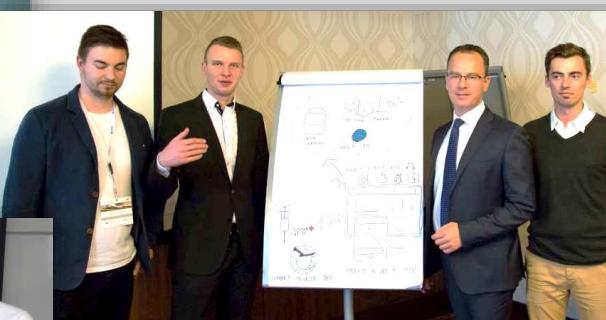
	Cloud-enabled	Edge-enabled
Approx. Trasfered data	100 %	20 %
Approx. Notification time	5 s	2 s
Cloud costs	higher	lower
Data security	lower	higher

## Monitorovanie kvality zdravotnej starostlivosti

- Aplikovanie najnovších princípov IoT
- Aplikovanie najnovších metód analýzy dát a strojového učenia Cognitive expert advisor
- Zniženie počtu kritických situácií



IBM Hackathon



Cisco Creathon



BEST + IBM  
Winter course



FPT Summer school

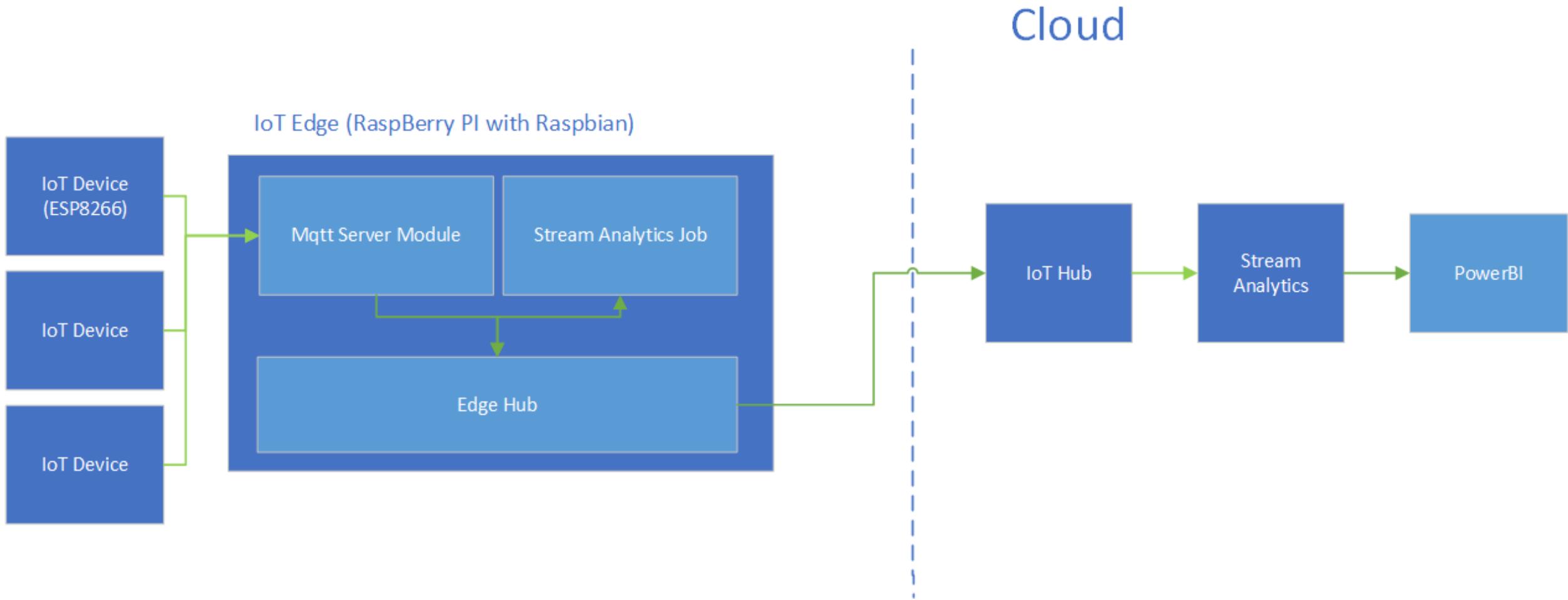
## Projekty

- Nadácia Tatrabanky
  - E-talent, IoT Net Take your knowledge to the Edge, 2017 (4000 €)
  - Business Idea, Enterprise IoT Net, 2017 (consultations)
  - Študenti do sveta, Výskumný pobyt University of Auckland, 2017 (2500 €)
- FEI grant, TUKE, CHECkuP, 2016 (2000 €)
- Microsoft Azure Research Award (Cloud services 2x 10 000 €)
- IBM Country Project (Cloud services, Pilot IoT Laboratory)

## StartUp súťaže

- ✓ IBM Hackathon, 2017, Bratislava
- AT&T Hackathon, 2017, Brno, Česká Republika
- ✓ Startup Centrum TUKE, 2017, Košice
- ✓ BEST a IBM - Smart future course, 2017, Košice
- ✓ CISCO Creathon, 2016, Bratislava
- ✓ FPT Summer School, 2015, Košice

# IoT Edge in Health Checkup Solution



# Azure IoT Edge Demo

# Enable edge intelligence with Azure IoT Edge



Extending the power of the cloud  
to the edge

Learn more: [aka.ms/azure-iot-edge](https://aka.ms/azure-iot-edge)

Get started: [aka.ms/azure-iot-edge-get-started](https://aka.ms/azure-iot-edge-get-started)

# Azure IoT Edge

- Deploy *Azure services* to IoT Edge devices
- Deploy your *own code in language of your choice*
- *Manage* IoT Edge and downstream devices
- Do all of this *securely, in a scalable fashion* from the Azure IoT Hub

