Internet of Things, Decentralization and The Role of Edge Computing

Fabio Antonelli

OpenIoT Research Unit
*Open Platforms and Enabling Technologies for the Internet of Things*

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Internet of Things: the Context

- *Emerging Trends*: growing number of devices, massive amount of generated data
- *IoT Challenges*: security, data privacy, trust associated to *centralized architectures*

Current Technological trends:

- From Cloud to Edge/Fog
- Smarter Devices
- Decentralization
- Trustless Environment
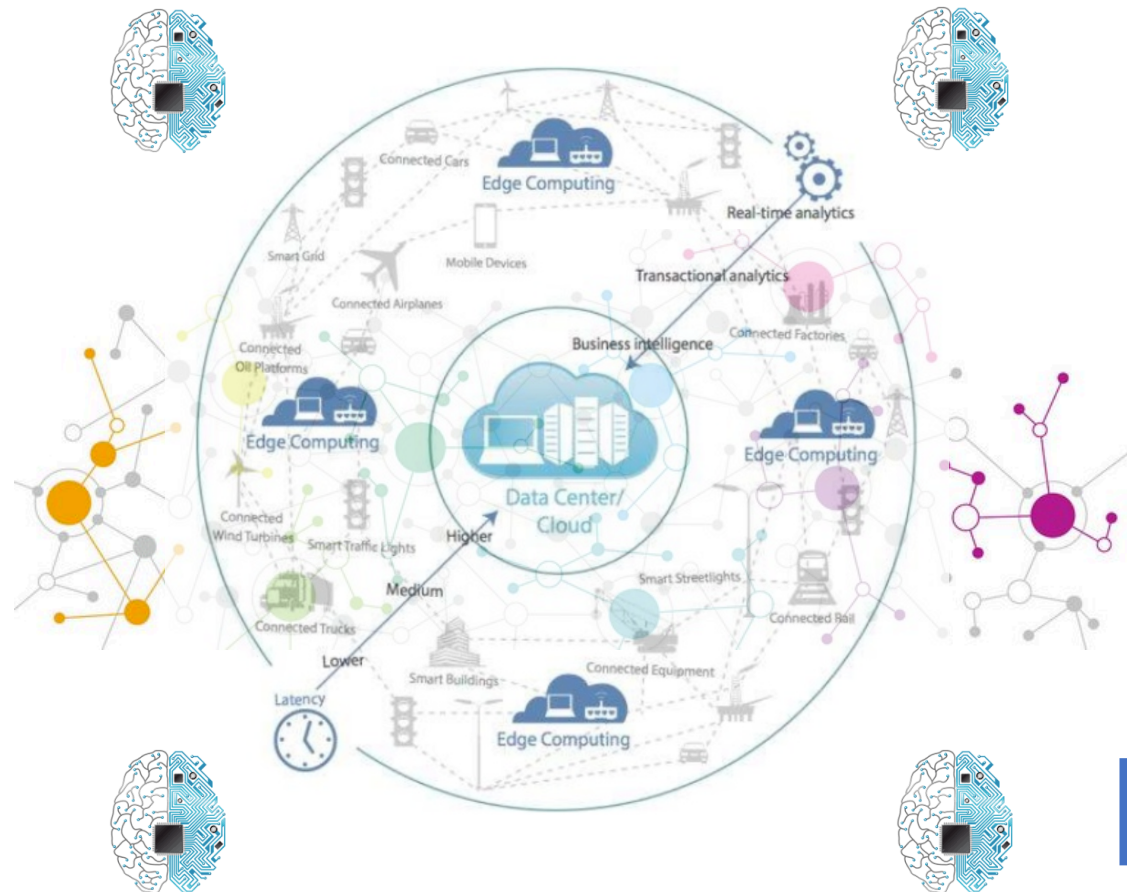
Our Research Focus

- *Emerging Trends*: growing number of devices, massive amount of generated data
- *IoT Challenges*: security, data privacy, trust associated to *centralized architectures*

Current Technological trends:

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Research Themes:

