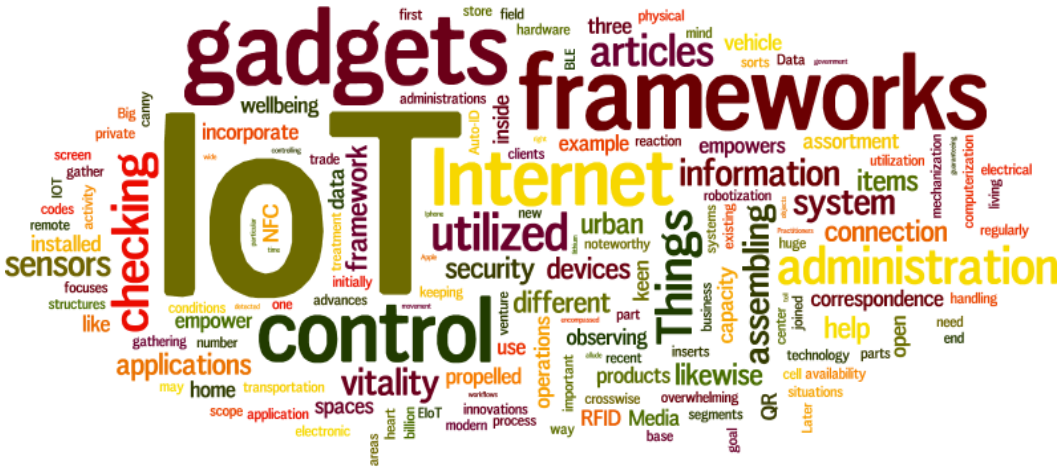
CS578: Internet of Things

IoT Architecture



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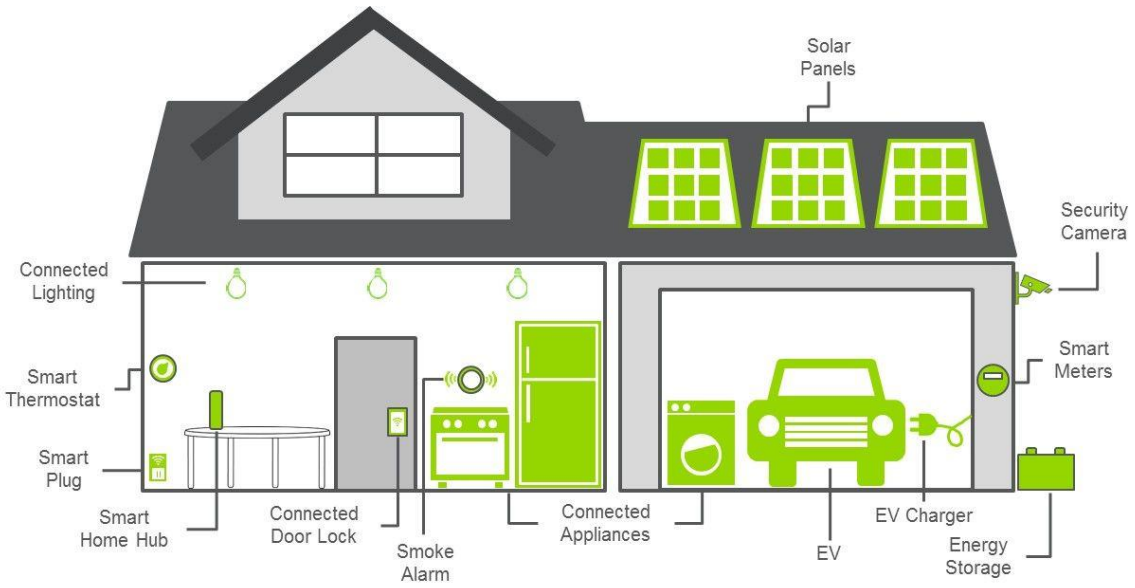
"We must have life-building, man-making, character-making assimilation of ideas." – **Swami Vivekananda**

Architectural Plan



Smart Home

Driving forces:

- Scale
- Security
- Constrained devices
- Massive data
- Data analysis
- Support to legacy devices

- Networks run the modern business
- It should never be built without careful planning

- The key difference between the IT and IoT is sensor & data
- Essence of IoT architecture:
  - how the data is transported,
  - collected,
  - analyzed, and
  - ultimately acted upon.

