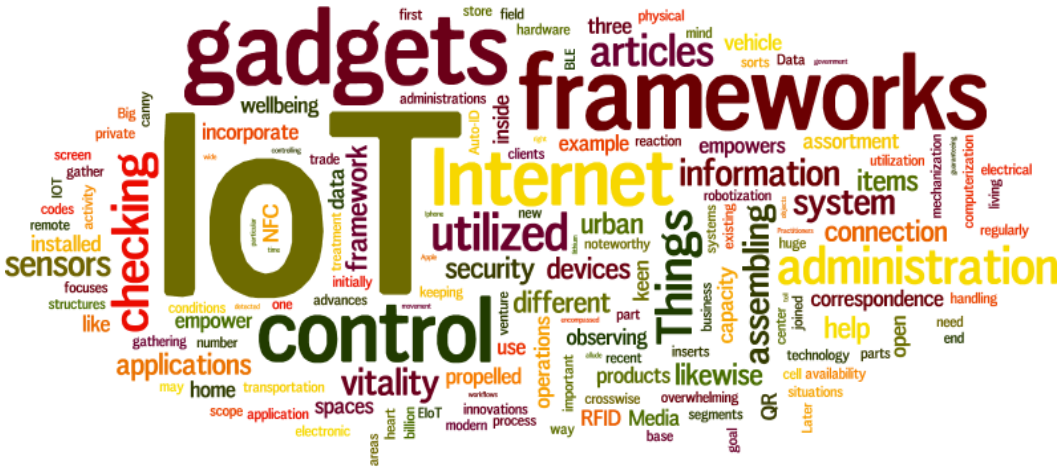
# CS578: Internet of Things

## IoT Architecture

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

# Traditional Data Flow in IoT

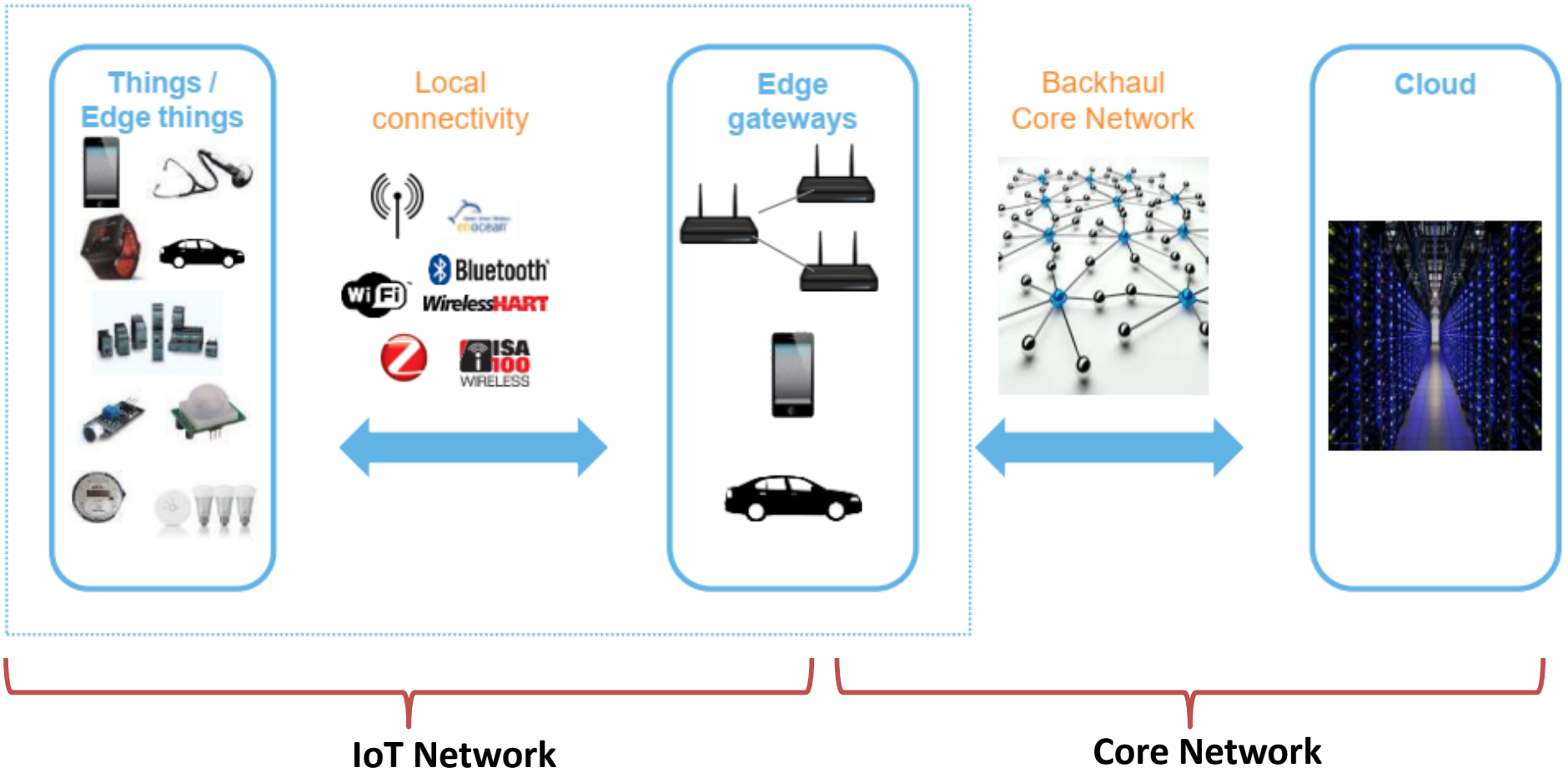
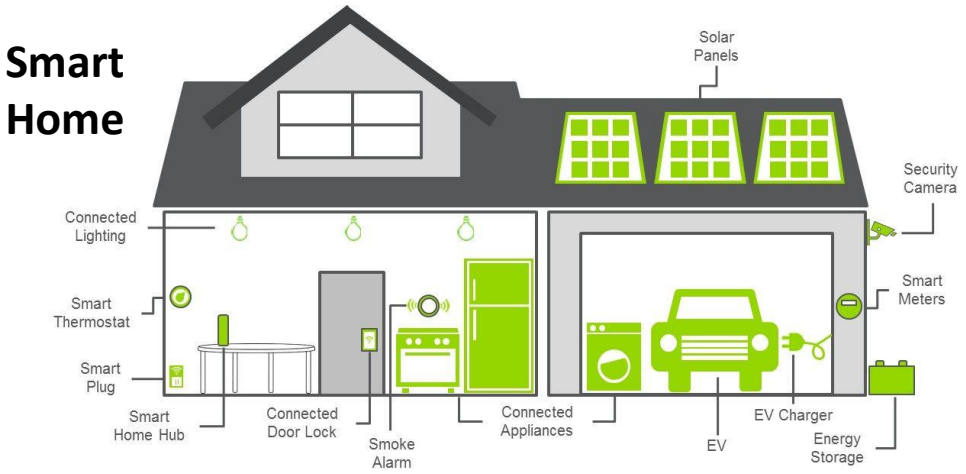