Embeddable Computational Intelligence

Edge Computing

Blockchain for decentralized IoT Apps
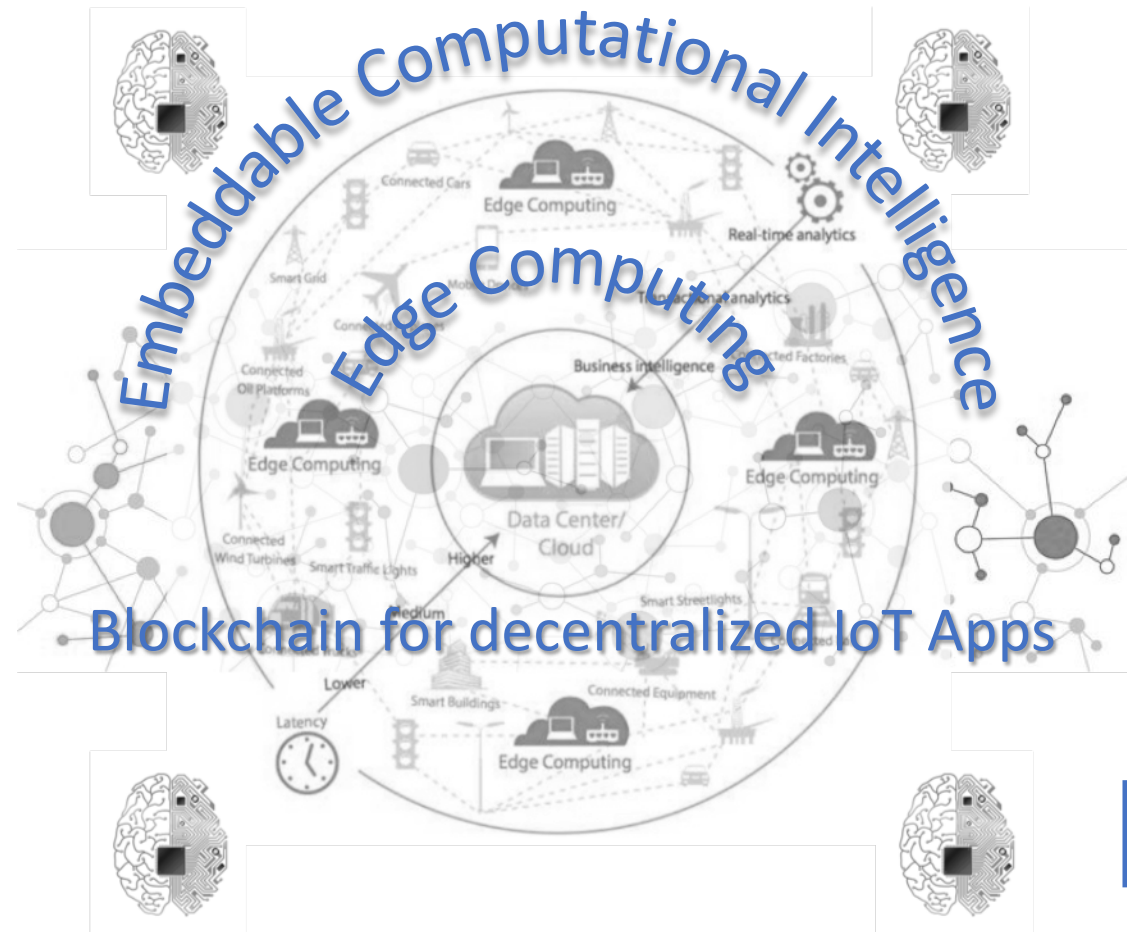
Cloud vs Edge: Proximity is the key

Maintaining **close proximity** to edge devices (rather than sending all data to a distant centralized cloud for processing) guarantees

1. *latency minimization*
2. *faster response times*
3. *reduced network bandwidth*
4. *more effective maintenance and operational strategies*
5. *increased security & privacy*

Latency · Privacy · Bandwidth · Reliability · Autonomy
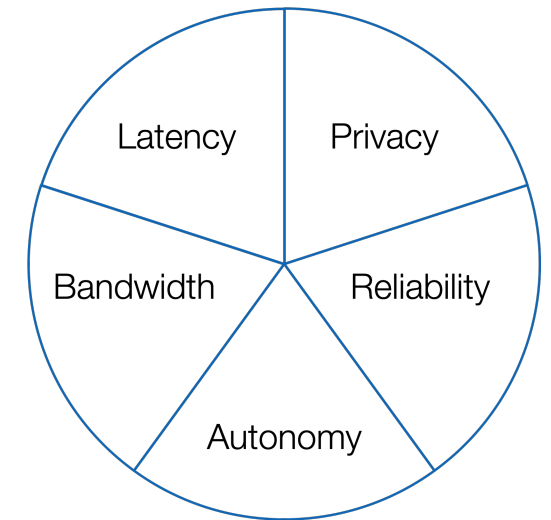
These features are extremely important in situations where even one second might mean the difference between a **safe and orderly** response (e.g. Industrial IoT, detection of a major equipment failure!)

Examples where Intelligence in the Edge offers Advantages

- *Smart Cities*
 - **Smart crossings**: decisions on traffic management based on localized contextual decisions

- *Security Surveillance*
  - **Local detection of anomalies** from video streams;
  - **Dynamic adaptation** of behavoiur (video quality, camera angle, ...) and triggering of edge/cloud analytical algorithms

- *Digital Manufacturing*
  - **Real-time response** on large volume of data (audio, video, vibrational signals)
  - **Responsiveness** and gain in **efficiency** of **automated** processes
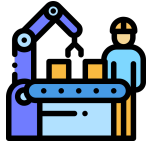
- *Autonomous Transport*, like:
 - Self-driving cars
  - Ships
  - Trains

 with **limited/no access** to **cloud resources**

What's the Fog/Edge?

