Internet of Things and Services
Service-oriented architectures

IoT edge computing

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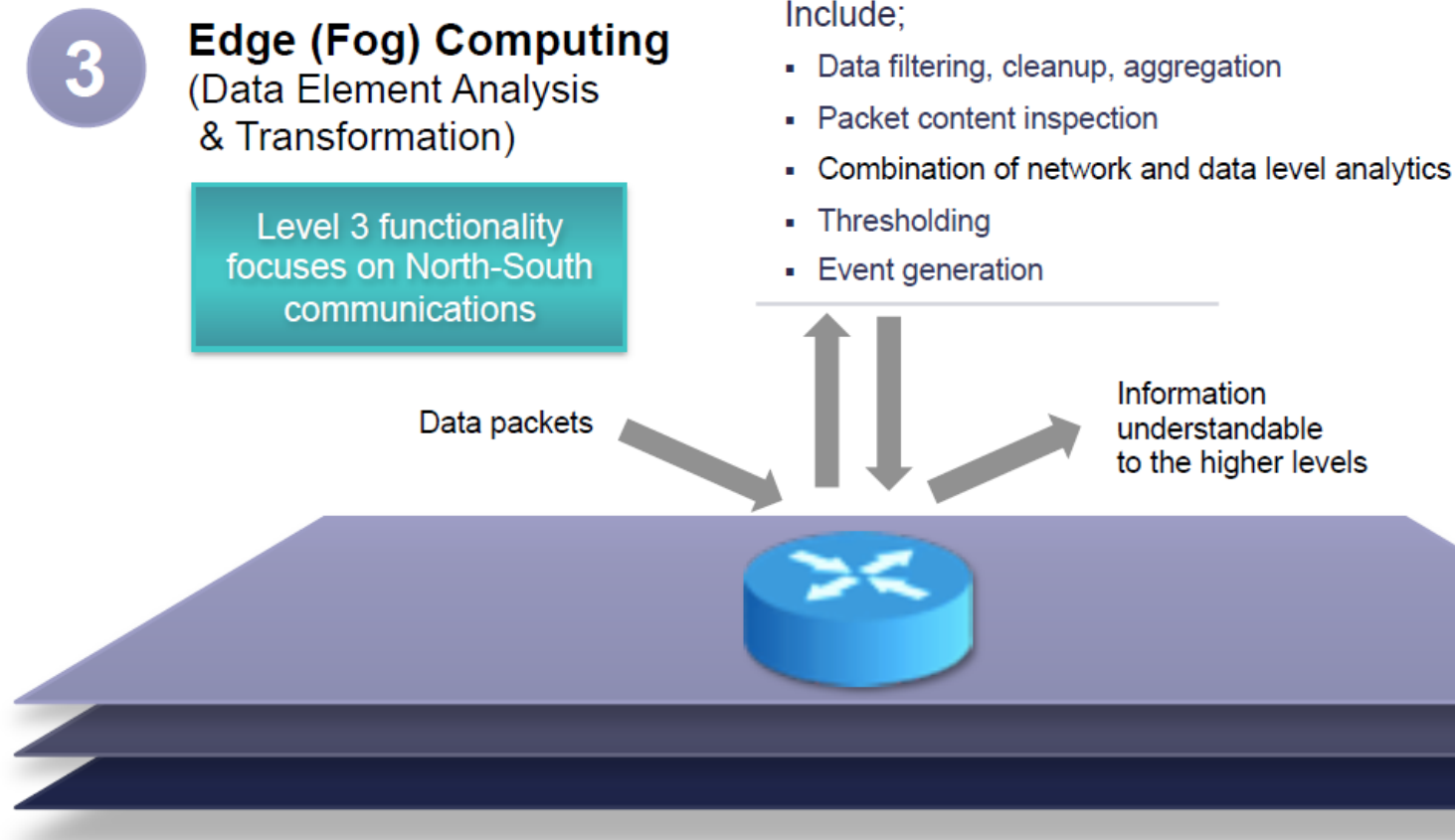
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CISCO IoT Reference model
Level 3: Edge (Fog) Computing

- Focus on high-volume data processing, analysis and transformation.