Image Source: http://events17.linuxfoundation.org/sites/events/files/slides/Intelligence%20at%20the%20Edge.pdf

# What is Architectural Plan?

- In present days, networks run the modern business
- So, it should never be built without careful planning

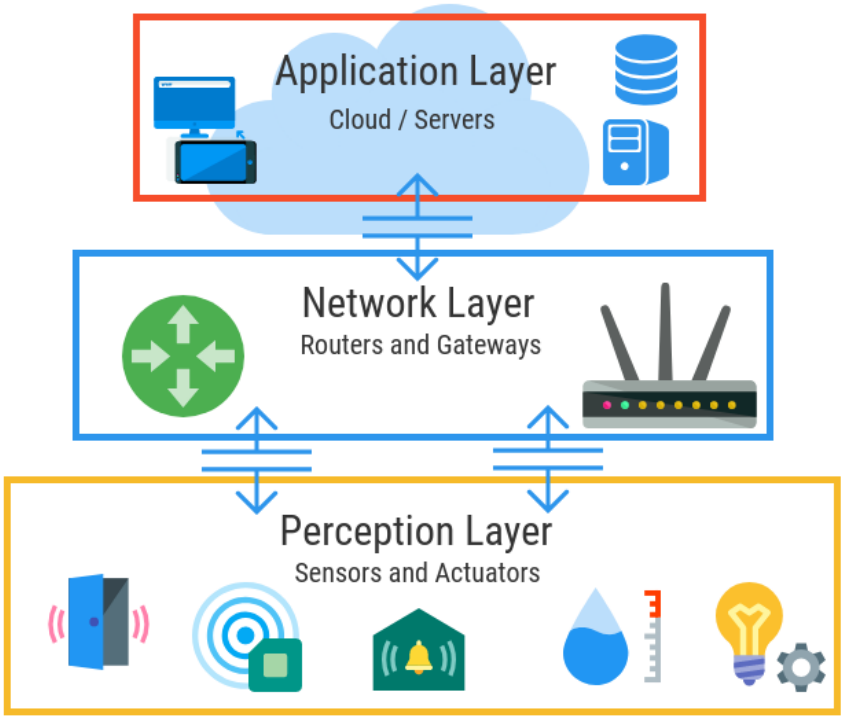



- Architecture is how you design (i.e. graphical structure) your application or solution.
- Essence of IoT architecture:
  - how the data is
    - transported,
    - collected,
    - analyzed, and
    - ultimately acted upon.