➢ Fog introduced by Bonomi in 2012 [†]

➢ Extends the Cloud to the edge of the network

➢ Reduces latency and bandwidth

➢ Processing closer to data-sources

➢ Enables latency-sensitive applications

➢ Introduces the concept of *Cloud-to-Thing Continuum*

CLOUD | Data Centers

FOG | Nodes

EDGE | Devices
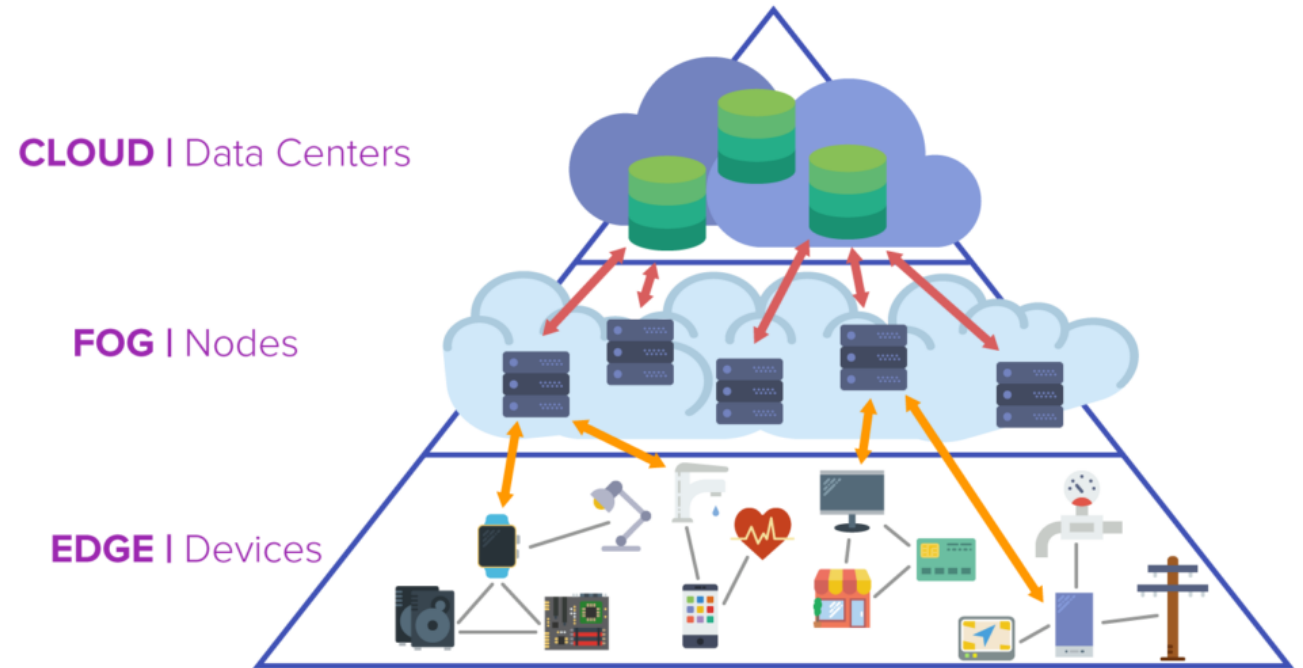
[†] F. Bonomi, R. Milito, J. Zhu, and S. Addepalli. 2012. *Fog Computing and Its Role in the Internet of Things*. In Proceedings of the First Edition of the MCC Workshop on Mobile Cloud Computing (MCC '12). ACM, New York, NY, USA, 13–16.

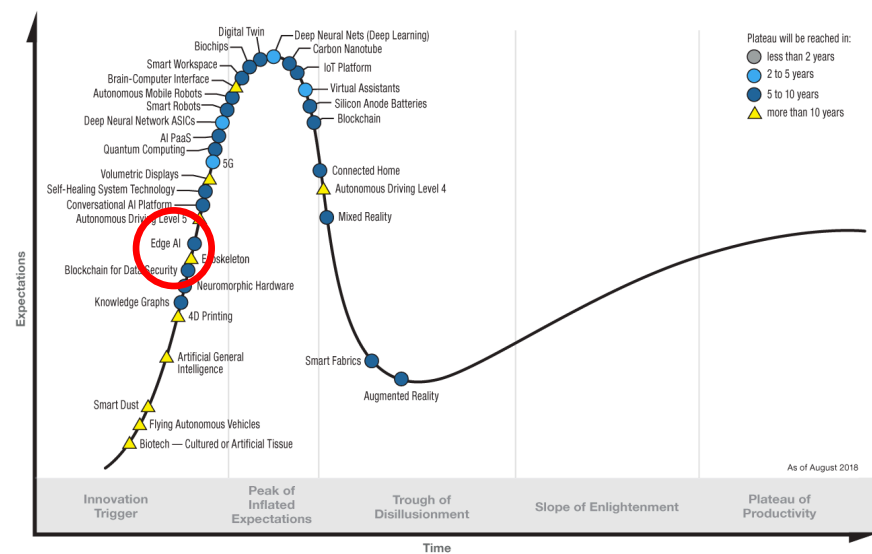# Design patterns for ML IoT Applications

