SNJB's KBJ College of Engineering

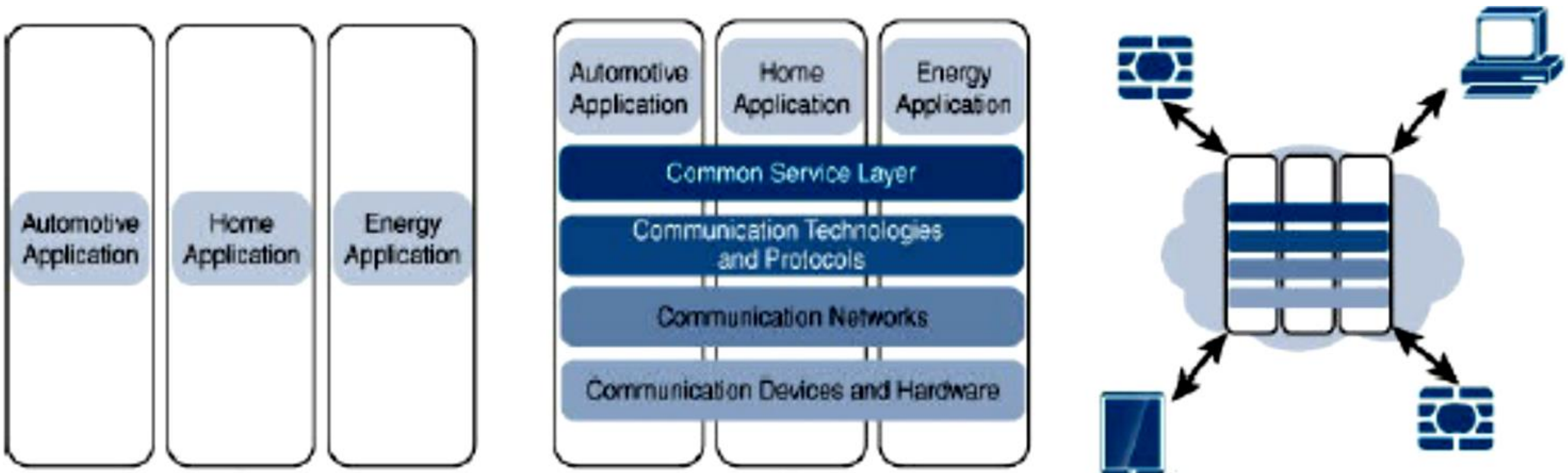
Chandwad–423101 (Nashik)

Department
of
Information Technology

Subject : Internet of Things (IOT) of BE 2015 Pattern

Unit 2
IoT NETWORK ARCHITECTURE AND DESIGN

One M2M IoT Standardized Architecture



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

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

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

One M2M IoT Standardized Architecture

- The one M2M architecture divides IoT functions into three major domains:
  - Application Layer
  - Services Layer
  - Network Layer
- Promotes interoperability through IT-friendly APIs & support wide range of IoT technologies

Application Layer

- The one M2M architecture gives major focus on connectivity between devices and their applications
- Includes the application-layer protocols
- Attempts to standardize northbound API definitions for interaction with BI systems
- Applications tend to be industry-specific and have their own sets of data models
- Thus shown as vertical entities

Services Layer

- Shown as horizontal framework across the vertical industry applications
- At this layer, horizontal modules include
  - Physical network that IoT applications run on
  - Underlying management protocols
  - Hardware
- Examples include backhaul communications via cellular, MPLS networks, VPNs, and so on

Services Layer

- Riding on top is the common services layer.
- This conceptual layer adds APIs & middleware supporting third-party services & applications

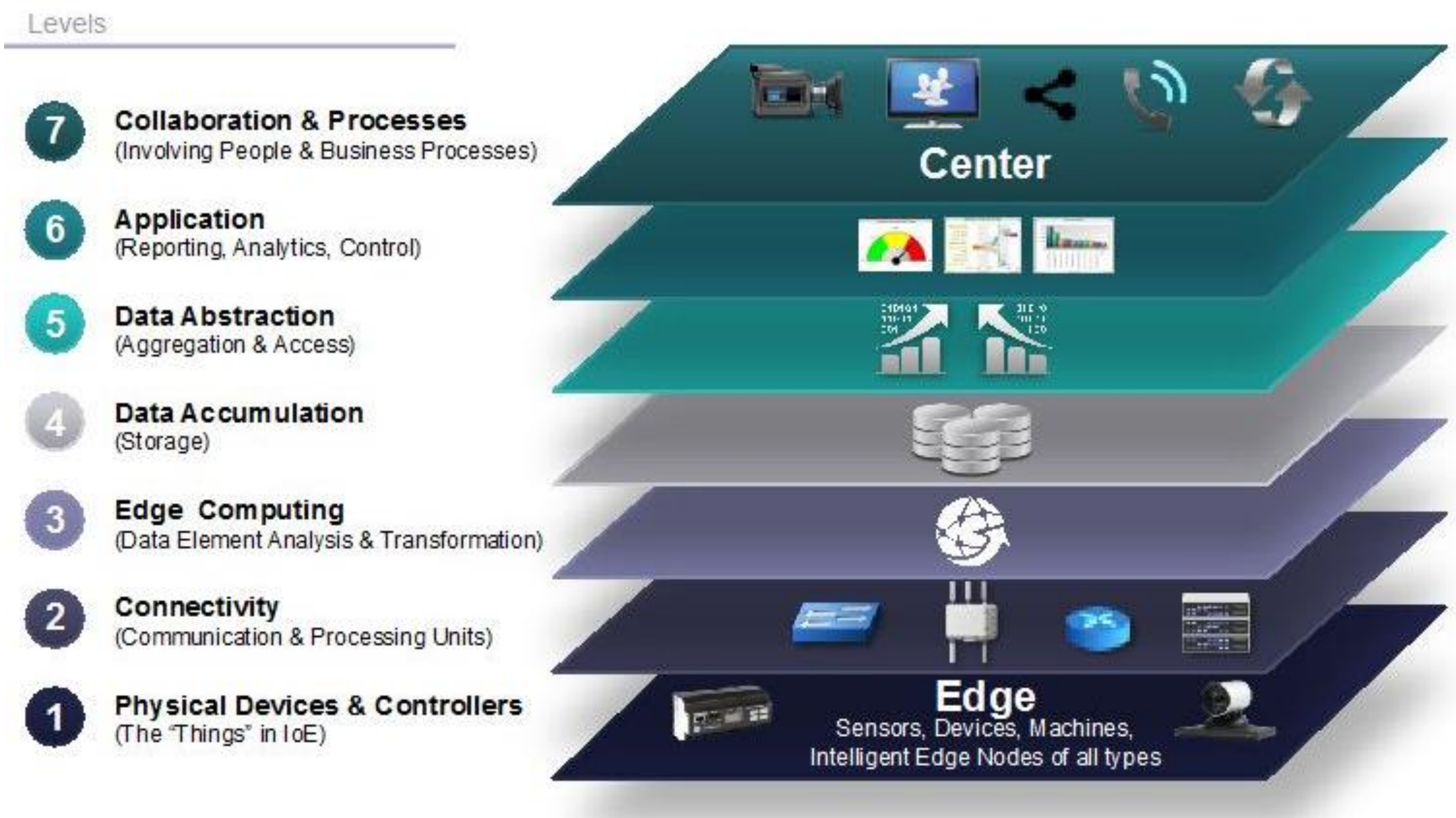
Network Layer

- Communication domain for the IoT devices and endpoints
- Includes devices themselves and the communications network that links them
- Examples include wireless mesh technologies, such as IEEE 802.15.4, and wireless point-to-multipoint systems, such as IEEE 801.11ah