3 **Edge (Fog) Computing**
(Data Element Analysis & Transformation)

Level 3 functionality focuses on North-South communications

Include;
- Data filtering, cleanup, aggregation
- Packet content inspection
- Combination of network and data level analytics
- Thresholding
- Event generation

Data packets

Information understandable to the higher levels

IoT edge computing

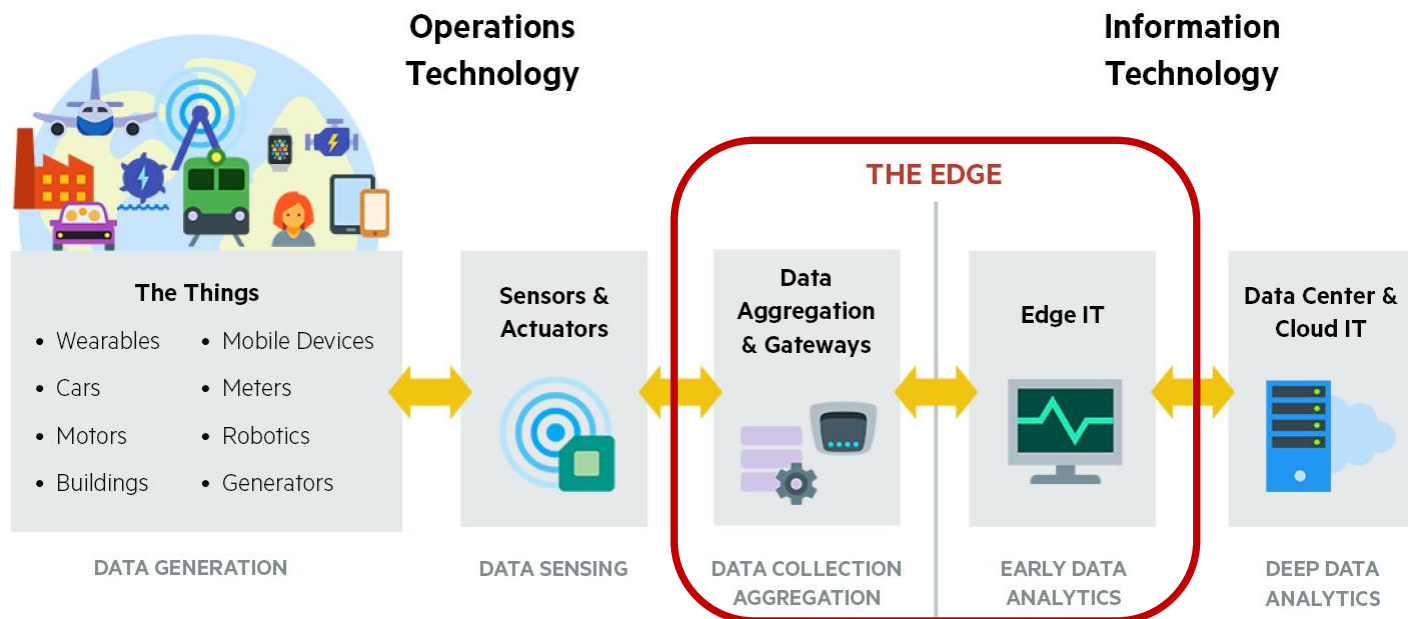# Edge computing

- **Edge computing** refers to *"the enabling technologies allowing computation to be performed at the edge of the network, on downstream data on behalf of cloud services and upstream data on behalf of IoT services."*

  - The rationale behind edge computing is that 45-75% of IoT data will be processed and analyzed at the edge of the network in the future

- Edge computing provides support for:

  - Gateway services for specific IoT protocols (Modbus, CAN bus, Zigbee, BLE,...) to Internet protocols (MQTT, COAP, HTTP,...)

  - Services for local storage, processing and analytics of streaming data

  - Privacy and security
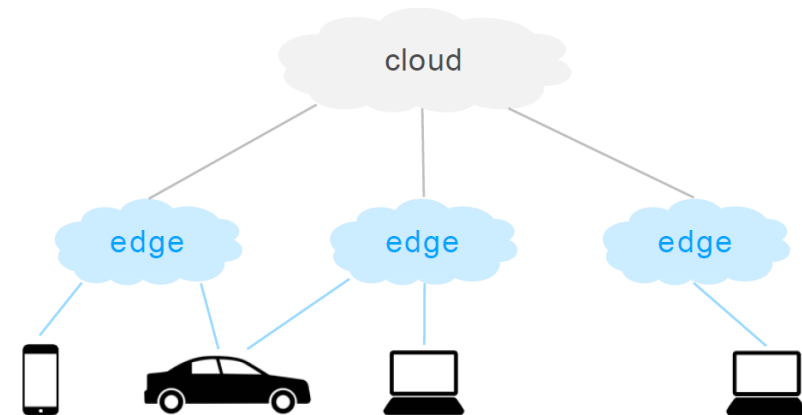
IoT edge computing

Edge computing

- While the data is moving from the device to the Cloud, Edge computing moves analytics/computing/decision-making from the Cloud towards the device and closer to sensor data.
  - Reduces the cost of transferring lots of data back and forth
  - Decreases the reaction time, thus making it truly "real-time"
  - Makes all the local decision-making less dependent on the availability of Wi-Fi and Cloud, on IT security restrictions, etc.