Cloud
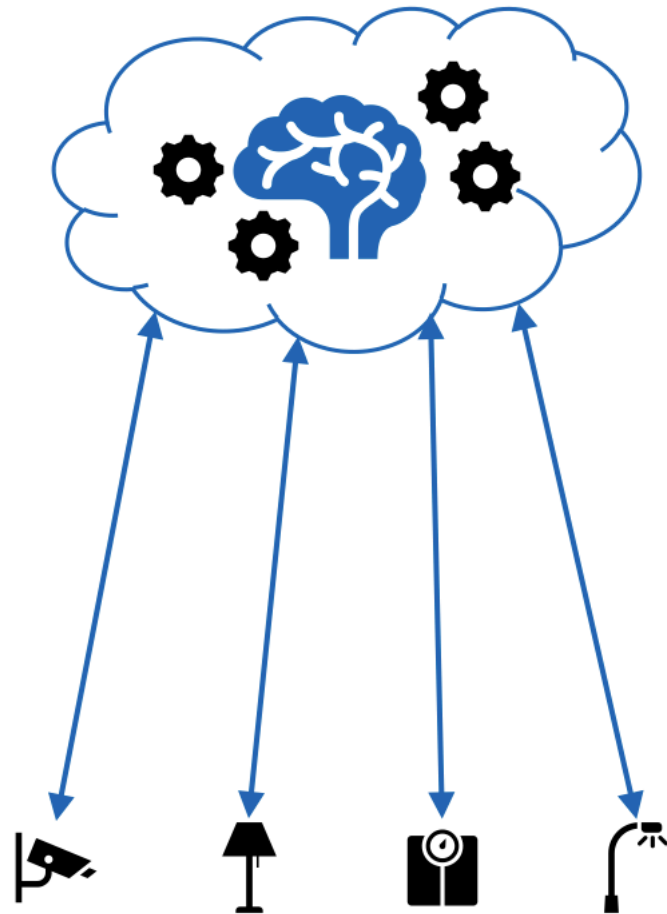
Gateways

Things

Cloud-Centric Approach
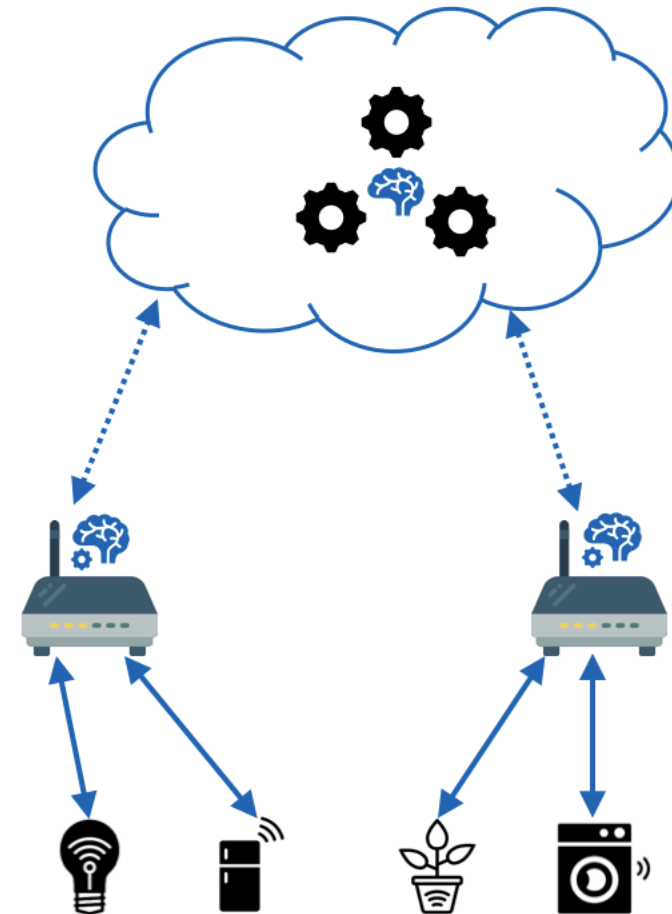
Edge/Fog-based Approach

Edge Intelligence: Tech Trends and the Market

Some examples:

AWS Greengrass [*]
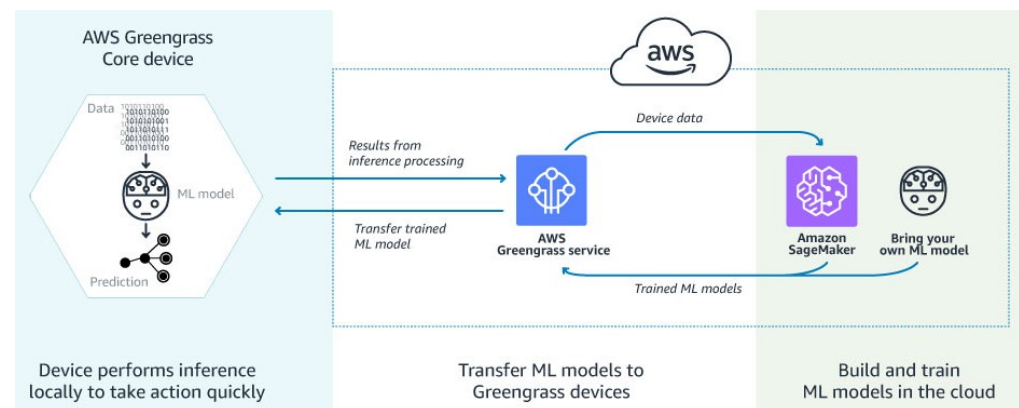
Microsoft Azure IoT Edge [**]