How IoT works?

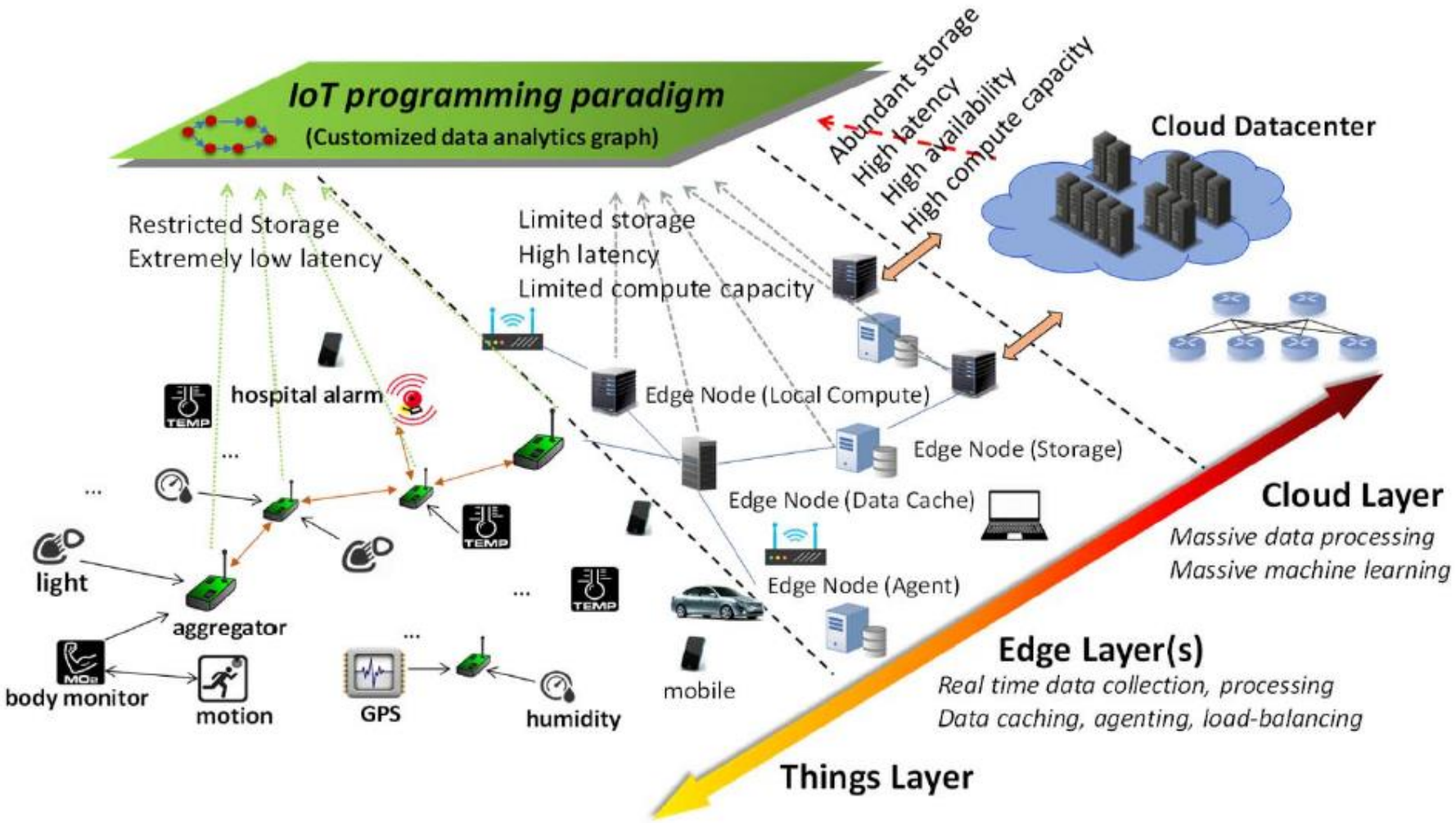


Image Source: Rajiv Ranjan *et. al.*, "Integrating the IoT and Data Science" *IEEE Cloud Computing, 2018*

IoT Architecture

- In the past several years, architectural standards and frameworks have emerged
- Two best-known architectures: oneM2M and IoT World Forum (IoTWF)

Goal of M2M architecture:

- to create a common architecture that would help accelerate the adoption of M2M applications and devices.