Operations Technology

Information Technology

THE EDGE

The Things	Sensors & Actuators	Data Aggregation & Gateways	Edge IT	Data Center & Cloud IT
• Wearables • Mobile Devices • Cars • Meters • Motors • Robotics • Buildings • Generators				

DATA GENERATION   DATA SENSING   DATA COLLECTION AGGREGATION   EARLY DATA ANALYTICS   DEEP DATA ANALYTICS

IoT edge computing

Edge computing benefits

- While the data is still moving to the Cloud, where some "deep analysis and compute" takes place, the decision-making is being moved closer to the devices and their sensor data.
- Applications and services then move towards the data, not the other way around, especially if we are dealing with a lot of data.
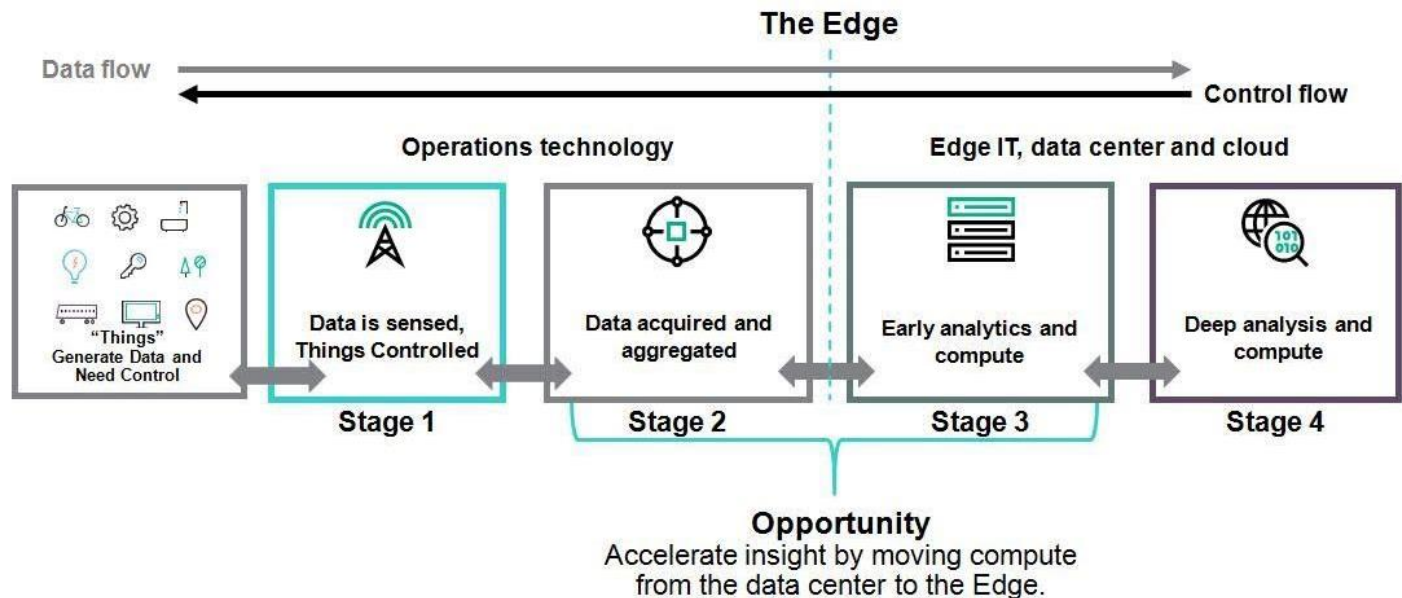
IoT edge computing

Advantages of Edge computing

- **S**ecurity
  - Supports additional security to IoT devices to ensure safety and trustworthiness in transactions
- **C**ognition
  - Enables fog providers the awareness of the objectives of their clients toward supporting autonomous decision-making
- **A**gility
  - Brings the opportunity to individual and small businesses to participate in providing FEC services
- **L**atency
  - Provide rapid responses for the applications that require low latency
- **E**fficiency
  - Reduces the unnecessary cost of outgoing communication bandwidth
  - Consume minimum power for data offloading and processing when compared to Cloud oriented IoT model