IoT World Forum (IoTWF) Standardized Architecture

- IoTWF architectural committee published 7-layer IoT architectural reference model in 2014
- This committee was led by Cisco, IBM, Rockwell Automation, and others
- While various IoT reference models exist, the one put forth by the IoT World Forum offers clean, simplified perspective on IoT
- Includes edge computing, data storage, and access

IoT World Forum (IoTWF) Standardized Architecture



IoT World Forum (IoTWF) Standardized Architecture

- Defines set of levels with control flowing from the center (cloud service or dedicated data center), to the edge
- May includes sensors, devices, machines, and other types of intelligent end nodes
- In general, data travels up stack, originating from edge, and goes northbound to the center

IoT World Forum (IoTWF) Standardized Architecture

- Using this model, we are able to achieve:
  - Decompose the IoT problem into smaller parts
  - Identify different technologies at each layer and how they relate to one another
  - Define a system in which different parts can be provided by different vendors
  - Have a process of defining interfaces that leads to interoperability
  - Define a tiered security model that is enforced at the transition points between levels

Layer 1: Physical Devices and Controllers Layer

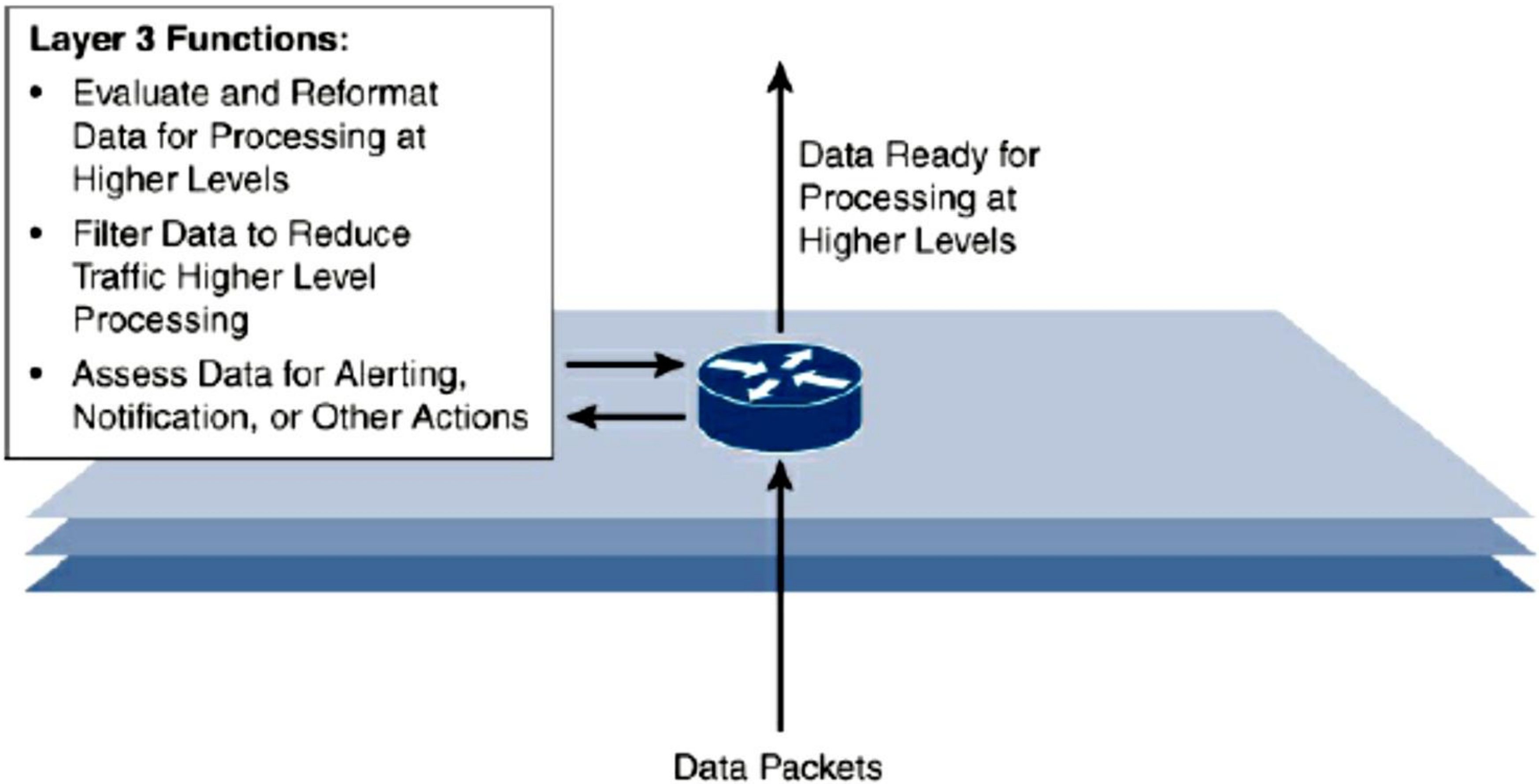
- This layer is home to the "things" in the IoT, including various endpoint devices & sensors
- Size of these "things" can range from almost tiny sensors to huge machines in factory
- Their primary function is generating data and being capable of being controlled over network

Layer 2: Connectivity Layer

Layer 2 Functions:

