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IoT Models

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The IoT Reference Model

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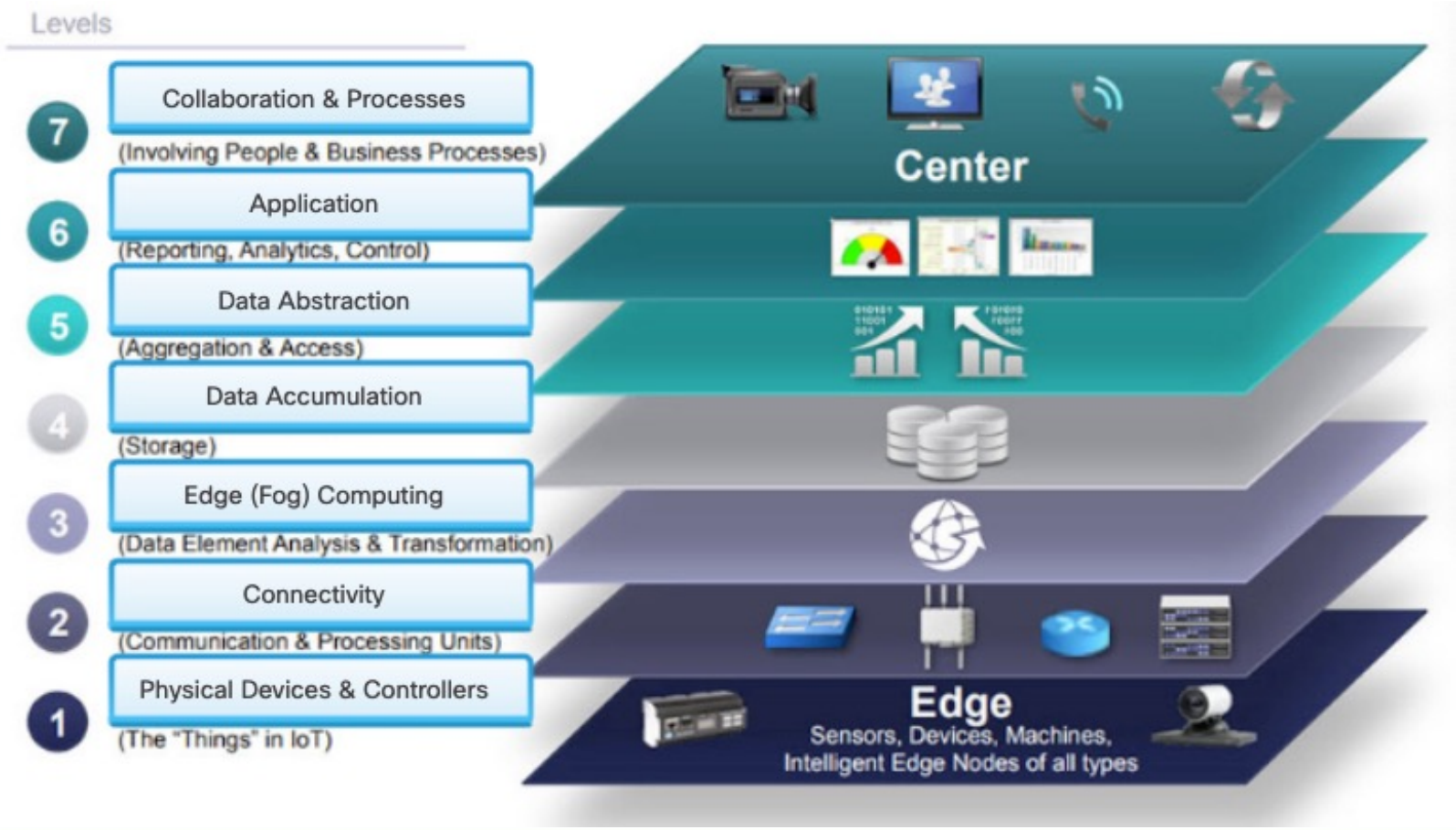

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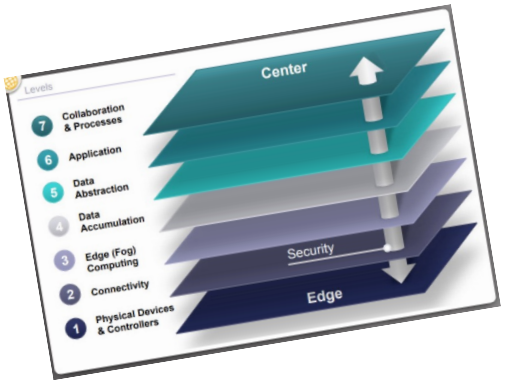
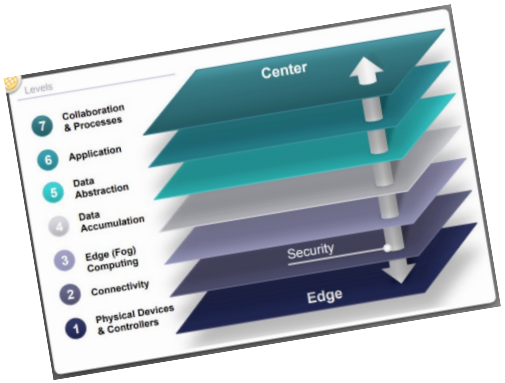