(*) https://aws.amazon.com/greengrass/
(**) https://azure.microsoft.com/en-us/services/iot-edge/
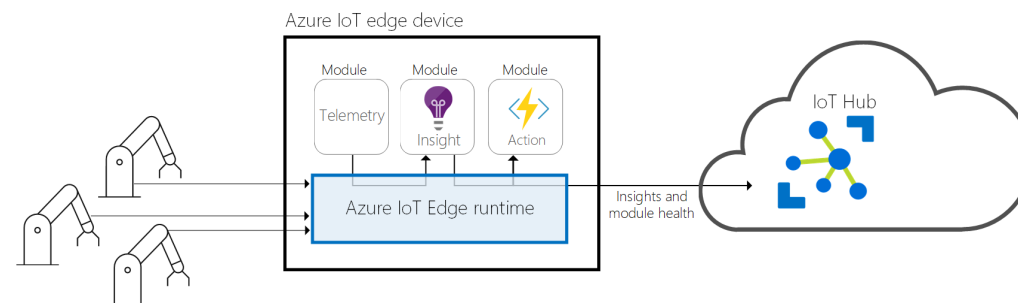
Edge Computing and Artificial Intelligence for Industry 4.0

Anomaly Detection

and

Predictive Maintenance

In The Edge
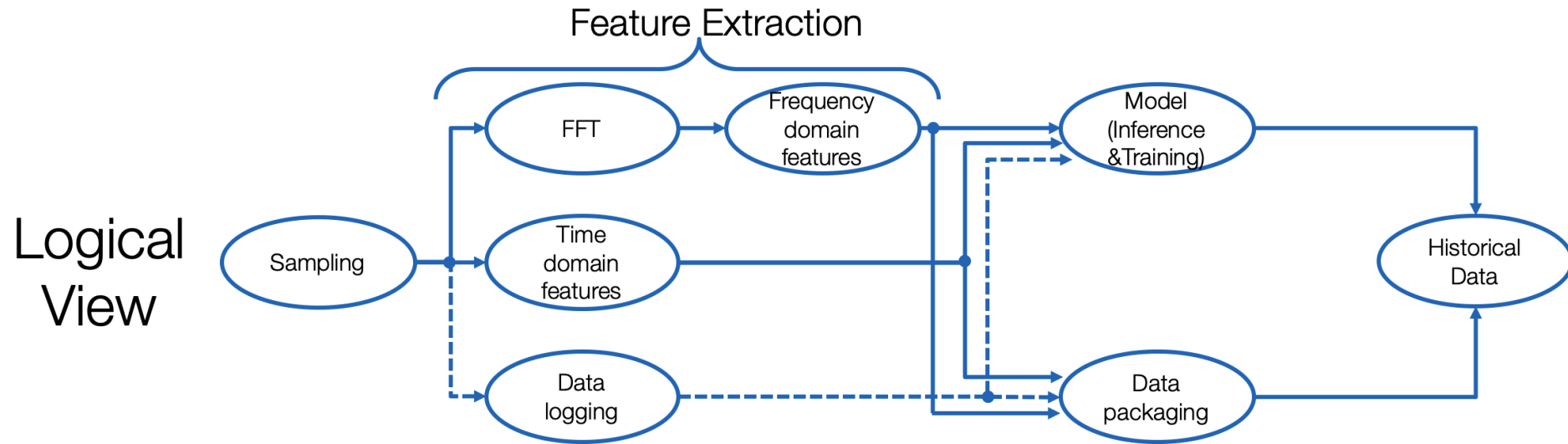
FONDAZIONE BRUNO KESSLER

CREATE-NET

SMACT