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

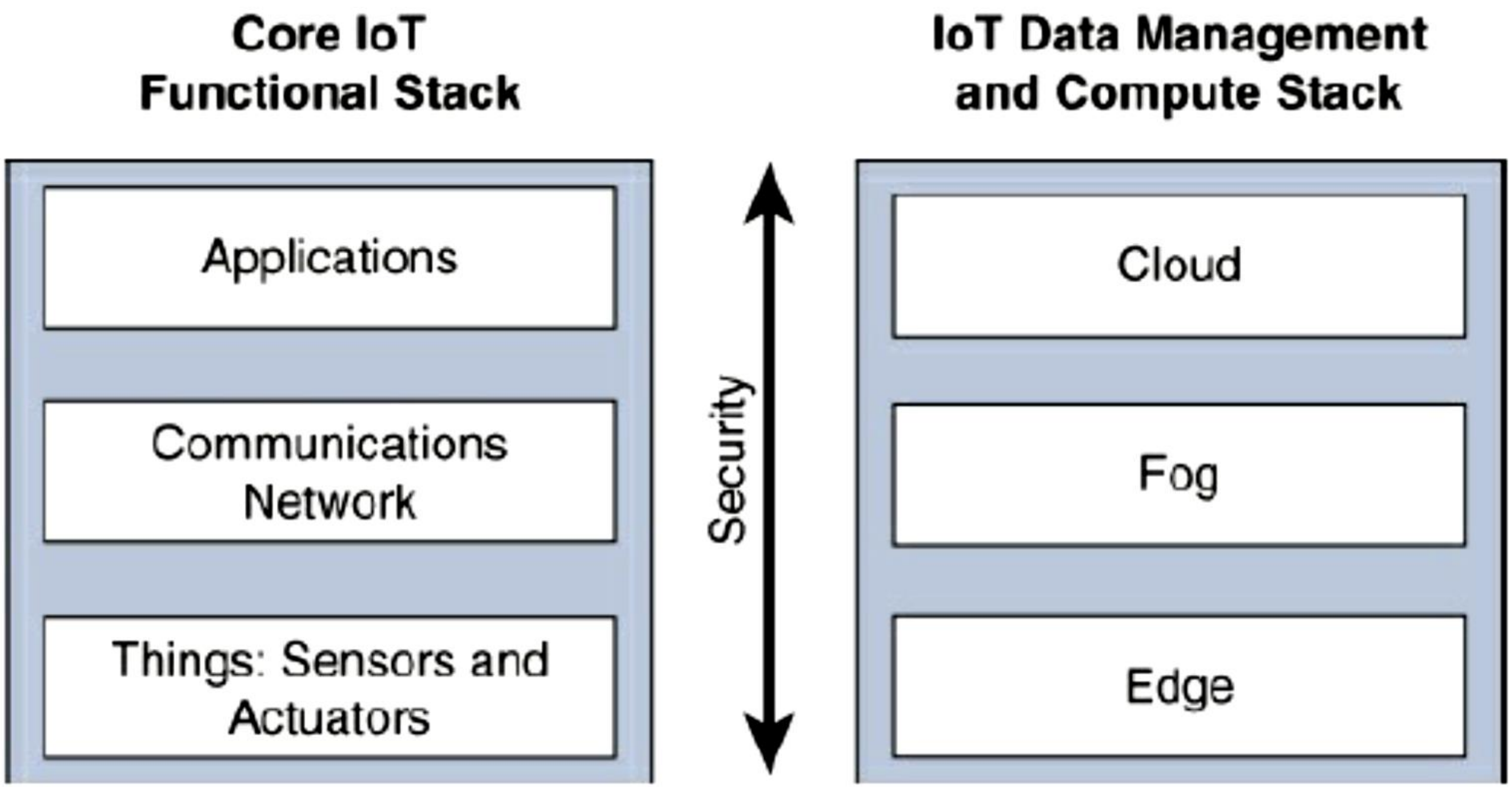
Layer 3: Edge Computing Layer



Upper Layers: Layers 4–7

IoT Reference Model Layer	Functions
Layer 4: Data accumulation layer	Captures data and stores it so it is usable by applications when necessary. Converts event-based data to query-based processing.
Layer 5: Data abstraction layer	Reconciles multiple data formats and ensures consistent semantics from various sources. Confirms that the data set is complete and consolidates data into one place or multiple data stores using virtualization.
Layer 6: Applications layer	Interprets data using software applications. Applications may monitor, control, and provide reports based on the analysis of the data.
Layer 7: Collaboration and processes layer	Consumes and shares the application information. Collaborating on and communicating IoT information often requires multiple steps, and it is what makes IoT useful. This layer can change business processes and delivers the benefits of IoT.

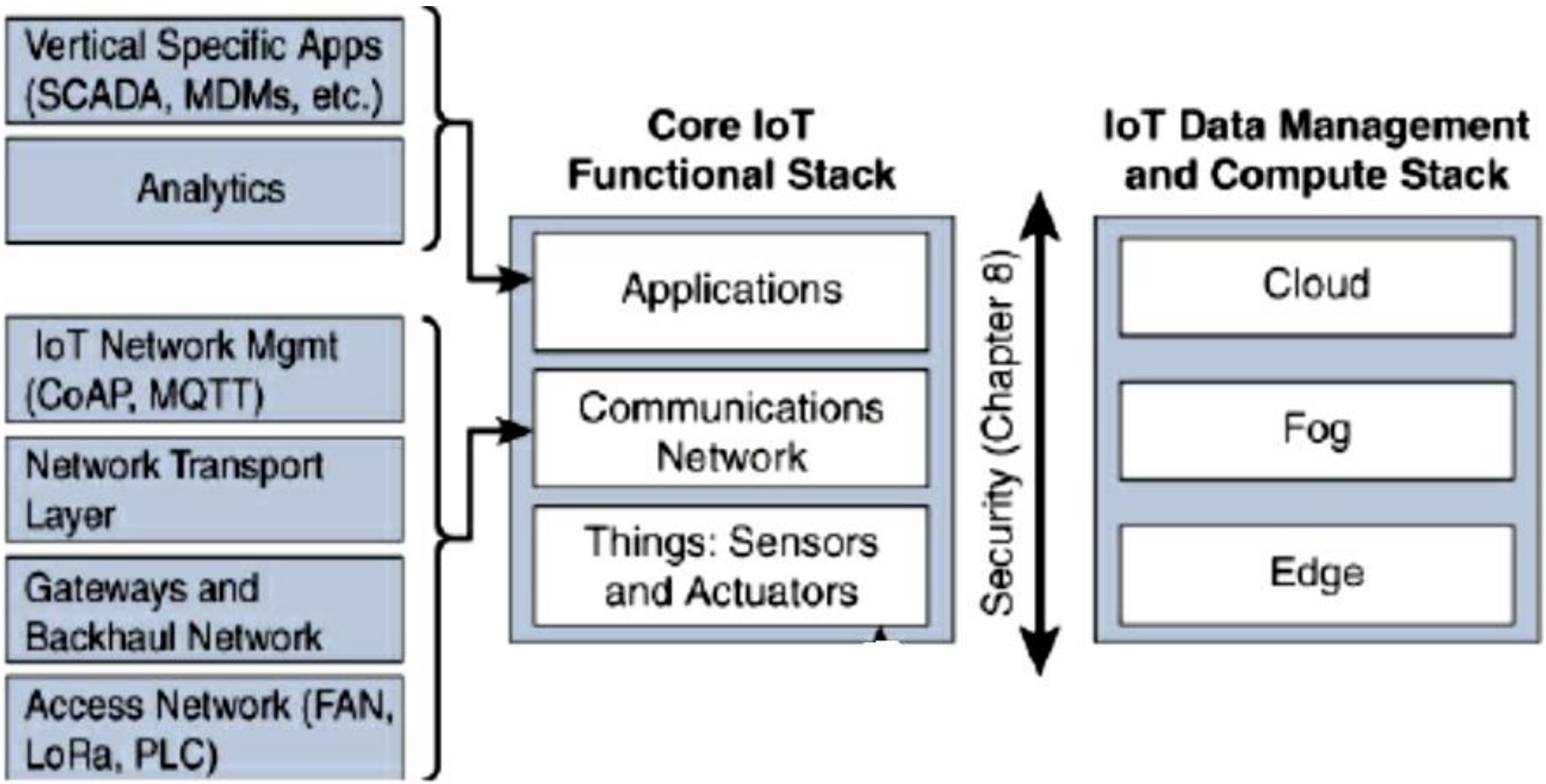
A Simplified IoT Architecture



A Simplified IoT Architecture

- Framework is presented as 2 parallel stacks:
  - IoT Data Management and Compute Stack
  - Core IoT Functional Stack
- Intention is to simplify the IoT architecture into its most basic building blocks

A Simplified IoT Architecture



Expanded View of the Simplified IoT Architecture

The Core IoT Functional Stack

- Every published IoT model include core layers, including “things,” a communications network, and applications
- Framework presented here separates core IoT & data management in parallel & aligned stack
- Allows you to carefully examine functions of both, network & applications, at each stage of complex IoT system