Edge computing

- Local processing, storage and analytics
- Get data from sensors, process, store & analyse, and send some data to the fog/cloud
- IoT Gateway
  - Gateway Protocols
    - 6LoWPAN
    - LoRaWAN / SigFox / NBIoT
    - BLE
  - Internet Protocols
    - CoAP
    - MQTT
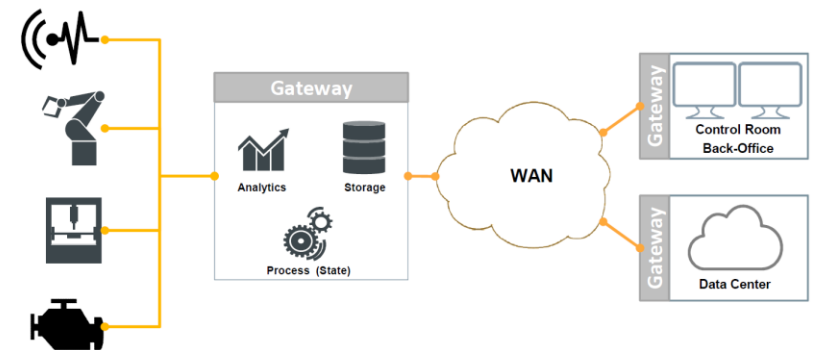   - HTTP
    - AMQP
    - XMPP

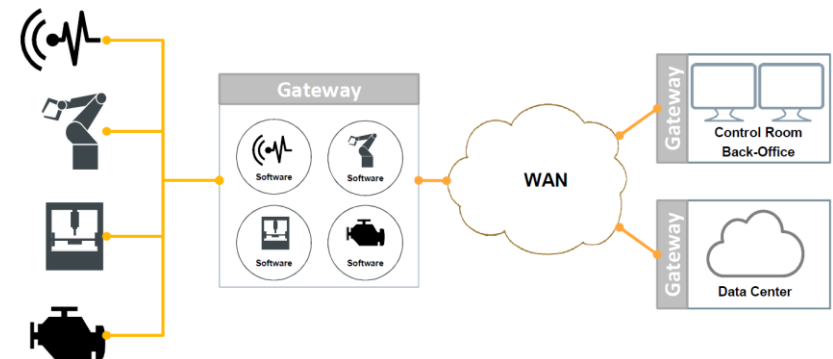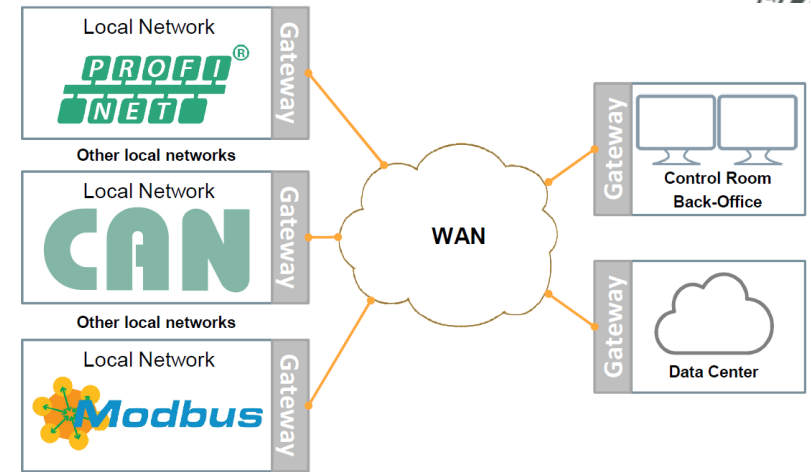**IoT edge computing**