Driving forces:

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

# Basic 3-Layer architecture




- **Perception layer** is the physical layer, which has sensors for sensing and gathering information about the environment.
- **Network layer** is responsible for connecting to other smart things, network devices, and servers. Its features are also used for transmitting and processing sensor data.
- **Application layer** is responsible for delivering application specific services to the user.
  - For example, smart homes, smart cities, smart health, etc.

Source: https://www.pinterest.com/pin/641129696942354756/

# Emergence of Standard IoT Architecture

- However, the basic 3-layer architecture did not address many issues.
  - e.g. Compatibility, Safety & Security, Reusability, Heterogeneity, etc.
- In fact, the IoT did not have any standard defined architecture of working which is strictly followed universally.


Few Issues:

- Highly fragmented marked with limited vendor-specific applications
- Each silo contains its own technologies without interoperability
- Incompatibility for seamless integration between heterogeneous applications and devices

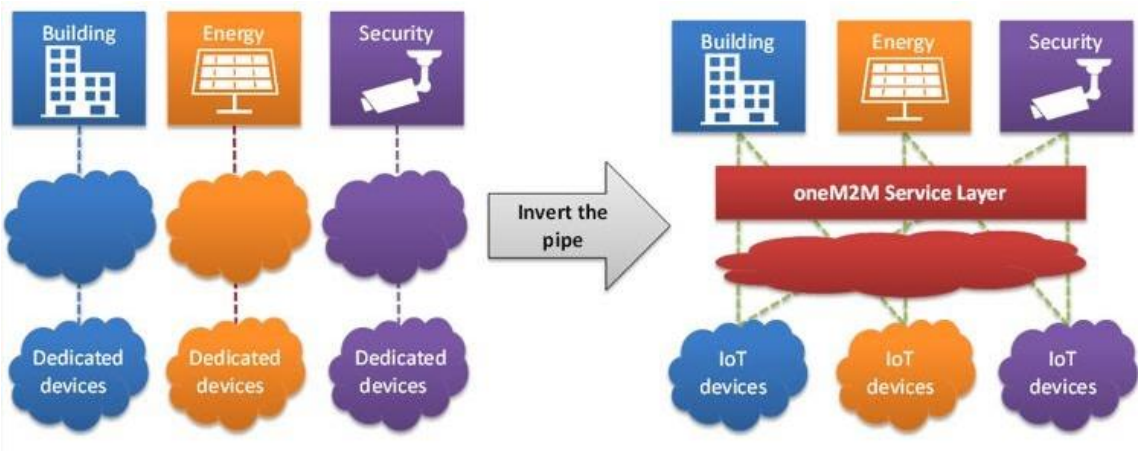
- So, in the past several years, architectural standards and frameworks have emerged
- Two best-known architectures:
  - oneM2M architecture
  - IoT World Forum architecture

Source: https://onem2m.org/using-onem2m/developers/basics

# oneM2M Architecture

Goal of **oneM2M** architecture:

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




## Challenges in IoT Architecture:

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

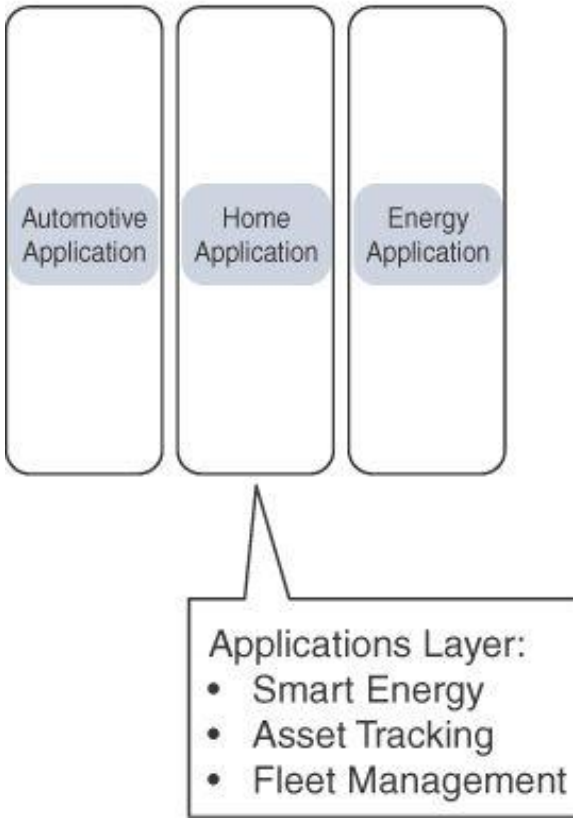
- Using the smart building use case, a security application can detect when nobody is in the building.
- It could then trigger lights to be switched off and for the HVAC system to operate on a reduced setting.