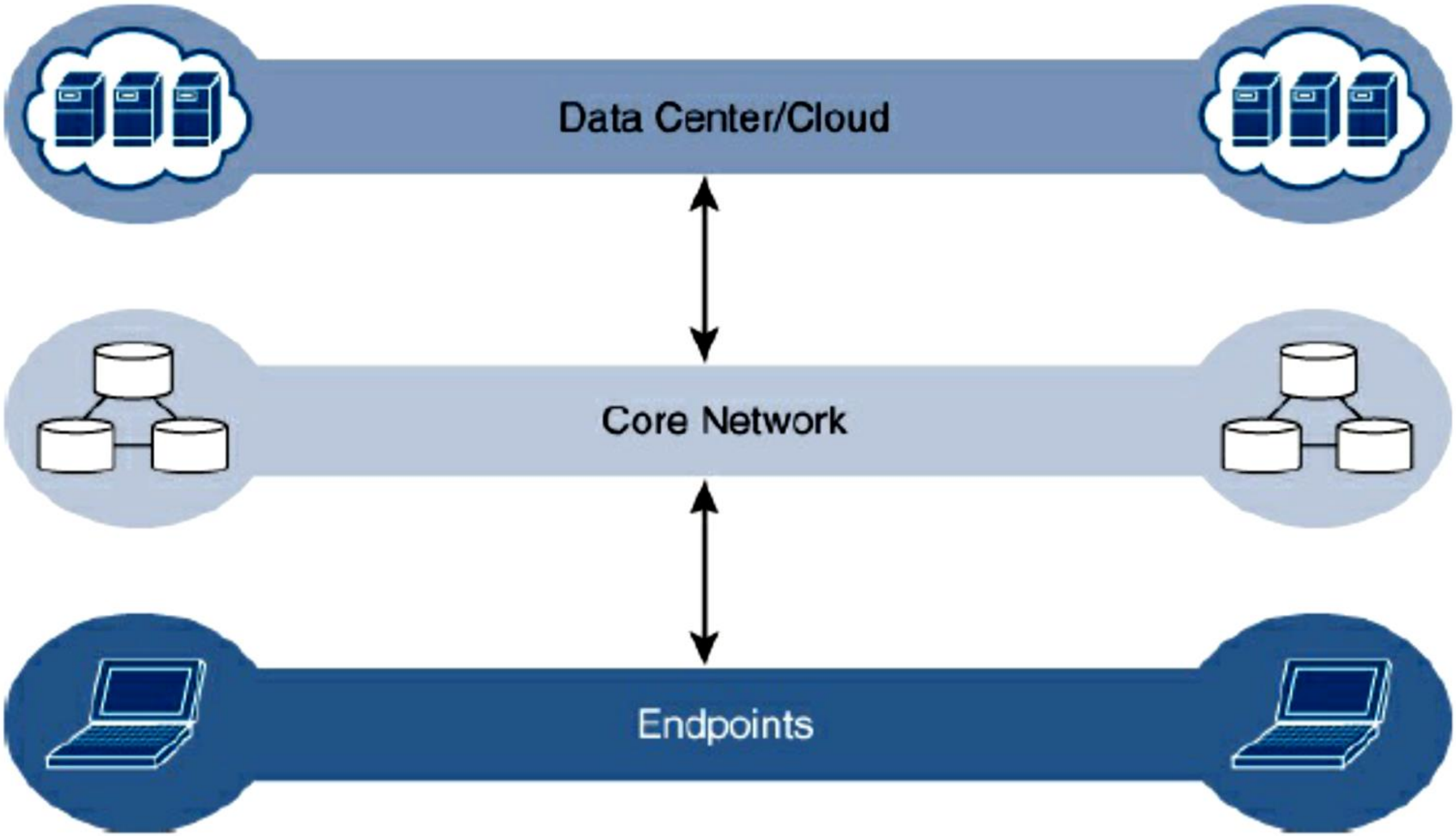
The Core IoT Functional Stack

- This separation gives you better visibility into the functions of each layer
- Presentation in 3 layers is meant to simplify your understanding of IoT architecture into its most foundational building blocks
- Such simple architecture needs to expanded

IoT Data Management and Compute Stack

- The “things” connected to the Internet are continuing to grow exponentially
- Cisco predicted that by 2020 there will be more than 50 billion devices connected to some form of an IP network
- If number of devices is beyond conventional numbers, surely the data generated by these devices must also be of serious concern

IoT Data Management and Compute Stack



IoT Data Management and Compute Stack

- Data-related problems need to be addressed:
  - Bandwidth in last-mile IoT networks is very limited
  - Latency can be very high (Instead of dealing with latency in the milliseconds range, large IoT networks latency of hundreds to thousands of milliseconds)
  - Volume of data transmitted can be high
  - Big data is getting bigger

Fog Computing

- Solution to the various challenges is to distribute data management throughout the IoT system, as close to the edge of the IP network as possible
- Best-known example of edge services in IoT is fog computing
- Any device with computing, storage, and network connectivity can be a fog node