Goal of oneM2M architecture:

- to create a common services layer, which can be readily embedded in **field devices** to allow communication with application servers.

- Applications: smart metering, smart grid, smart city, e-health, etc.

Major challenges:

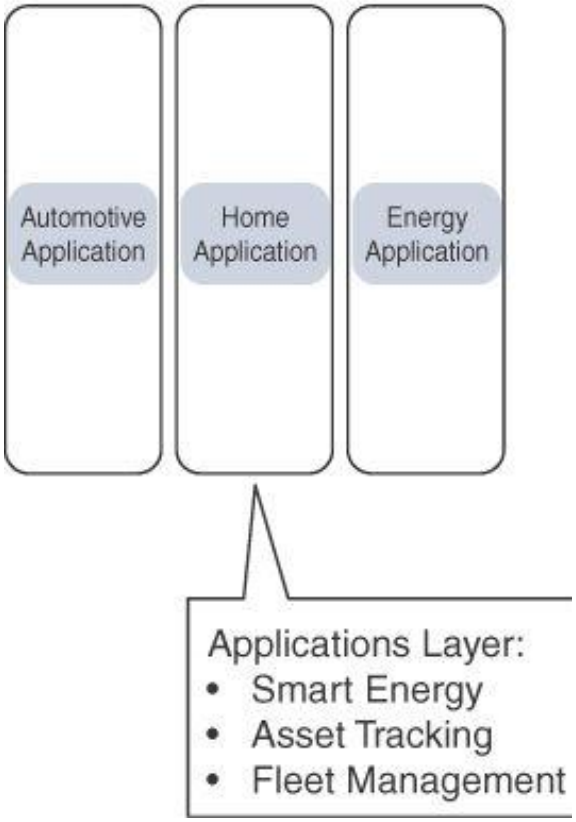
- heterogeneity of devices,
- heterogeneity of software,
- Heterogeneity of access methods

- Example: connecting two systems - BACnet system that the HVAC and BMS run; and LoRaWAN technology that the sensor network uses

oneM2M Architecture

- Proposed by European Telecommunications Standards Institute (ETSI)
- oneM2M architecture divides IoT functions into three major domains.

First



- Defines **application-layer protocols**
- Attempts to standardize **northbound API** definitions for interaction with business intelligence (BI) systems
- A northbound interface allows a particular component of a network to communicate with a higher-level component.
- Applications have their own sets of data models

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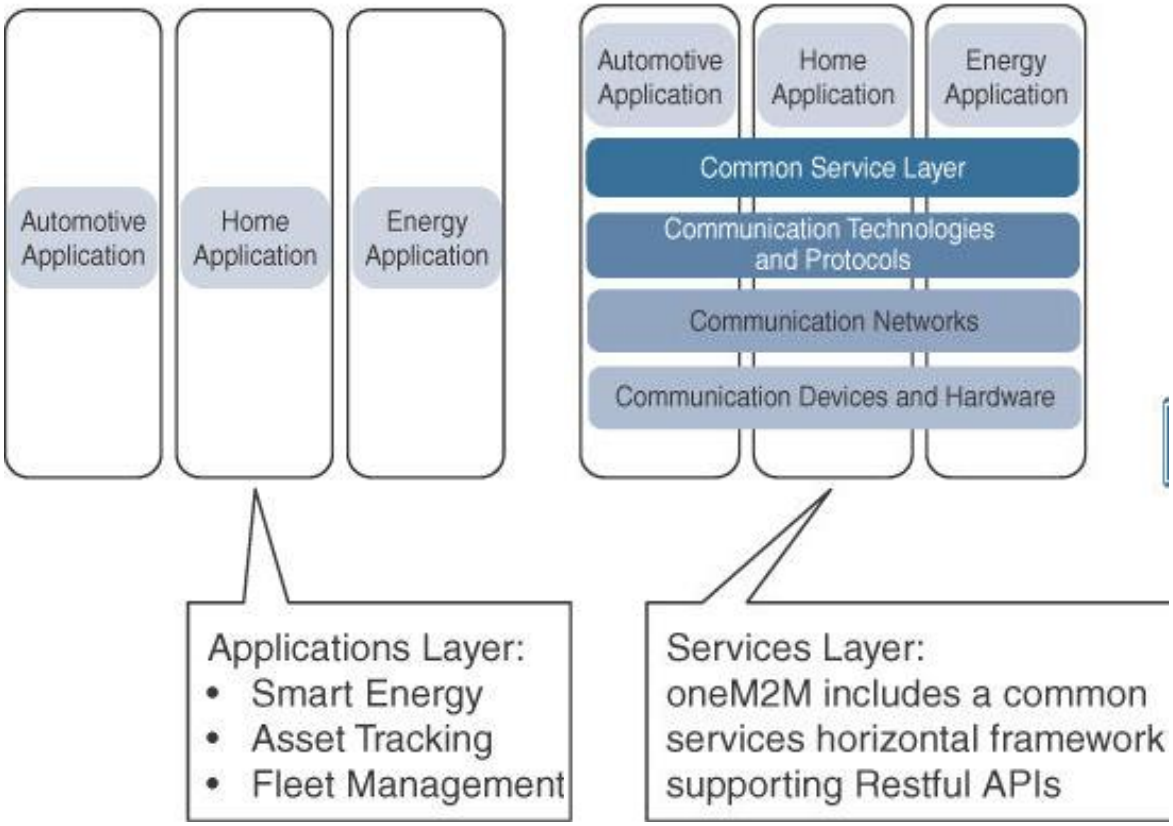
First **Second**