IoT gateway

- Bridging of separated communication networks, including protocol adaptation

- Acting as a proxy to connect dumb things to the IoT, making them intelligent

- Providing common management, processing and analytics services to things close to the field
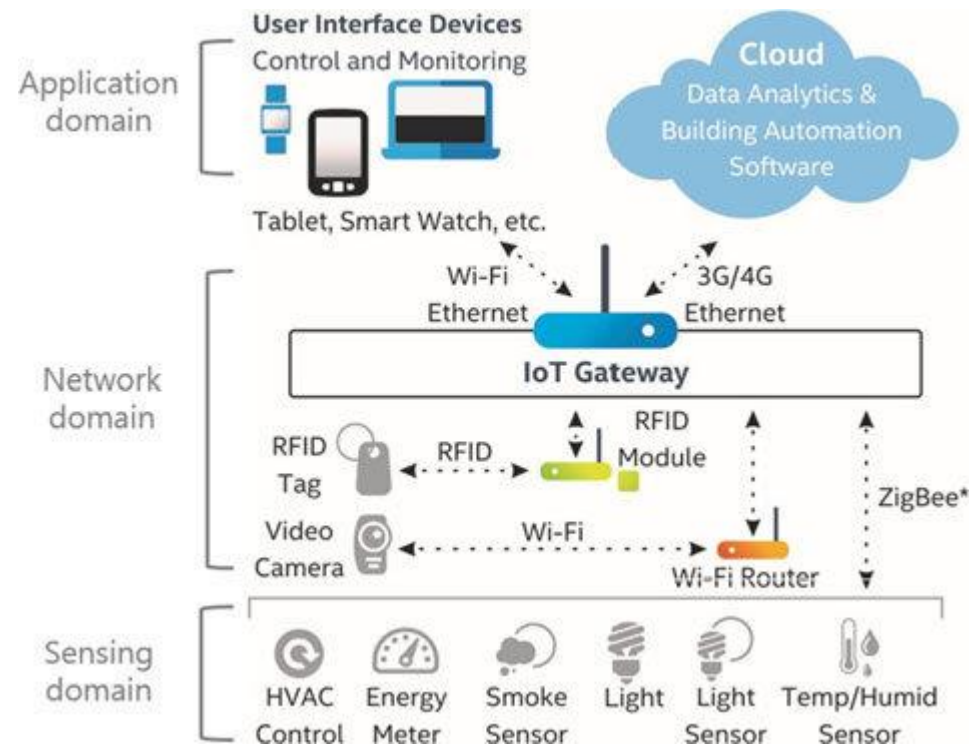

IoT edge computing

IoT edge processing & analytics

- Primarily deals with the sensor data acquisition and provisioning
- Embedded processing saves the communication latency
- Descriptive, diagnostics & predictive analytics
- Mobile device/smartphones can also participate as Gateways
  - This brings in the scope of mobile web services and mobile cloud services for IoT

IoT edge computing

Open source IoT edge platforms

- EdgeX Foundry
  - https://www.edgexfoundry.org/
- Eclipse Kura
  - https://www.eclipse.org/kura/
- StarlingX
  - https://www.starlingx.io/
- Baetyl (OpenEdge)
  - https://baetyl.io/
- KubeEdge
  - https://kubeedge.io
- Eclipse ioFog
  - https://iofog.org/
- Macchina.io
  - https://macchina.io/
- Apache Edgent
  - http://edgent.incubator.apache.org/

Cloud/edge IoT platforms

- Microsoft Azure IoT Edge

    - https://docs.microsoft.com/en-us/azure/iot-edge/
    - https://github.com/Azure/iotedge

- Amazon Web Services IoT & AWS IoT for the Edge

    - https://aws.amazon.com/greengrass/

- IBM Watson IoT Platform

    - https://www.ibm.com/internet-of-things/solutions/iot-platform/watson-iot-platform