Image Source: https://onem2m.org/using-onem2m/developers/basics

# oneM2M Architecture

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

**First**




- Defines **application-layer protocols**
- Attempts to standardize **northbound API**
  - API stands for Application Programming Interface.

  Note: Interface can be thought of as a contract of service between two applications or parties. This contract defines how the two communicate with each other using requests and responses.

- 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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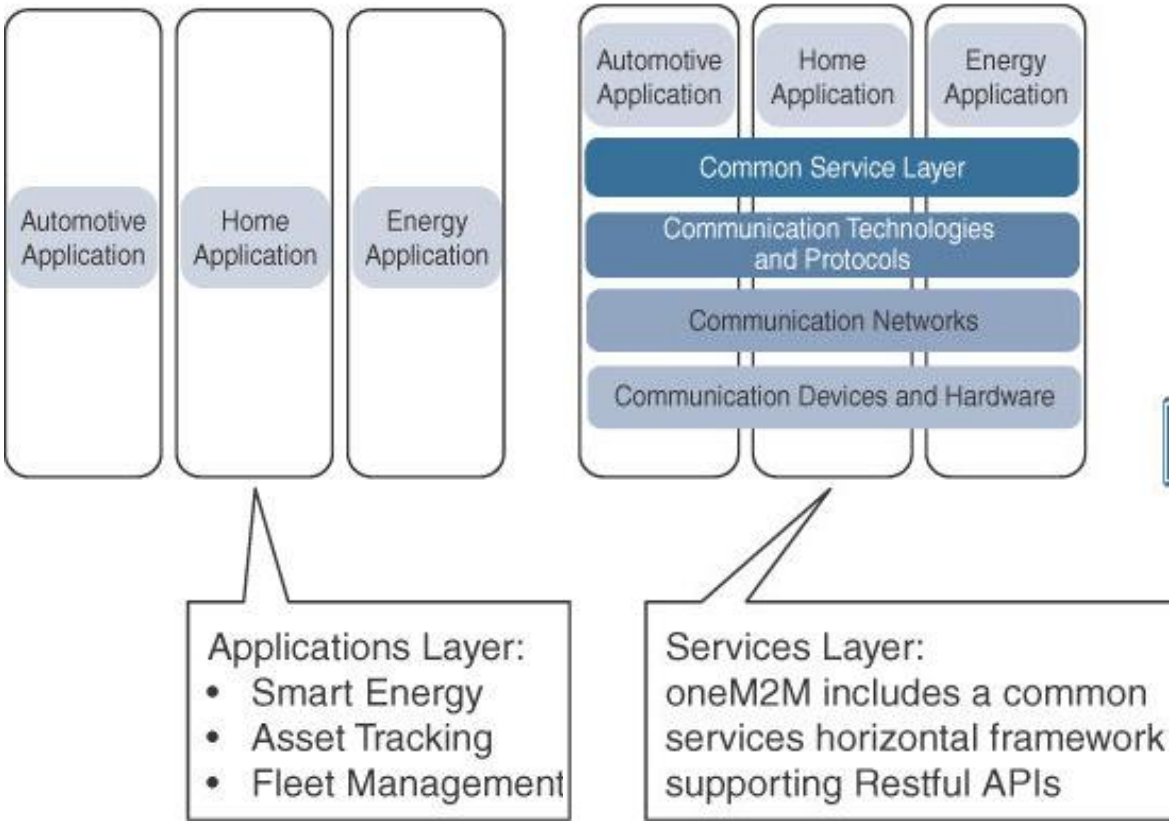