- horizontal framework across the vertical industry applications.
- Include:
  - the physical network that the IoT applications run on. (e.g. backhaul network)
  - the underlying management protocols
  - the hardware

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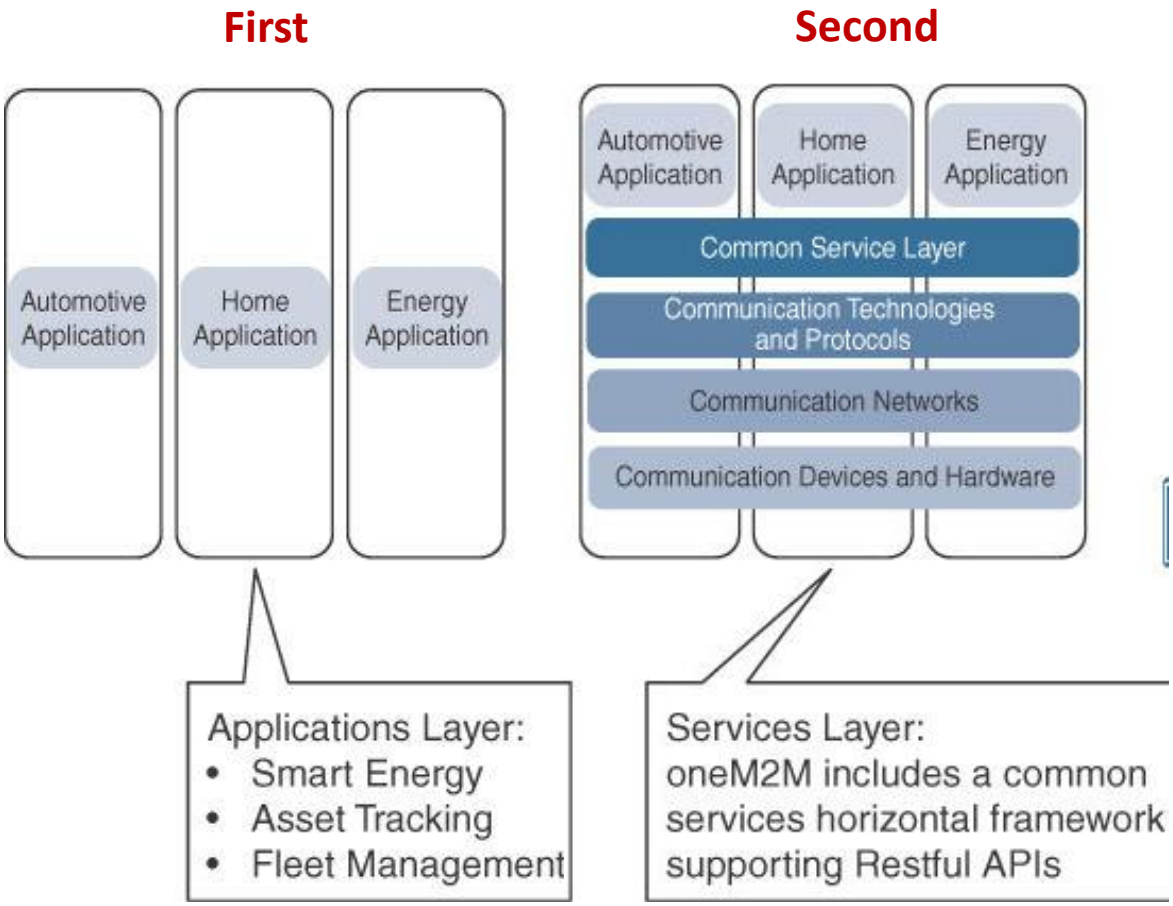