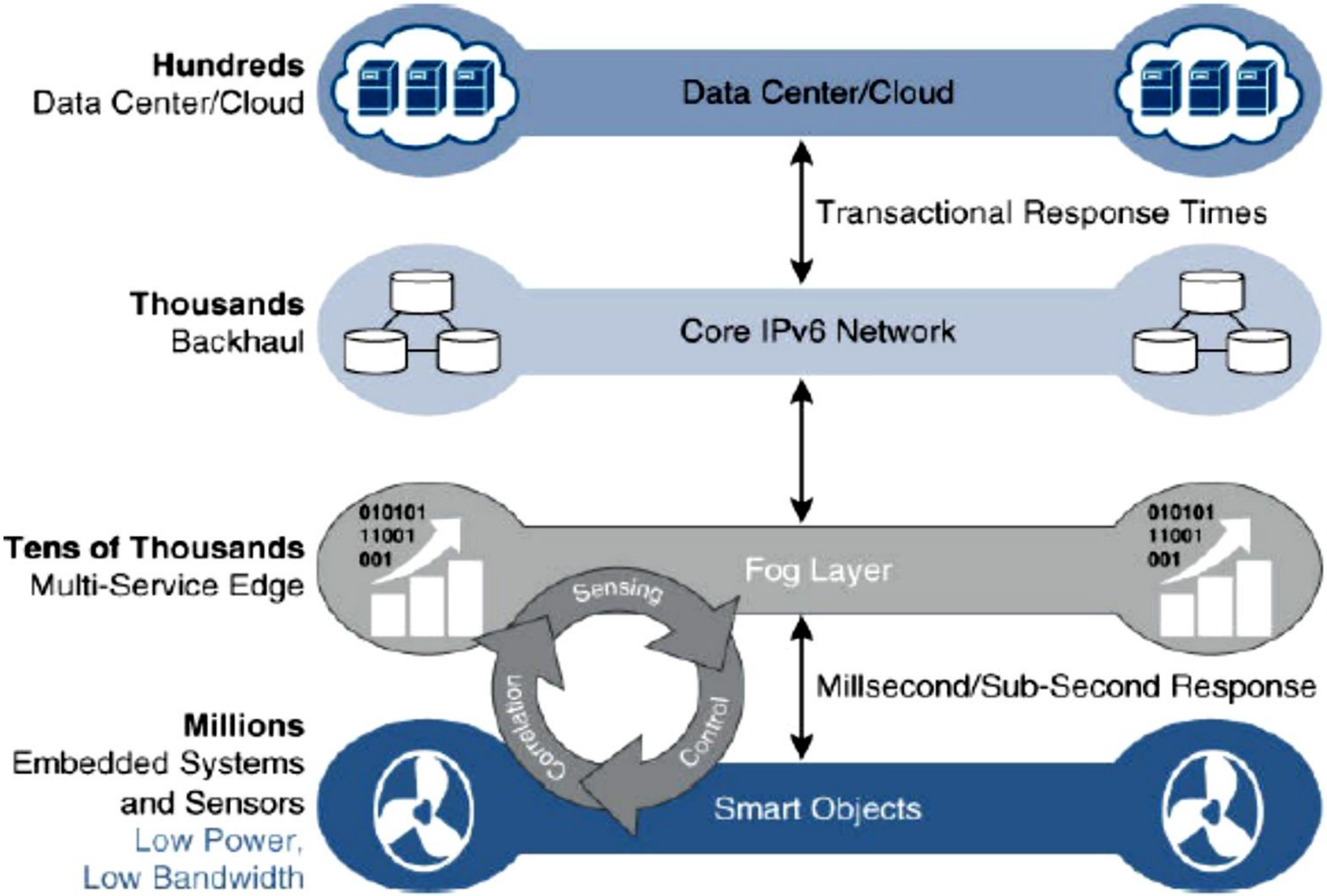
Fog Computing

- Concept of fog was first developed by Flavio Bonomi and Rodolfo Milito of Cisco Systems
- In world of IoT, fog gets name from a relative comparison to computing in cloud layer
- Like clouds exist in sky, fog rests near ground
- In the same way, the intention of fog computing is to place resources as close to the ground—that is, the IoT devices—as possible

Fog Computing

- Examples : industrial controllers, switches, routers, embedded servers, and IoT gateways
- An advantage of this structure is that fog node allows intelligence gathering (analytics) and control from the closest possible point
- In one sense, this introduces new layer to the traditional IT computing model, one that is often referred to as the “fog layer”

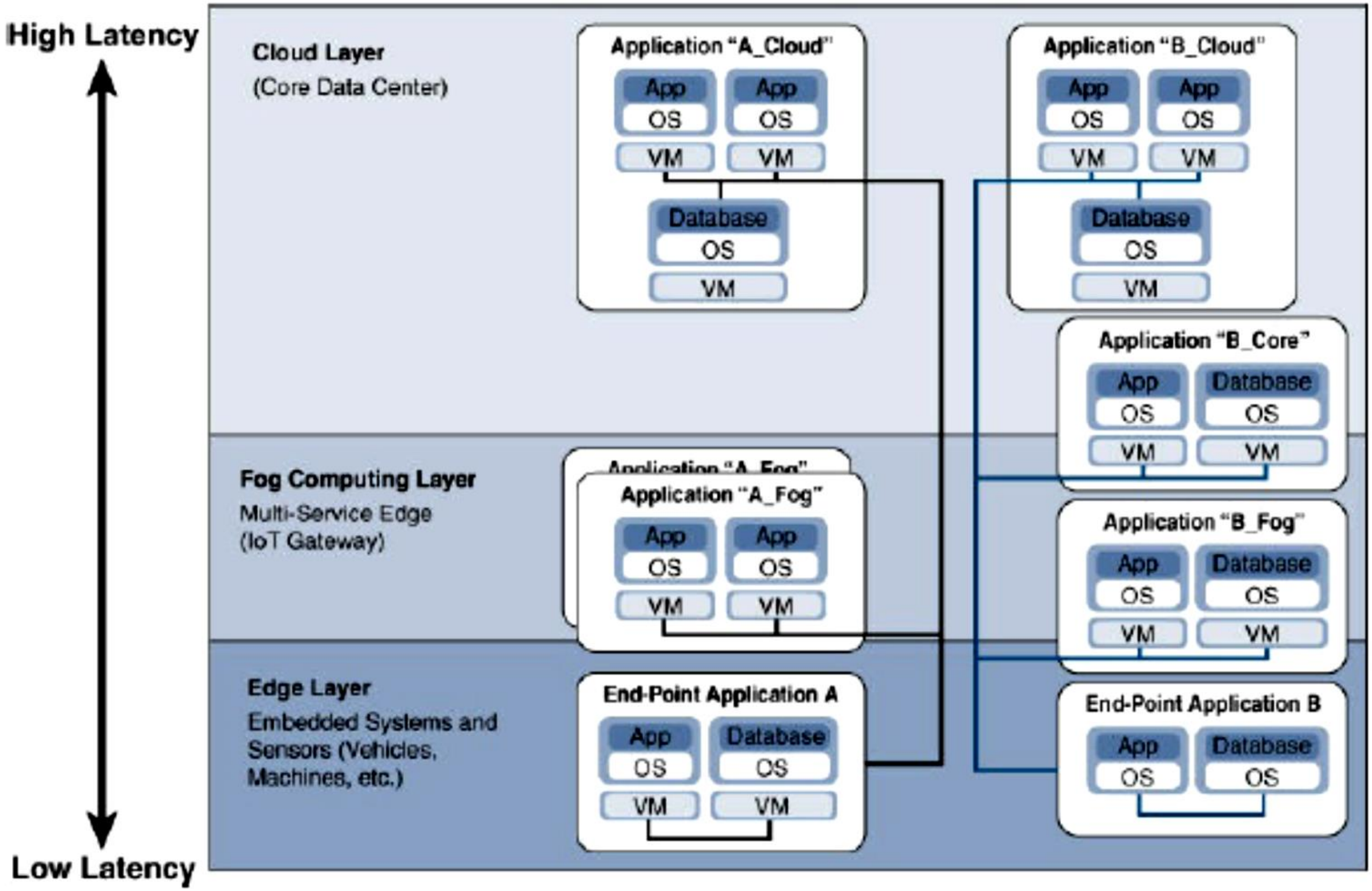
Fog Computing



Edge Computing

- Also called as “mist” computing
- If clouds exist in sky, and fog sits near ground, then mist is what actually sits on the ground
- Thus, concept of mist is to extend fog right into IoT endpoint device itself
- Fog computing solutions are being adopted by many industries