- Google Cloud IoT Edge

    - https://cloud.google.com/solutions/iot
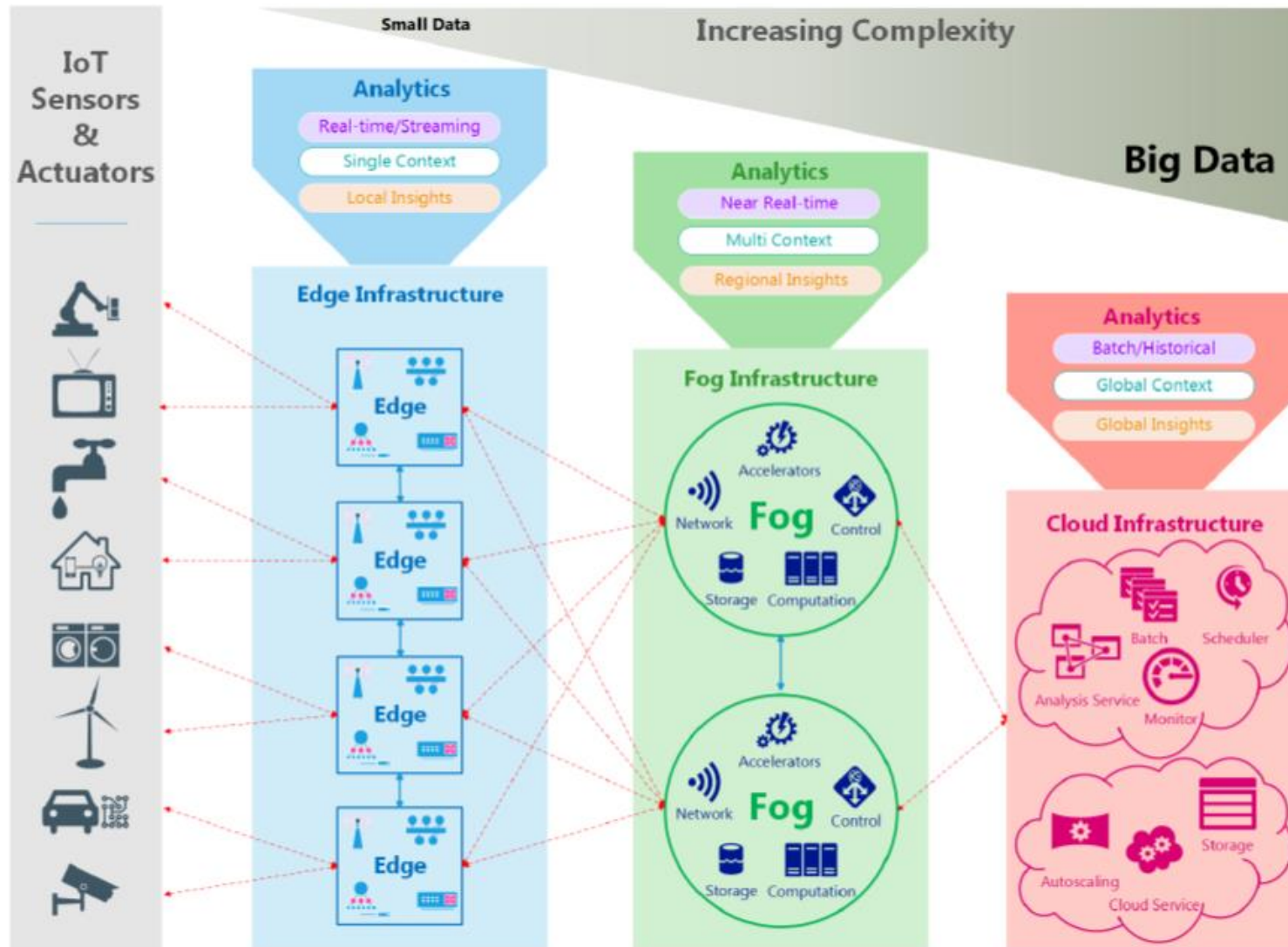
Fog computing

- Fog computing was first introduced by Cisco in 2014, as a bridge between the edge and cloud resources, and as a way to bring cloud computing capabilities to the edge of the network.

- Similar concepts and technologies are cloudlets, mobile cloud computing, as well as mobile edge computing

- Fog computing is an intermediate resource that can seamlessly integrate edge and cloud resources.