- top is the common services layer
- This layer adds APIs and middleware supporting third-party services and applications.
- Service layer can be readily embedded within various hardware and software nodes
- A **RESTful API** uses HTTP requests to GET, PUT, POST and DELETE **data**.

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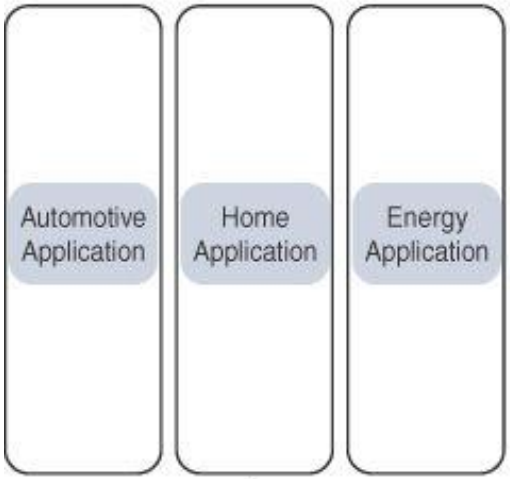
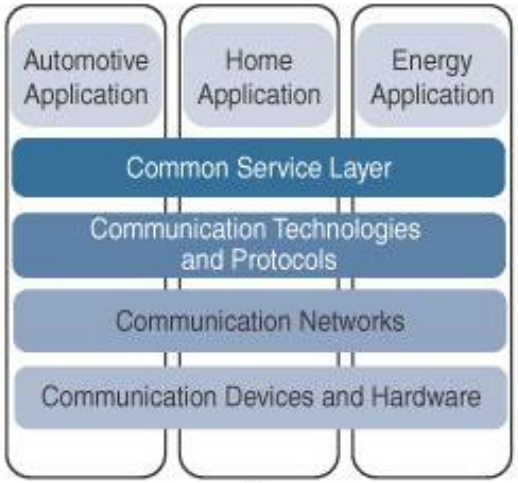


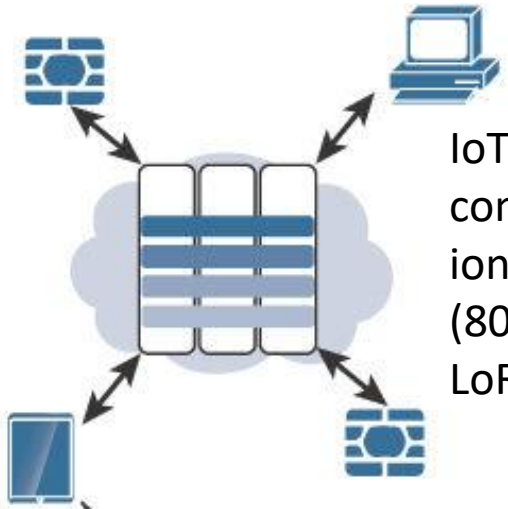
Applications Layer:
- Smart Energy
- Asset Tracking
- Fleet Management

Second



Services Layer:
oneM2M includes a common services horizontal framework supporting Restful APIs