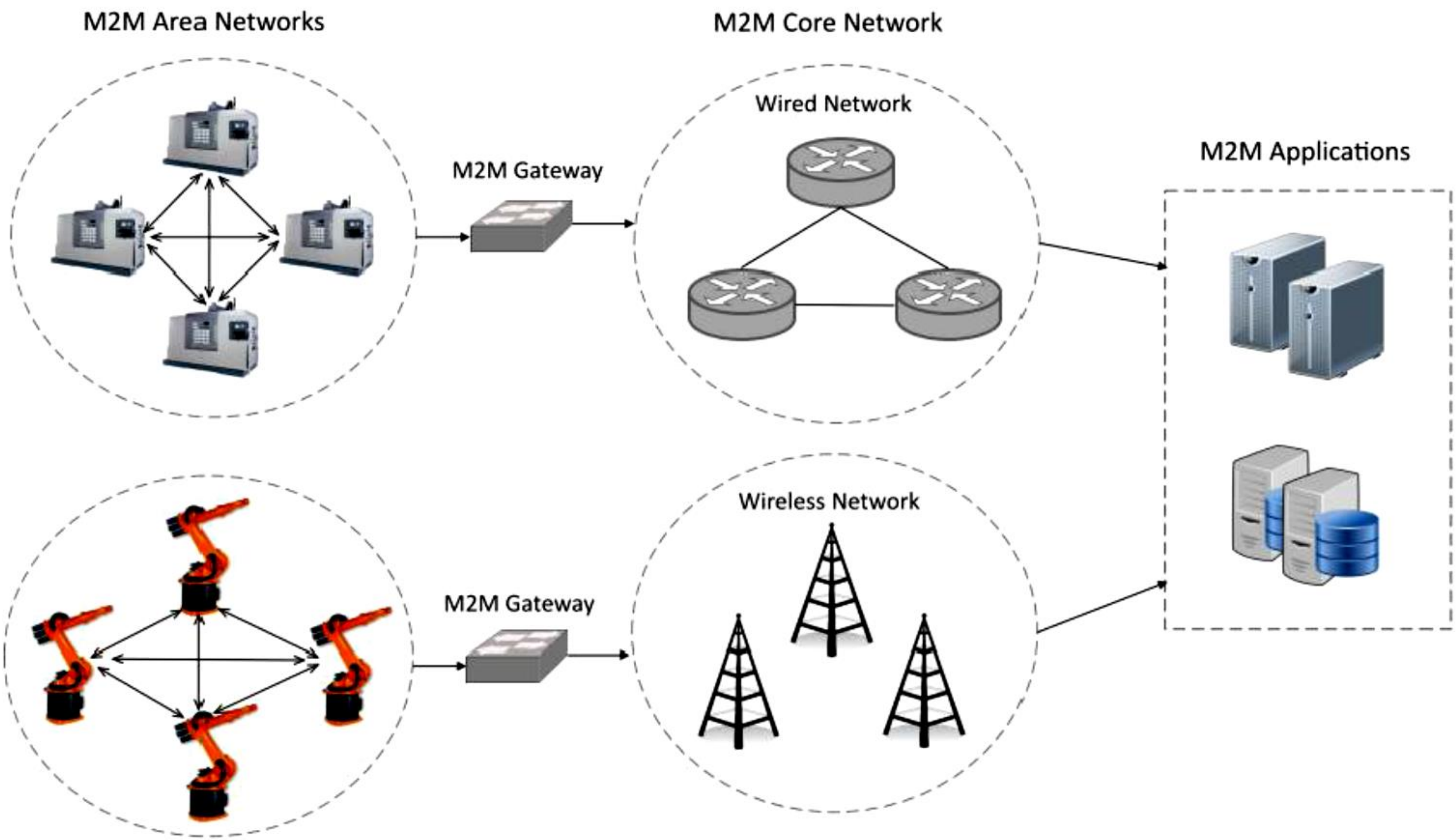
Hierarchy of Edge, Fog and Cloud



Introduction to M2M

- Machine-to-Machine (M2M) refers to networking of machines (or devices)
- Purpose of remote monitoring and control and data exchange

Introduction to M2M



Introduction to M2M

- M2M area network comprises of machines which have embedded hardware modules for sensing, actuation and communication
- Various communication protocols such as ZigBee, Bluetooth, ModBus, M-Bus, Wireless M-Bus, Power Line Communication (PLC), 6LoWPAN, IEEE 802.15.4, etc. can be used

Introduction to M2M

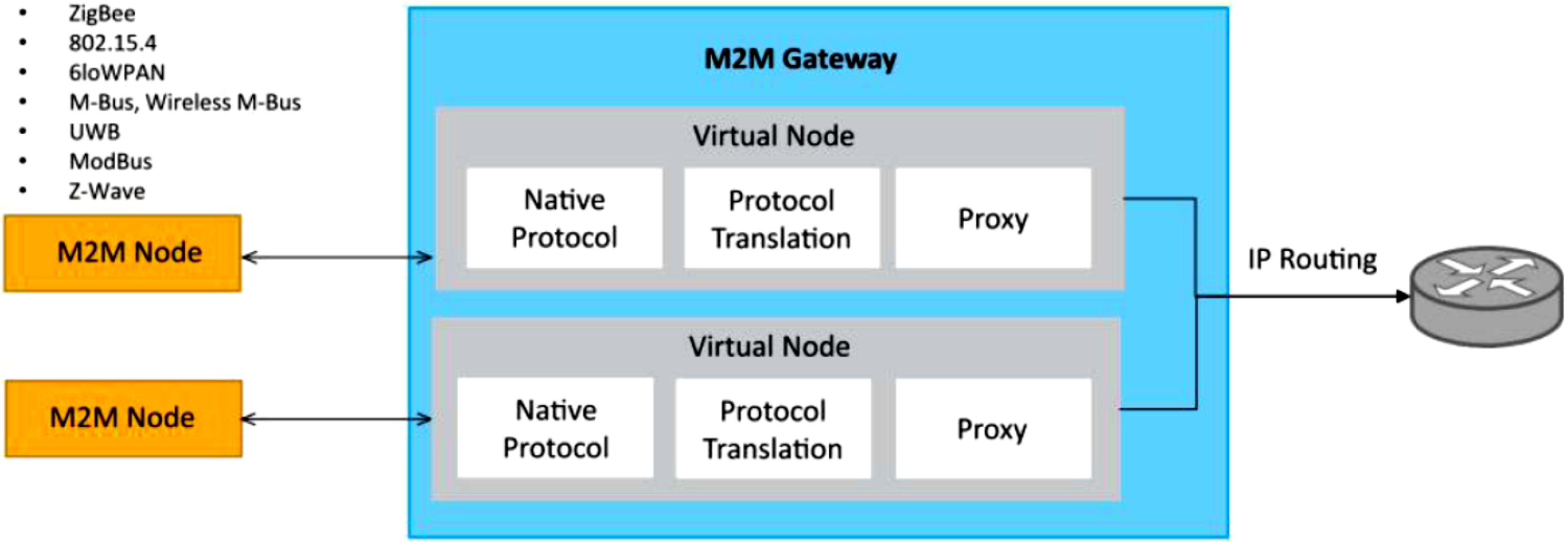
- Communication network provide connectivity to remote M2M area networks
- Communication network can use either wired or wireless networks (IP based)

M2M Gateway

- Since non-IP based protocols are used, M2M nodes within one network can’t communicate with nodes in an external network
- To enable communication between remote M2M area networks, M2M gateways are used

M2M Gateway

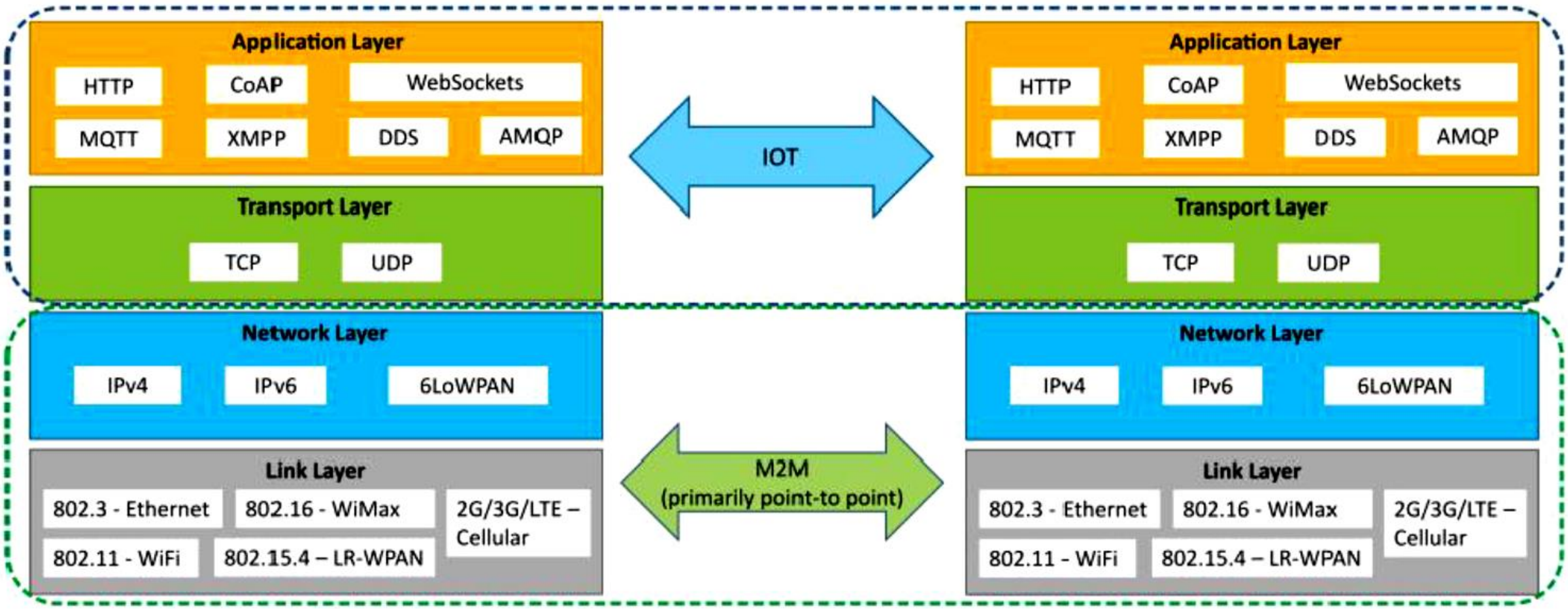
M2M Area Networks:
- Bluetooth
- ZigBee
- 802.15.4
- 6loWPAN
- M-Bus, Wireless M-Bus
- UWB
- ModBus
- Z-Wave