**Second**




- 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

cont…

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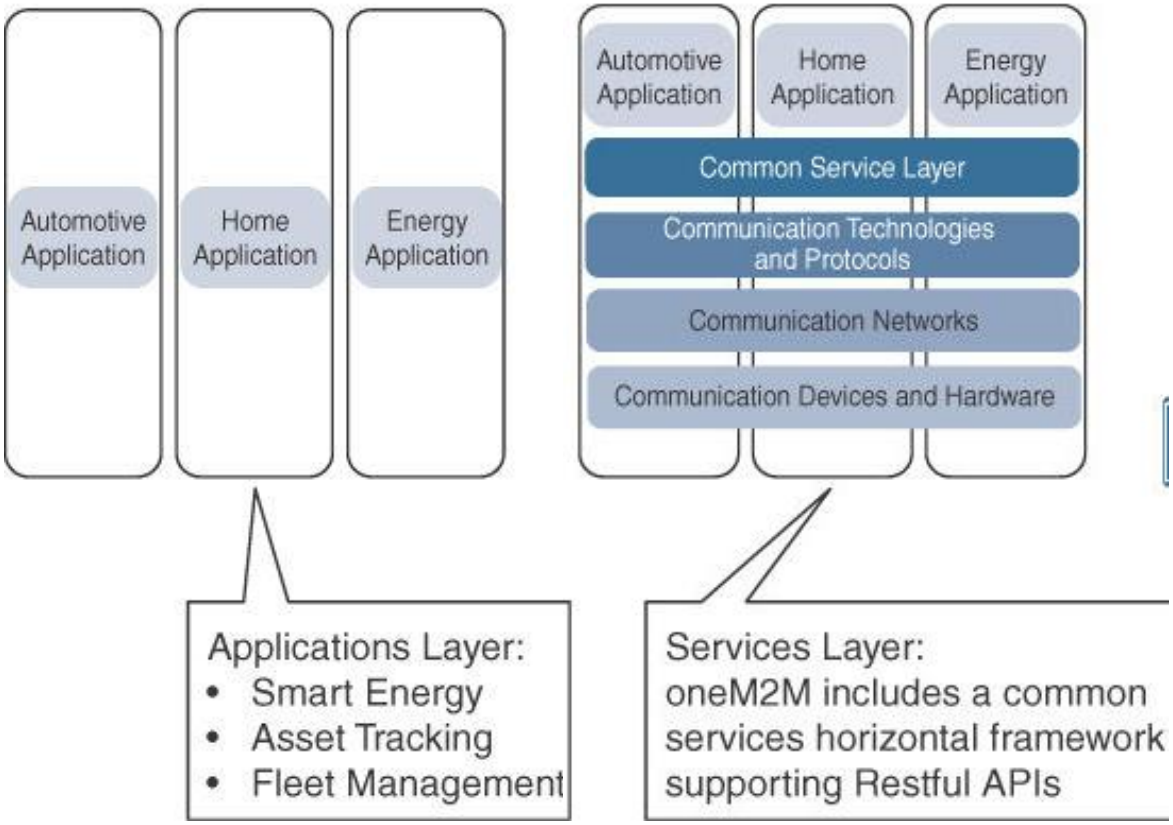