Third

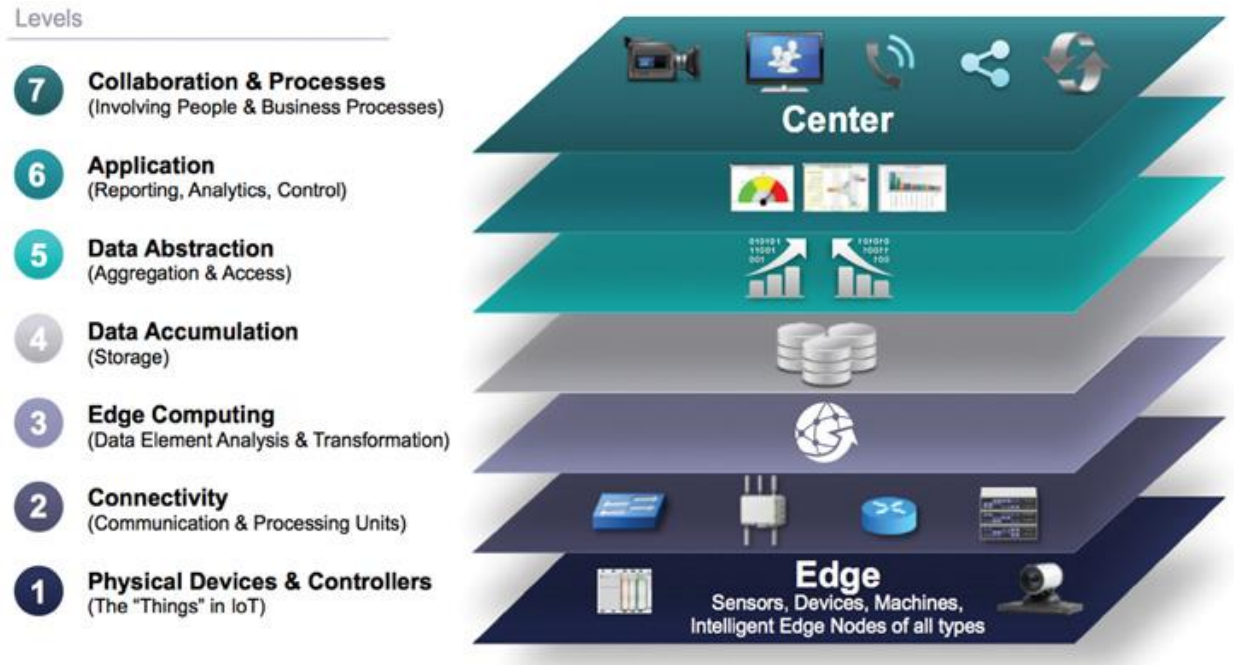


IoT devices, communication network (802.15.4, LoRa, WiFi)

Network Layer:
Applications talk to the APIs to communicate to sensors

IoTWF Architecture

- IoTWF architectural committee (led by Cisco, IBM, Rockwell Automation, and others)



- offers a clean, simplified perspective on IoT
- includes edge computing, data storage, and access
- succinct way of visualizing IoT from a technical perspective

- Control flowing from the center to the edge
- Decompose the IoT problem into smaller parts
- Identify different technologies at each layer
- Different parts of a system can be provided by different vendors
- Tiered security model enforced at the transition points between levels
- Define interfaces that leads to interoperability

Layers 1 & 2

Layer 1: Physical Devices and Controllers Layer

- home of the “things” in IoT
- “things” can be from a microscopic sensors to giant machines in a factory
- primary function is generating data
- capable of being queried and/or controlled over a network.

Layer 2: Connectivity Layer

- focus is on connectivity

② **Connectivity**
(Communication and Processing Units)