Difference between IoT and M2M

Topic	M2M	IOT
Communication Protocols	Proprietary or Non-IP Based	IP Based
Machines in M2M vs Things in IoT	Homogeneous Machine	Physical Objects that have Unique Identifiers
Hardware vs Software Emphasis	More On Hardware	More On Software
Data Collection & Analysis	Collected In Point Solutions And Often In On-premises Storage	Collected In The Cloud (Can Be Public, Private Or Hybrid Cloud
Applications	Diagnosis Applications, Service Management Applications, And On Premises Enterprise Applications	Analytics Applications, Enterprise Applications, Remote Diagnosis And Management Applications, etc.

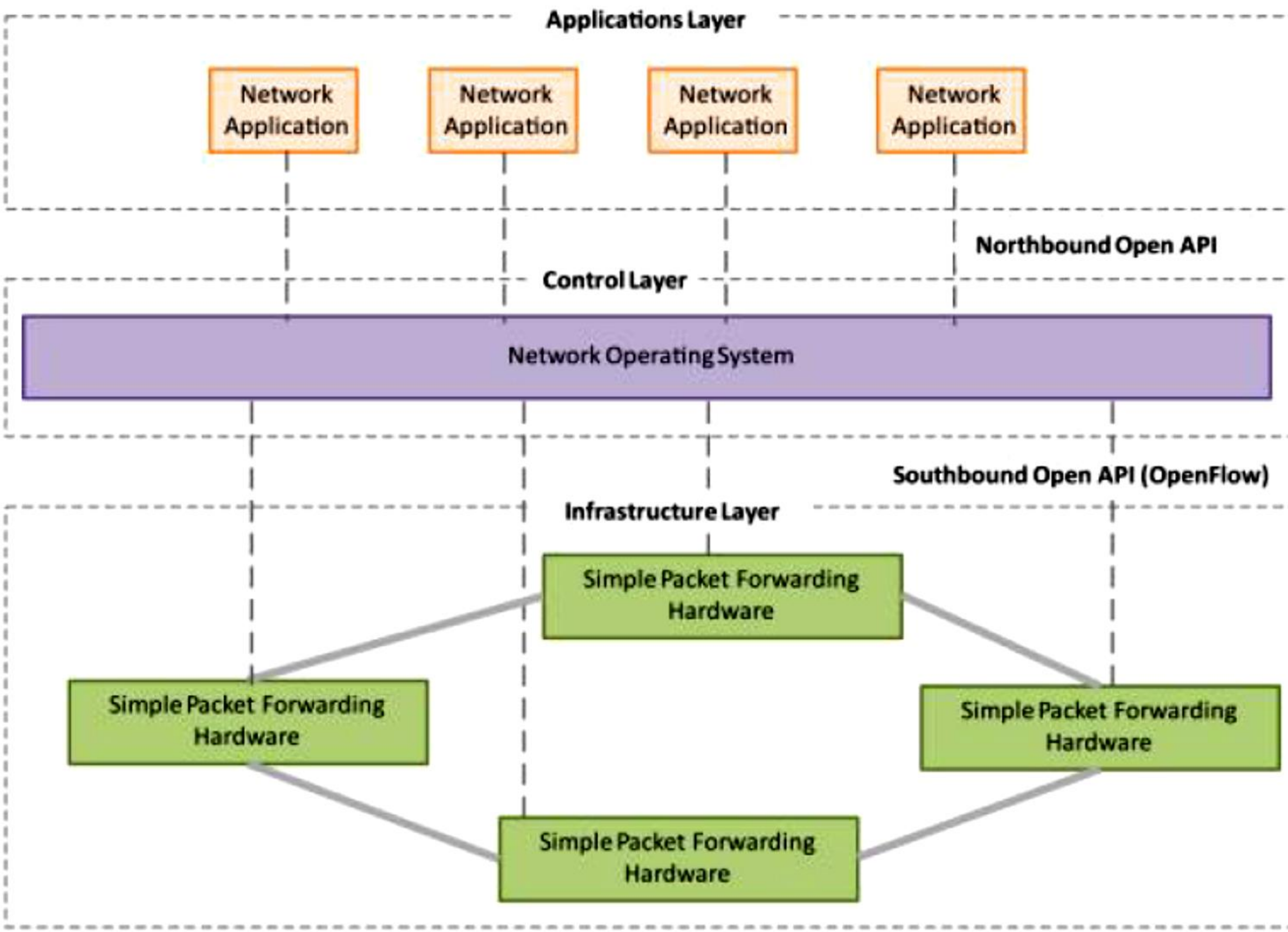
Communication in IoT vs M2M

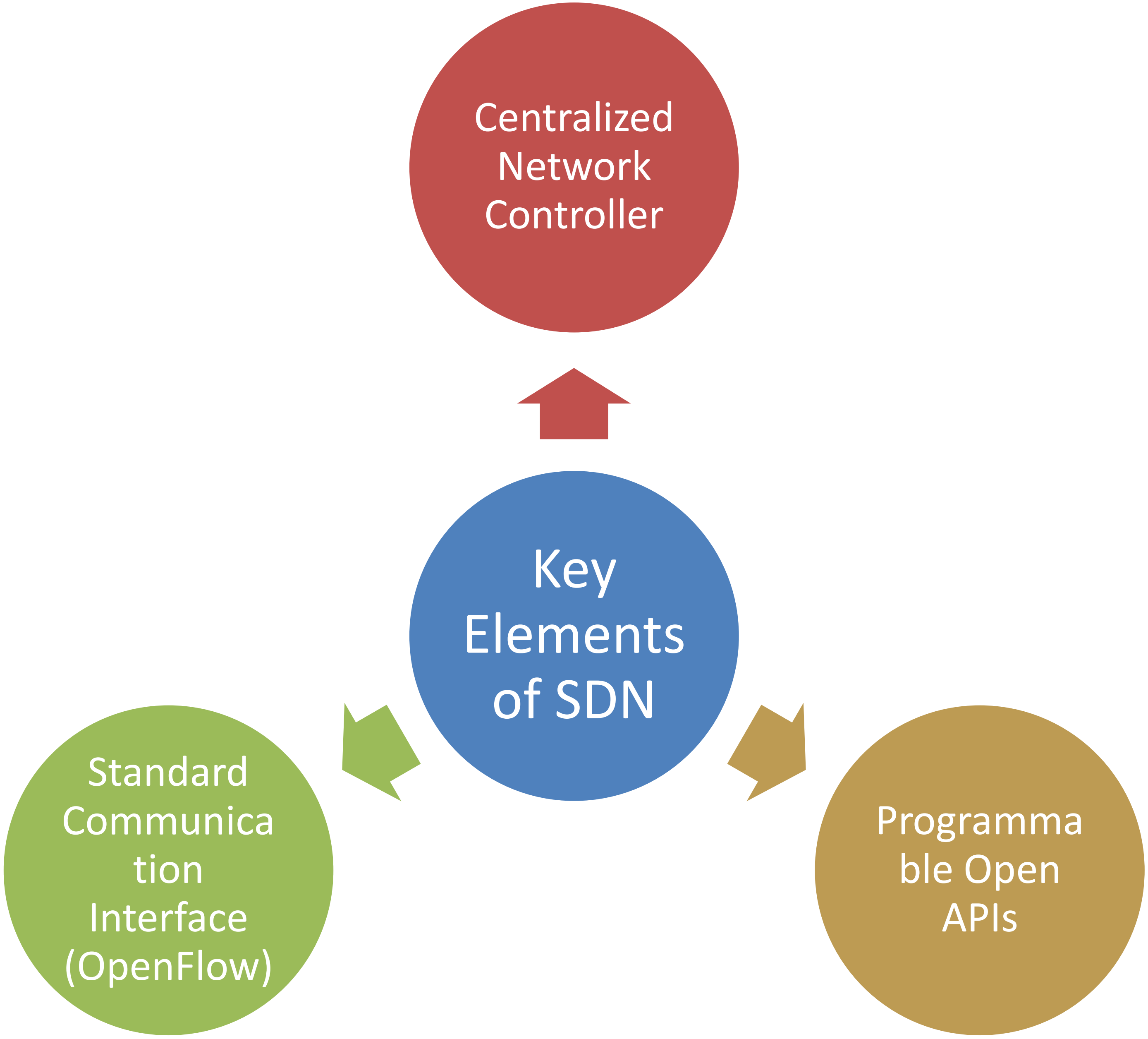


Software-Defined Networking (SDN)

- Architecture that separate control plane from data plane and centralizes network controller
- SDN controllers maintain a unified view of the network & make configuration, management and provisioning simpler
- Underlying infrastructure in SDN uses simple packet forwarding hardware as opposed to specialized hardware in conventional network