- Fog computing can eliminate resource contention at the edge by supporting several analytical tasks at the fog nodes and coordinating the use of geographically distributed IoT devices more efficiently than in the cloud
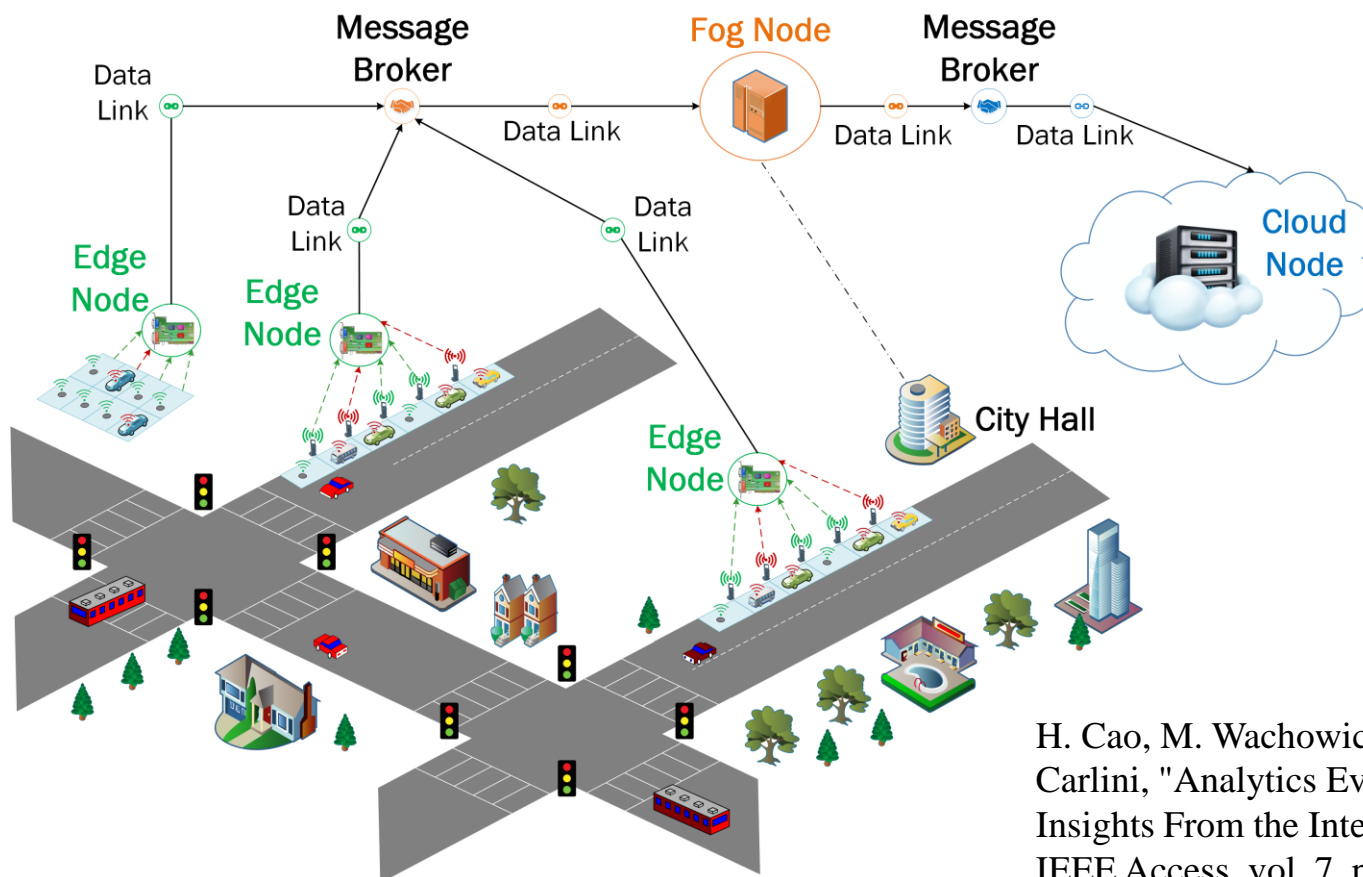
Edge-fog-cloud architecture