CompetenceCenter

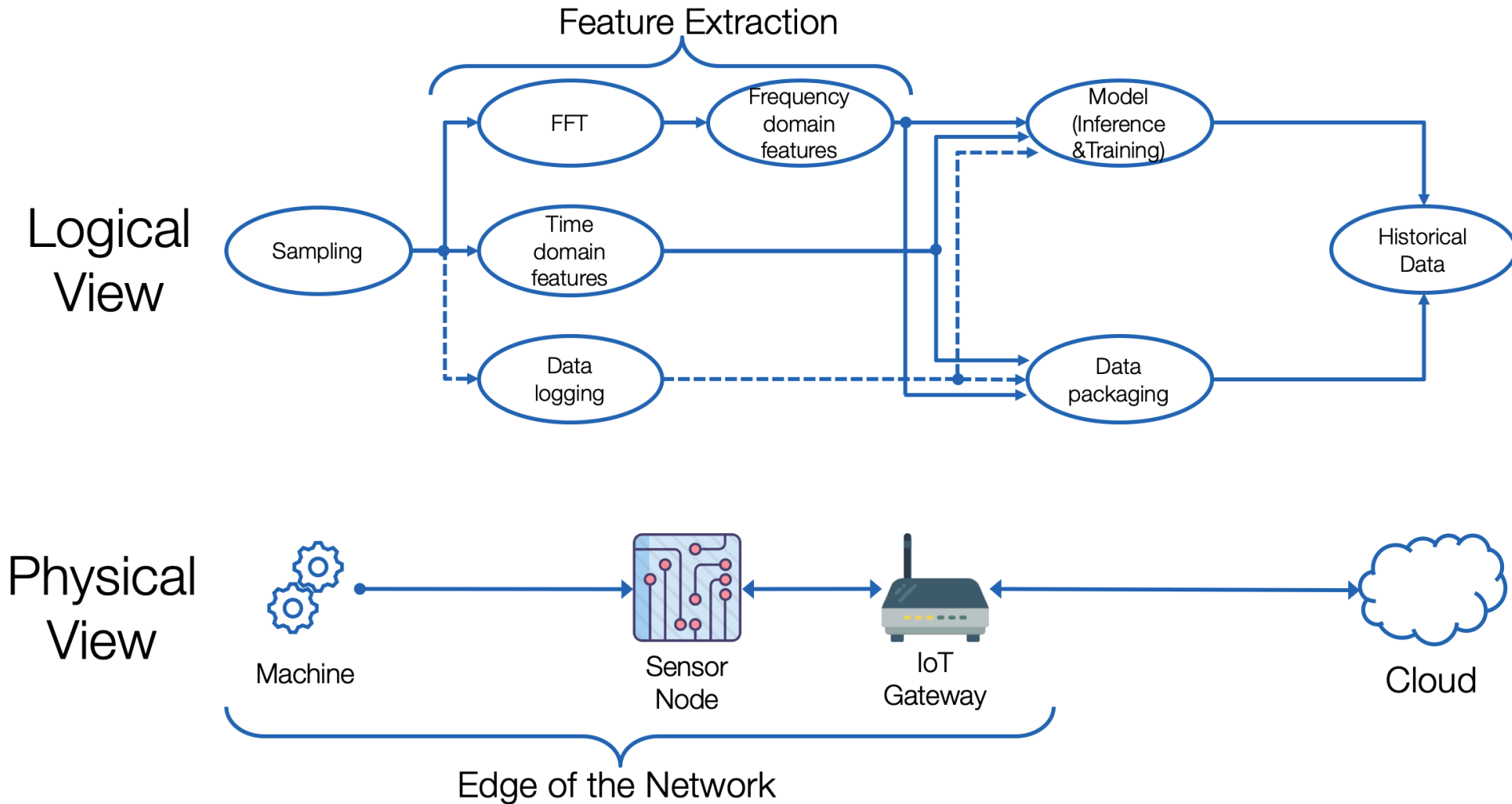Le tecnologie SMACT per *Industria 4.0* e il *Made in Italy* digitale

SOCIAL NETWORK   MOBILE PLATFORMS & APPS   ADVANCED ANALYTICS & BIG DATA   CLOUD   INTERNET OF THINGS
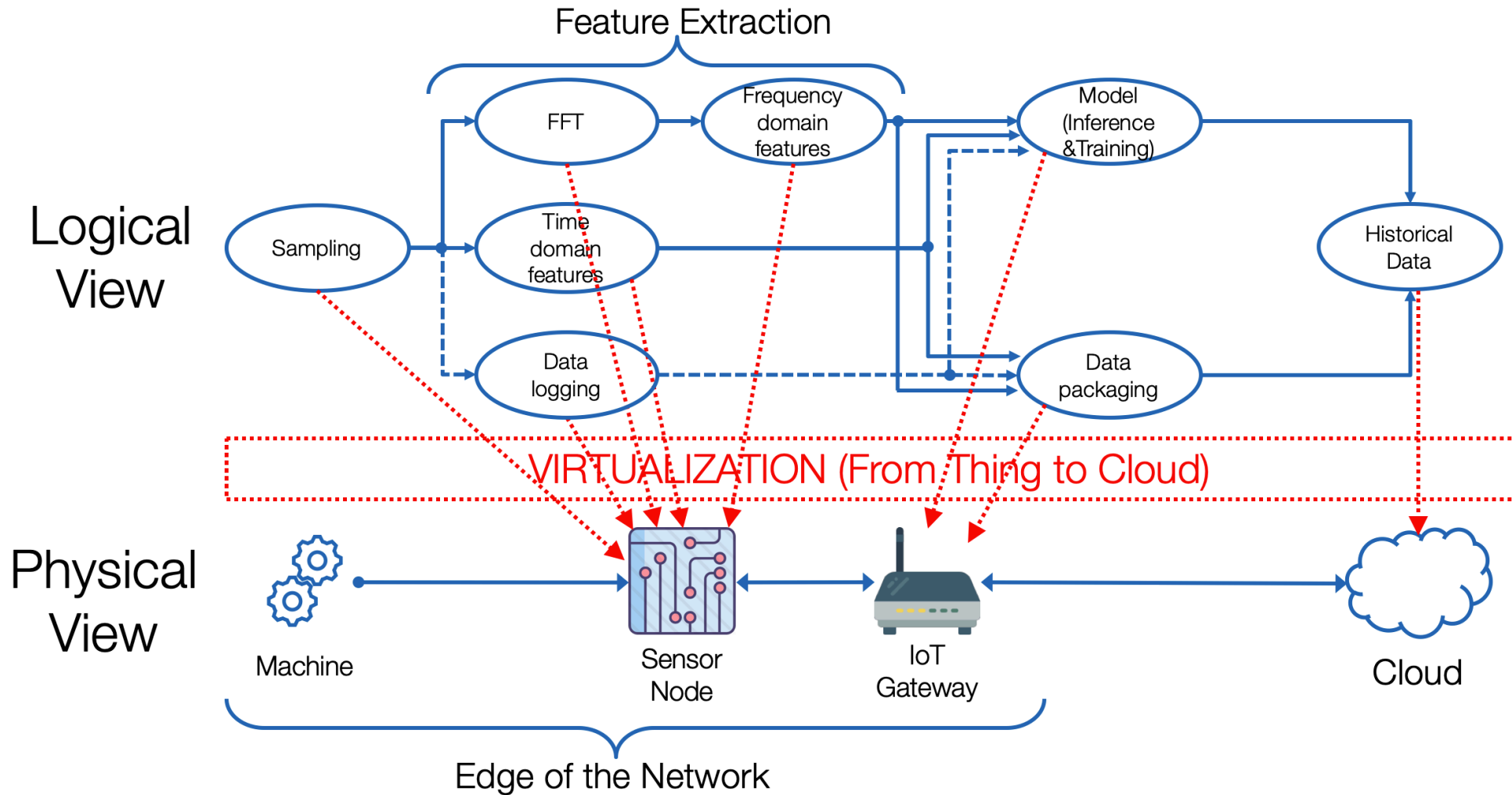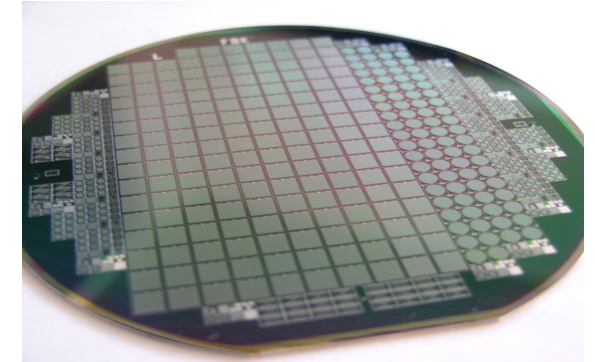
Industrial Machine Monitoring - An example