Software-Defined Networking (SDN)

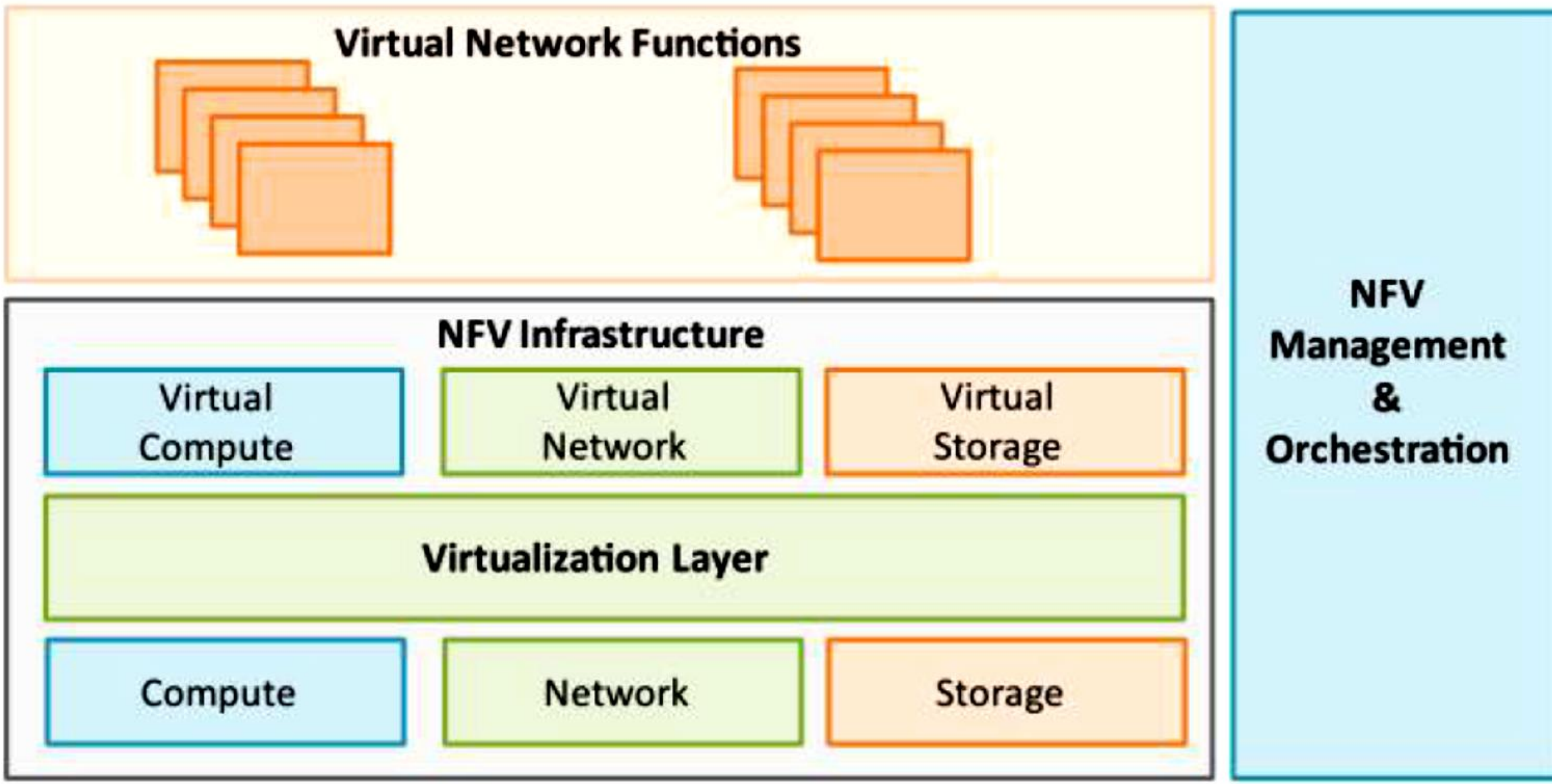



Centralized Network Controller
Key Elements of SDN
Standard Communica tion Interface (OpenFlow)
Programma ble Open APIs

Network Function Virtualization (NFV)

- Technology that controls virtualization to combine the heterogeneous network devices onto industry standard high volume servers, switches and storage
- NFV is complementary to SDN as NFV can provide infrastructure on which SDN can run

Network Function Virtualization (NFV)



Key Elements of NFV

Virtualized Network Function (VNF)

- Software implementation of network function which is capable of running over NFV Infrastructure

NFV Infrastructure

- Includes compute, network and storage resources that are virtualized

NFV Management and Orchestration

- Focuses on all virtualization-specific management tasks
- Covers orchestration and life-cycle management of physical and/or software resources that support the infrastructure virtualization, and the life-cycle management of VNFs