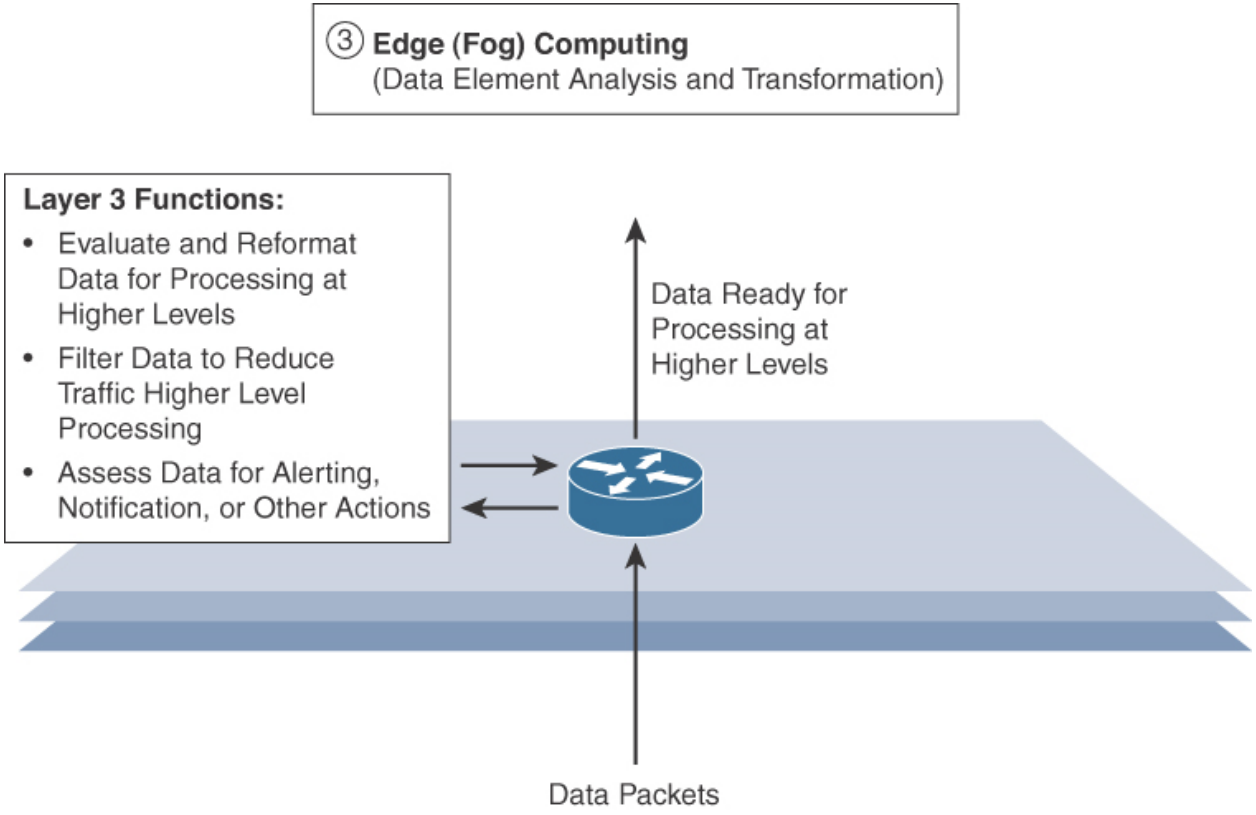
Layer 2 Functions:

- Communications Between Layer 1 Devices
- Reliable Delivery of Information Across the Network
- Switching and Routing
- Translation Between Protocols
- Network Level Security

Layer 3

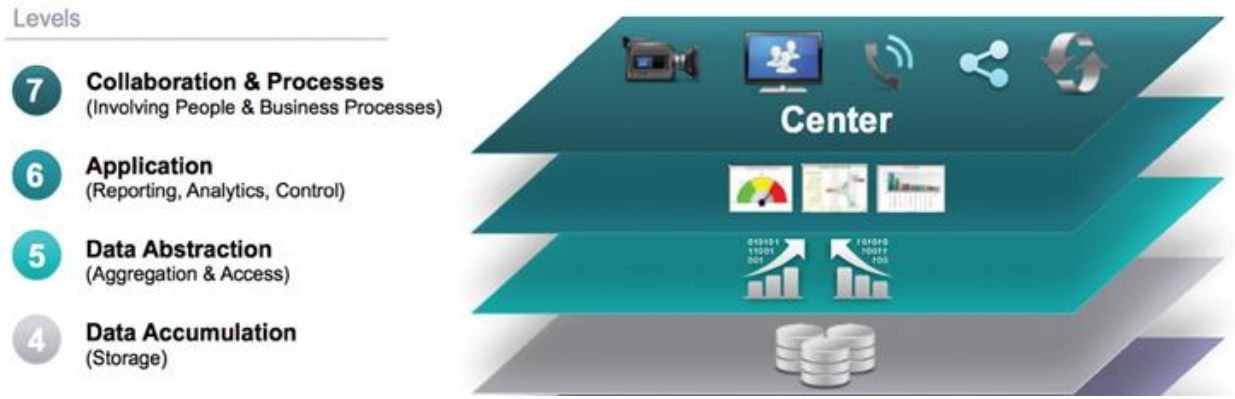
Layer 3: Edge Computing Layer

- often referred to as the "fog" layer
- emphasis is on data reduction and converting network data flows



Basic principle: information processing is initiated as early and as close to the edge of the network as possible.