**Second**




- 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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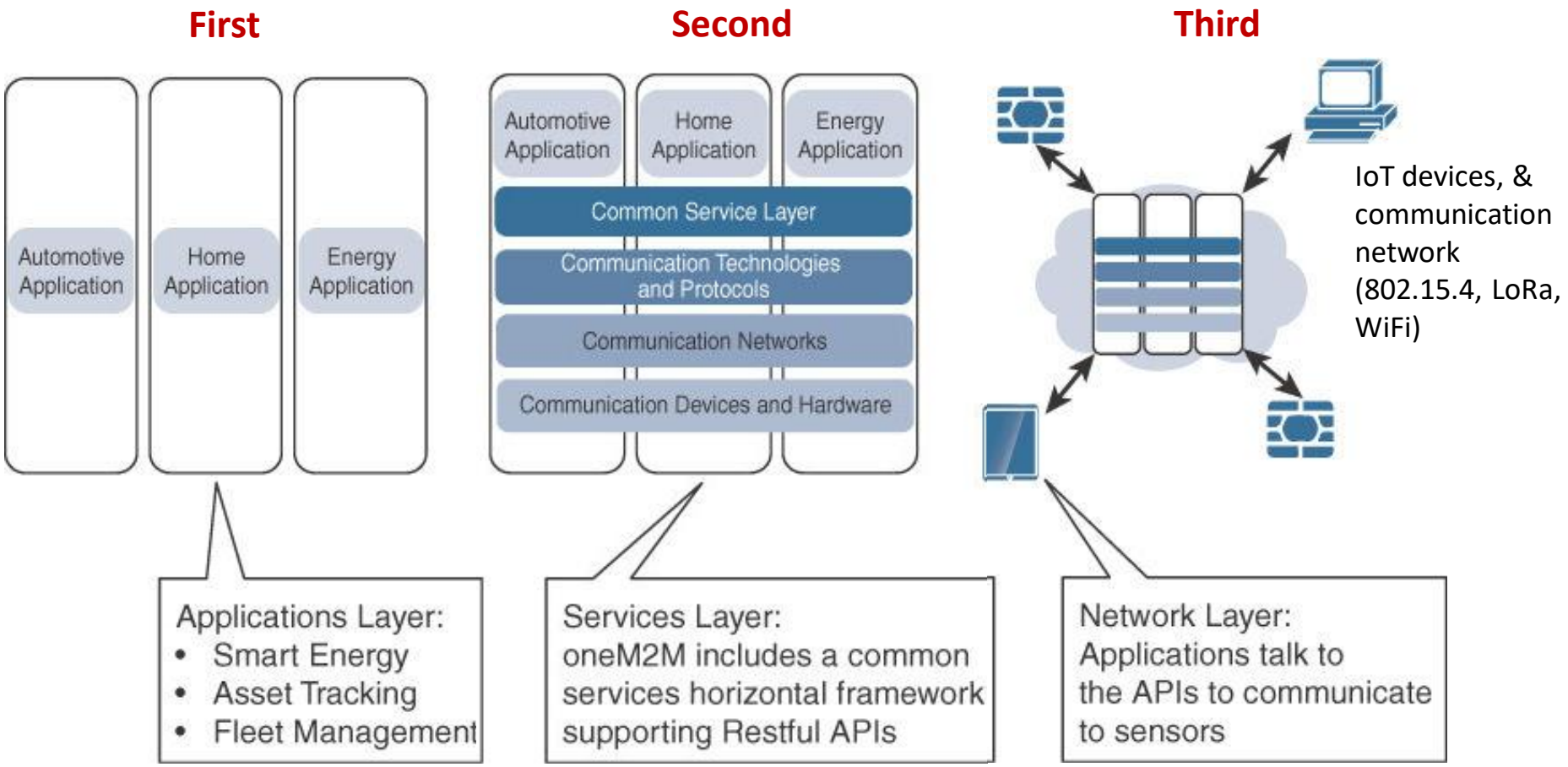
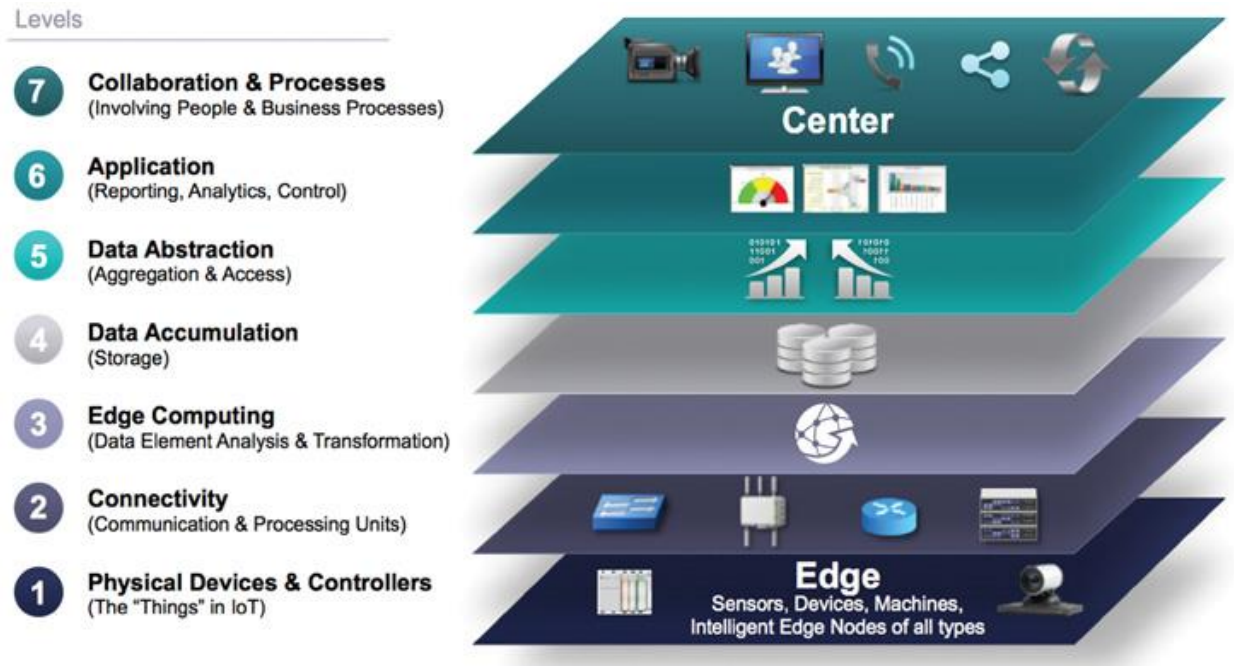