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Industrial Machine Monitoring – Our Approach

A Real Use-Case: the FBK Micro-Nano Facility

Silicon wafer with devices: working with 10^{-6} to 10^{-8} meter dimension

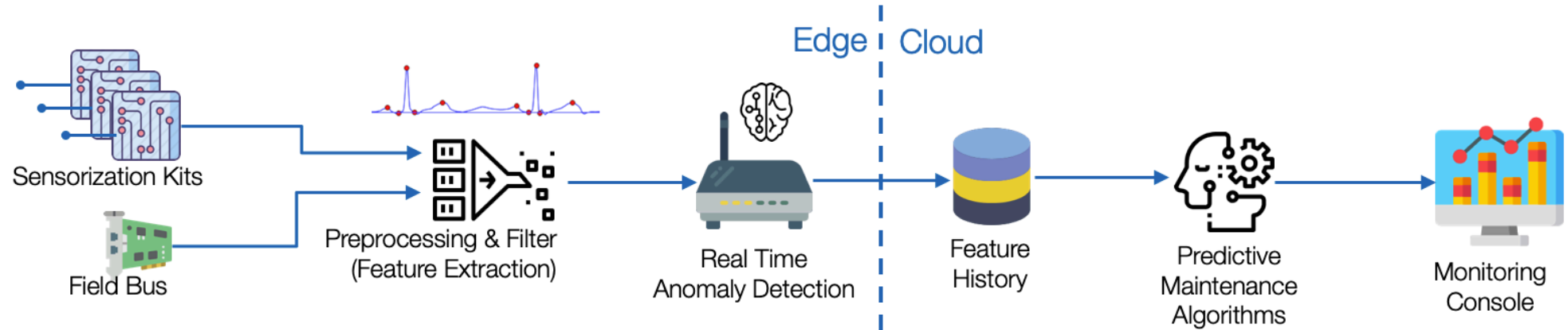White areas and sensitive equipments

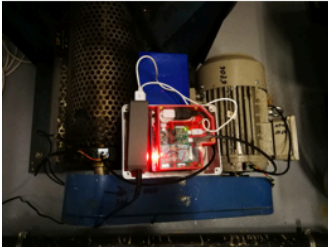# Air Generation System
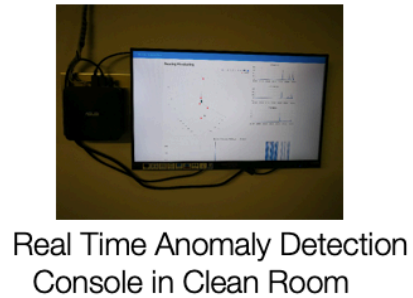

The room

Pumps

Controller

Platform Deployment

Edge | Cloud

Sensorization Kits

Field Bus

Preprocessing & Filter
(Feature Extraction)