Upper Layers: Layers 4–7

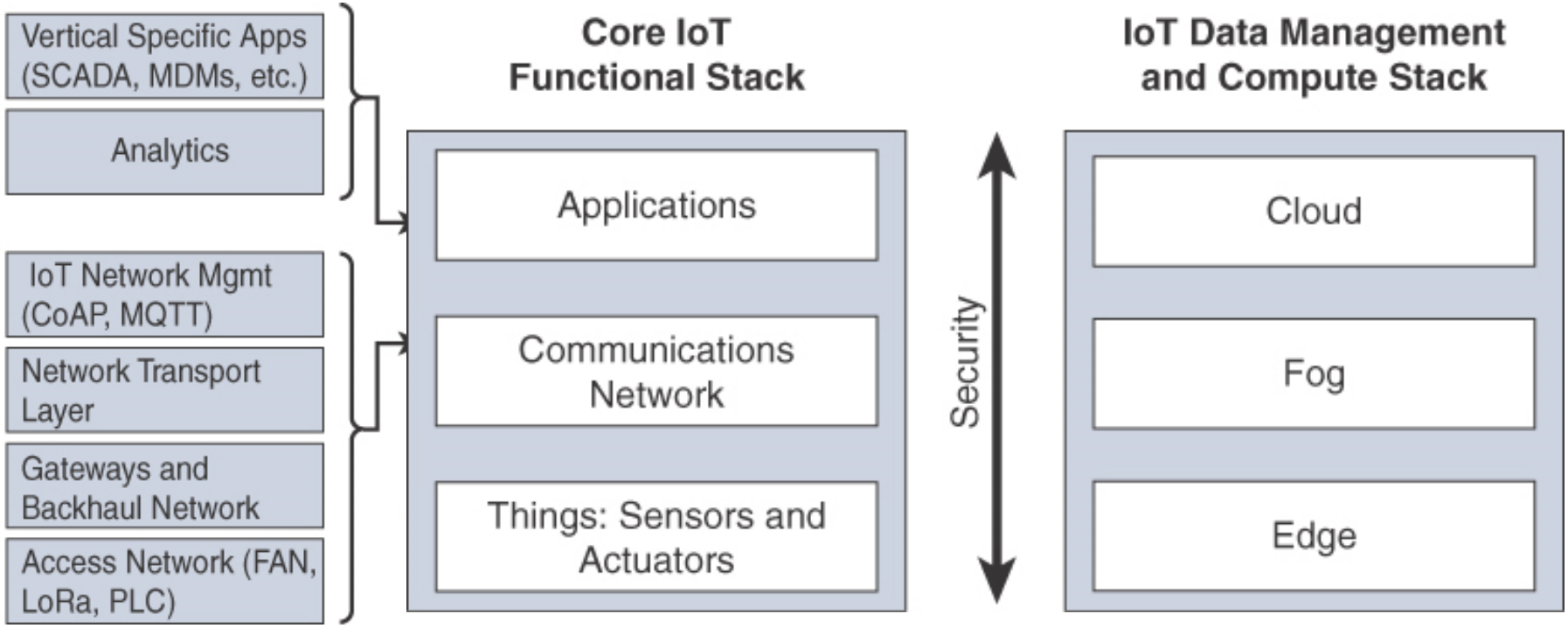


Layers	Functions
Layer 4: Data Accumulation layer	• Captures data and stores it for applications • Convert event-based data to query-based processing
Layer 5: Data Abstraction layer	• Reconciles multiple data formats • Ensures consistent semantics for various data sources • Confirmation about dataset completeness
Layer 6: Application layer	• Interpret data using software applications • Applications may monitor, control, and provide report based on analysing the data
Layer 7: Collaboration and processes layer	• Consumes and shares the application information • Collaborating and communicating IoT information

Simplified IoT Architecture

- It highlights the fundamental building blocks that are common to most IoT systems and which is intended to help in designing an IoT network.

- IoT architectural framework is presented as two parallel stacks
  - Core IoT Functional Stack
  - IoT Data Management and Compute Stack



Thanks!

Figures and slide materials are taken from the following sources:

1. David Hanes *et al.*, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, 1st Edition, 2018, Pearson India.