# IoTWF Architecture – 7 Layer Stack

- 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

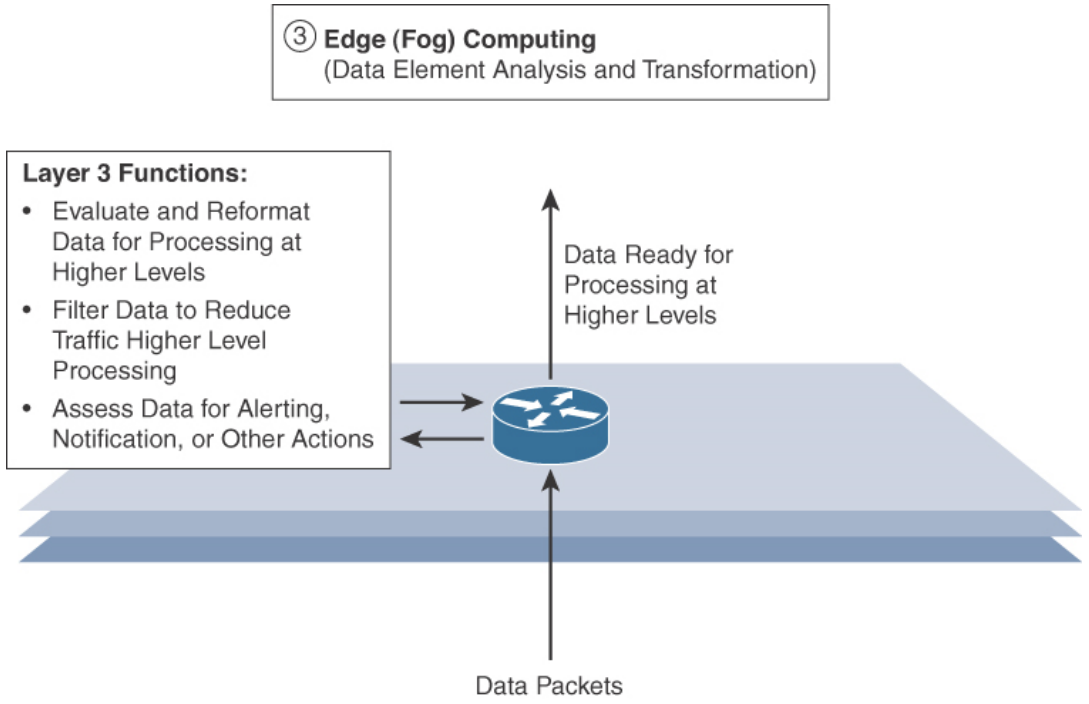
# Layer 3 : Fog Layer

**Layer 3**: Edge Computing Layer

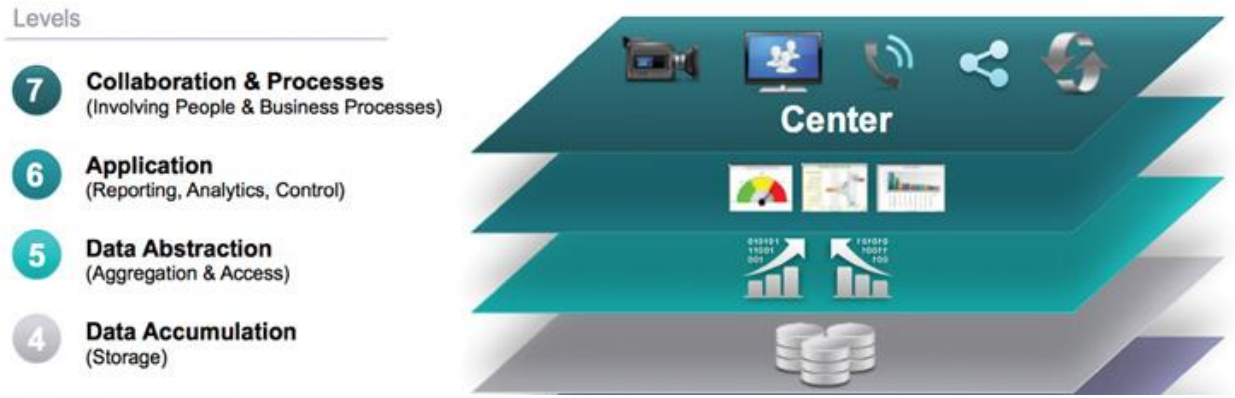
- often referred to as the "fog" layer
- emphasis is on
  - Data reduction by filtering and cleaning up
  - Reformatting and compressing data
  - Initial processing of data (e.g. alert generation, data validation, etc)