Real Time
Anomaly Detection

Feature
History

Predictive
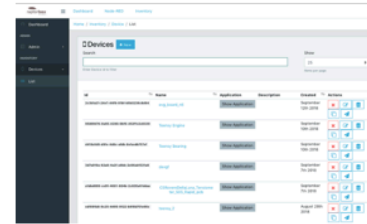Maintenance
Algorithms

Monitoring
Console

- Drive Shaft Bearing
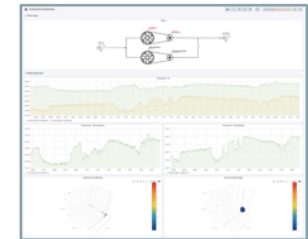- Electrical Engine

Sensorization Kit
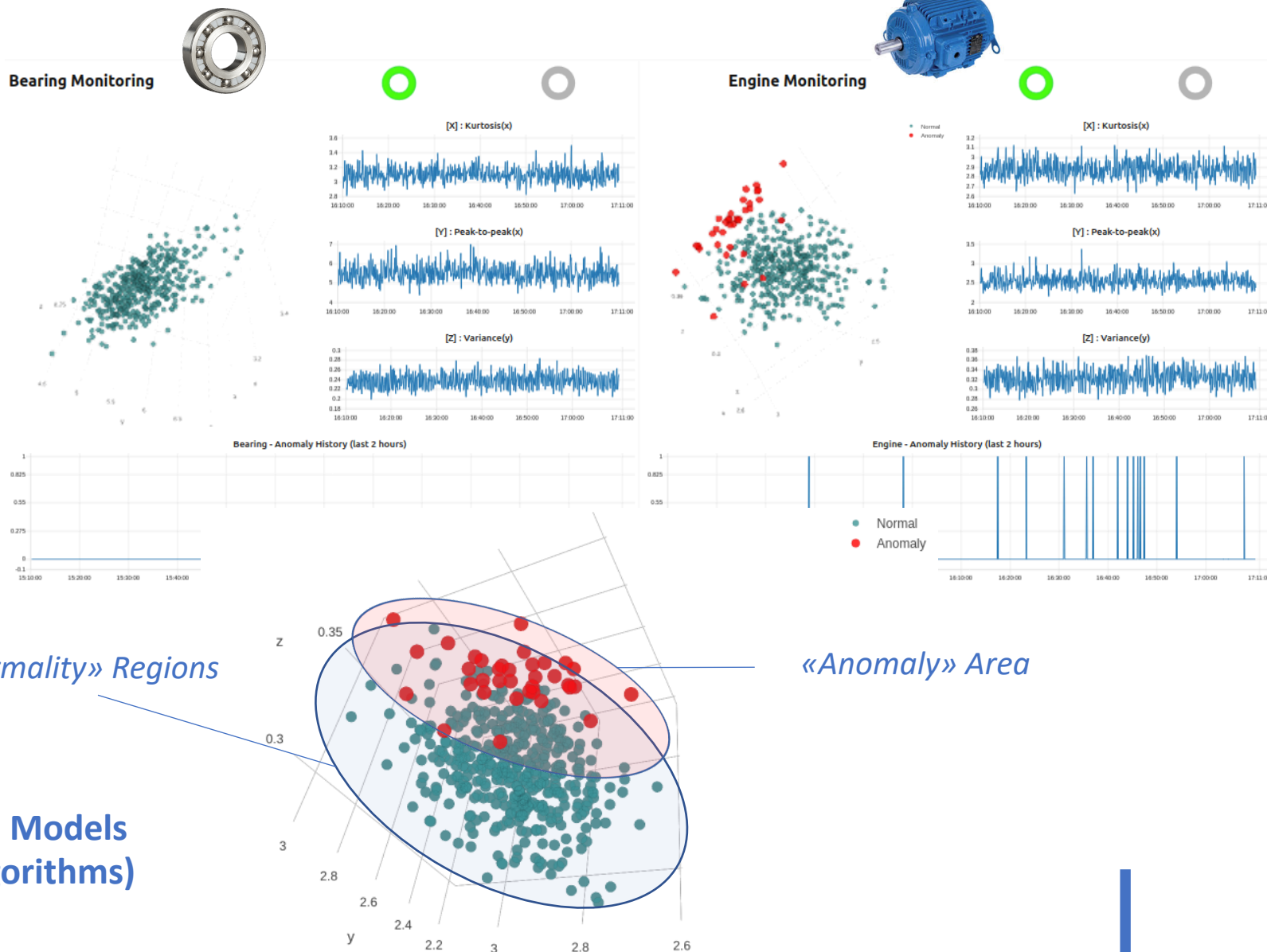
Real Time Anomaly Detection
Console in Clean Room

Data Brokering
Console

Analytics and
Predictive Maintenance
Console

Edge Anomaly Detection Console

Bearing Monitoring

Engine Monitoring

«Normality» Regions

«Anomaly» Area

**Anomaly Detection Models
(Elliptic Envelope Algorithms)**

My Contacts

Fabio Antonelli

fantonelli@fbk.eu