H. Cao, M. Wachowicz, C. Renso and E. Carlini, "Analytics Everywhere: Generating Insights From the Internet of Things," in IEEE Access, vol. 7, pp. 71749-71769, 2019
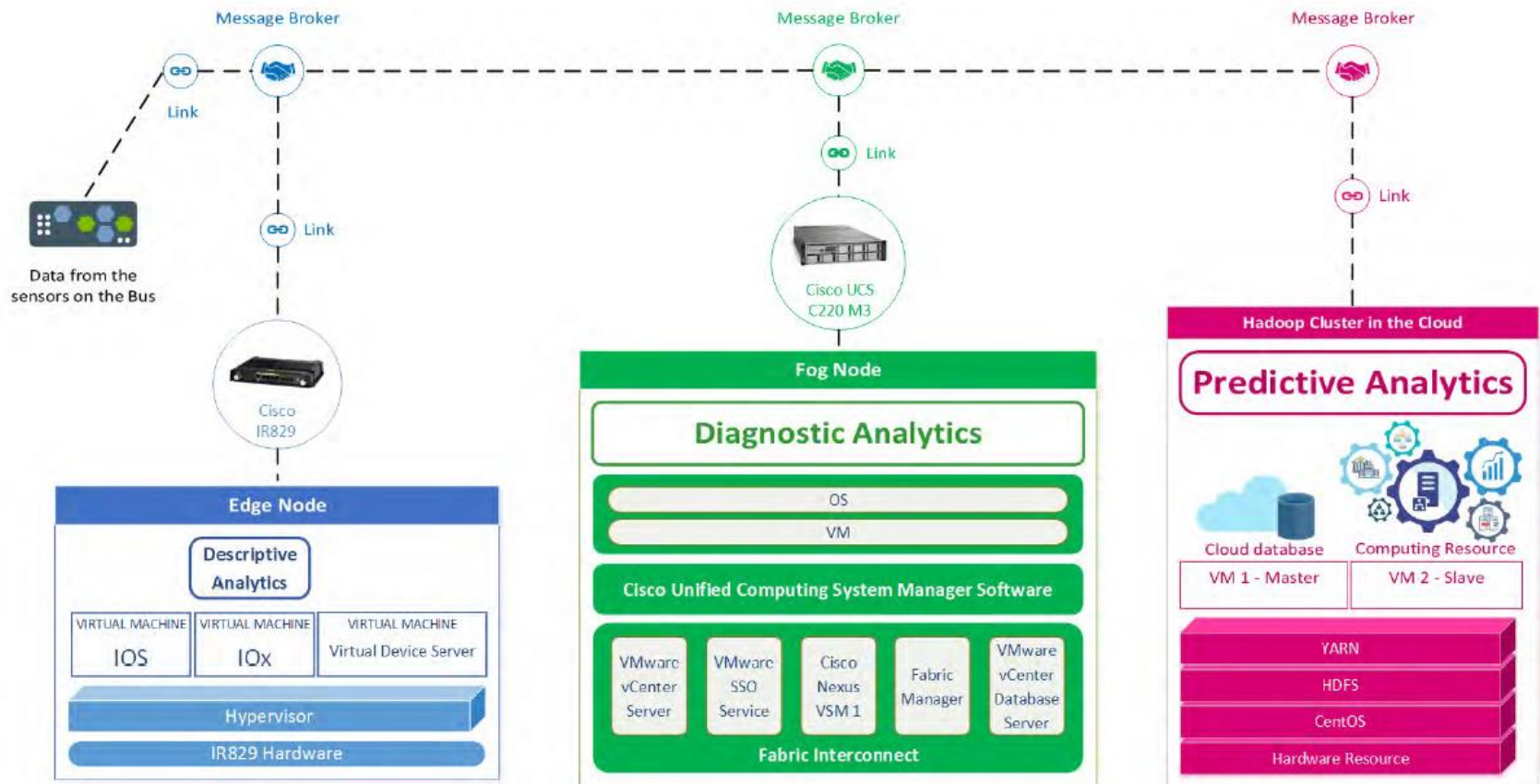
IoT edge computing

Edge-fog-cloud example

- Distribution of the edge-fog-cloud nodes for the smart parking application

H. Cao, M. Wachowicz, C. Renso and E. Carlini, "Analytics Everywhere: Generating Insights From the Internet of Things," in IEEE Access, vol. 7, pp. 71749-71769, 2019

IoT edge computing

Edge-fog-cloud example 2

- Distributed software architecture implemented for the public transport scenario.

IoT edge computing

EdgeX Foundry

EdgeX Foundry

- **EdgeX Foundry** is a vendor-neutral open-source platform hosted by the **Linux Foundation**, providing a common framework for industrial IoT edge computing. https://www.edgexfoundry.org/

- The goal of the project is the simplification and standardization of **edge computing** architectures applicable in industrial IoT scenarios, where a heterogeneous set of devices, sensors, actuators and other IoT objects (the so-called South Side) produce data that should be computed, and eventually analyzed, stored or aggregated on the fog and up to the cloud (the so-called North Side).

- The framework is structured in different layers, each one composed of multiple **microservices**.

- The part of LF Edge project that aims to create a common framework for hardware and software standards and best practices critical to sustaining current and future generations of IoT and edge devices.

- https://www.lfedge.org/

References

- Perry Lea, ***IoT and Edge Computing for Architects,*** 2nd Edition, Packt Publishing, 2020
  - Chapter 8: Edge Computing
  - Chapter 11: Cloud and Fog Topologies
  - Chapter 12: Data Analytics and Machine Learning in the Cloud and in the Edge
- Hung Cao, Monica Wachowicz, Chiara Renso, Emanuele Carlini, *Analytics Everywhere: Generating Insights From the Internet of Things*. IEEE Access 7: 71749-71769 (2019)
- LF Edge - Building an Open-source Framework for the Edge
  - https://www.lfedge.org/
- Open Glossary of Edge Computing
  - https://www.lfedge.org/projects/openglossary/