**Basic principle**:

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



# Upper Layers: Layers 4–7

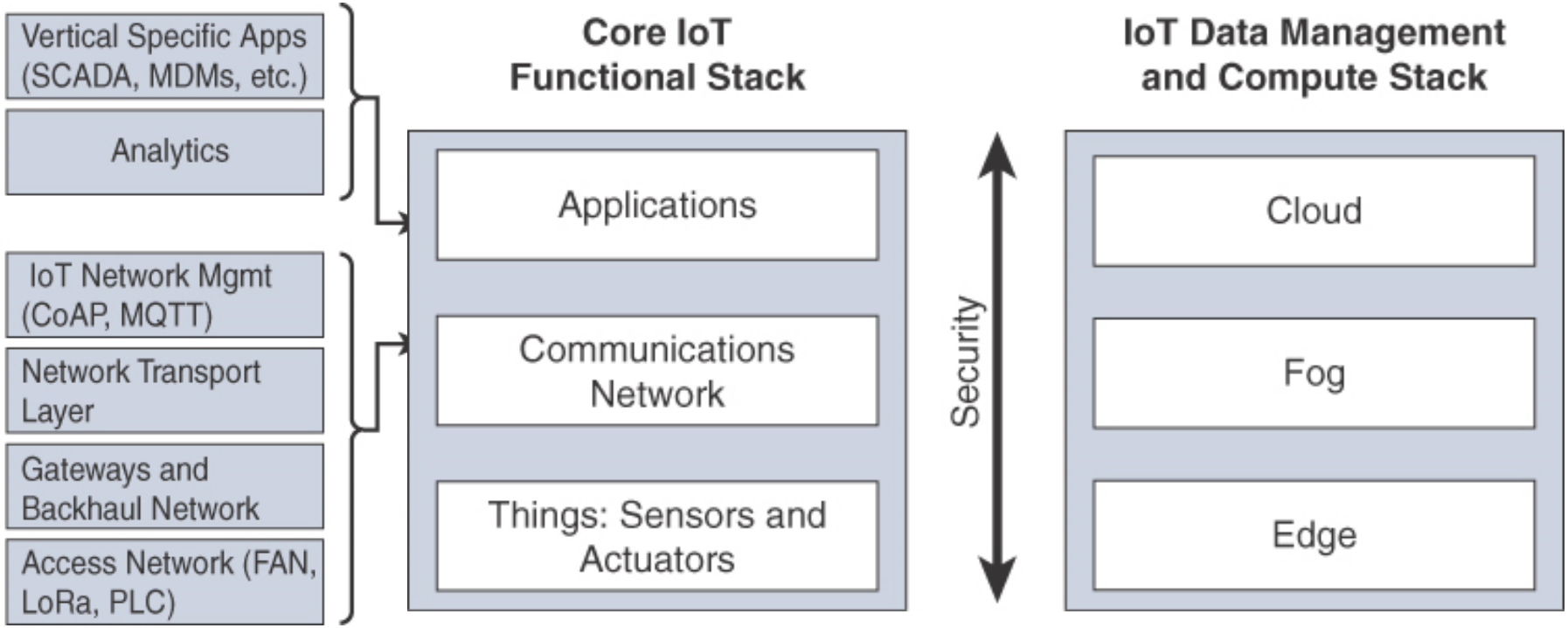



| Layers | Functions |
|---|---|
| **Layer 4**: Data Accumulation | • Captures data and stores it for applications<br>• Convert event-based data to query-based processing |
| **Layer 5**: Data Abstraction | • Reconciles multiple data formats<br>• Ensures consistent semantics for various data sources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



# Lessons Learned

- ✓ What is the need of IoT architecture?
- ✓ Different type of IoT Architectures
- ✓ About oneM2M architecture
- ✓ About IoT WF architecture
- ✓ About Simplified IoT Architecture

# 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.