1- End point devices sending and/or receiving data

The IoT Reference Model



2- Transmit data between devices and the network across networks

1- End point devices sending and/or receiving data

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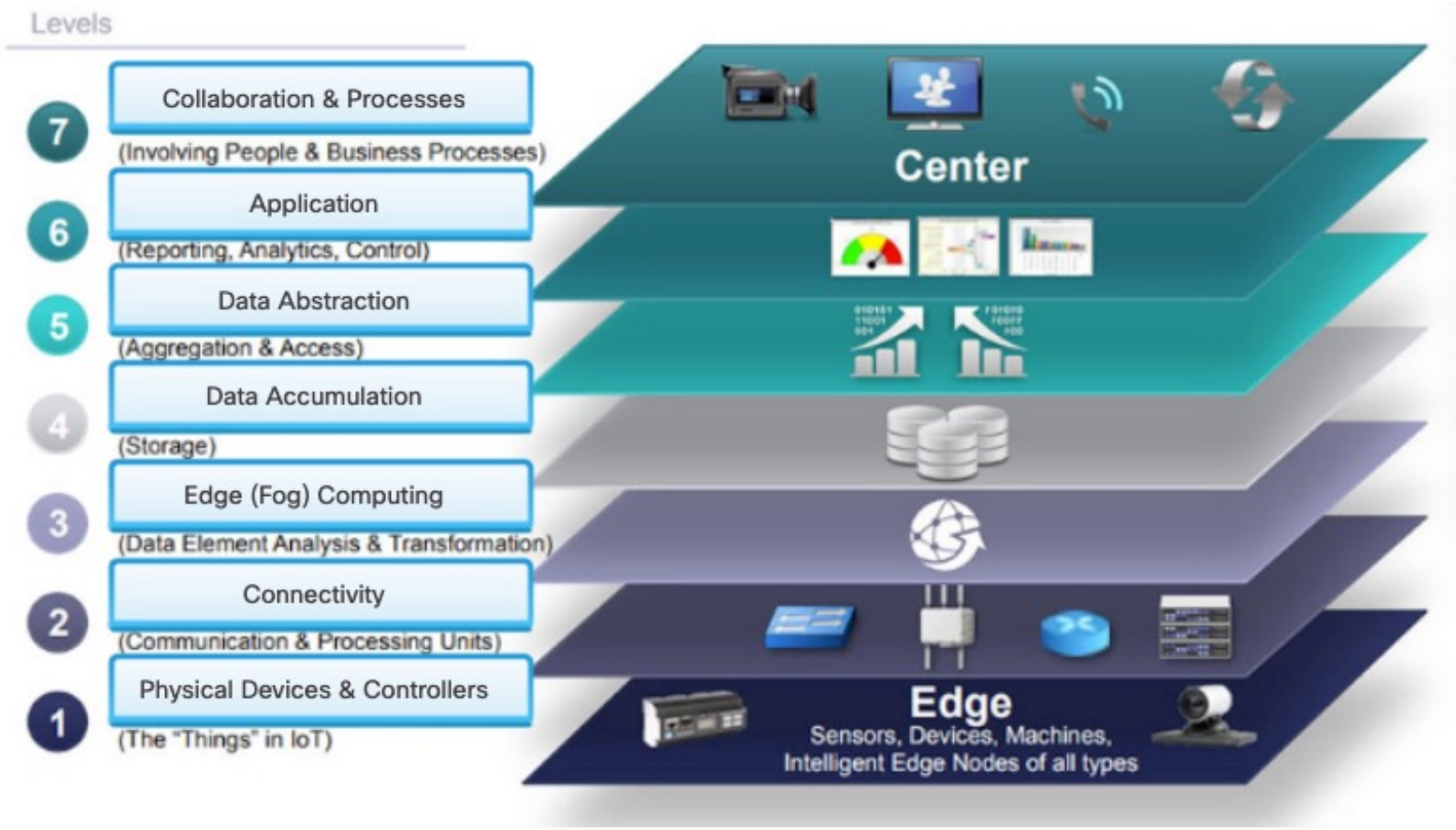

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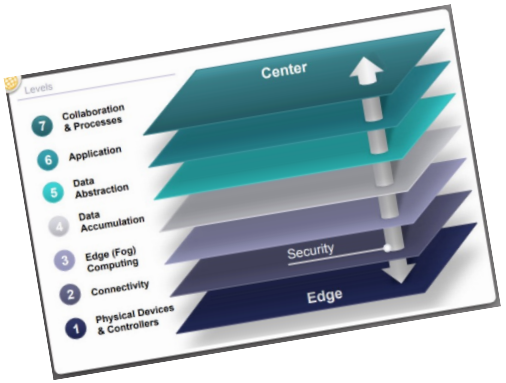

3- Converts data into information that is suitable for storage and higher-level processing

2- Transmit data between devices and the network across networks

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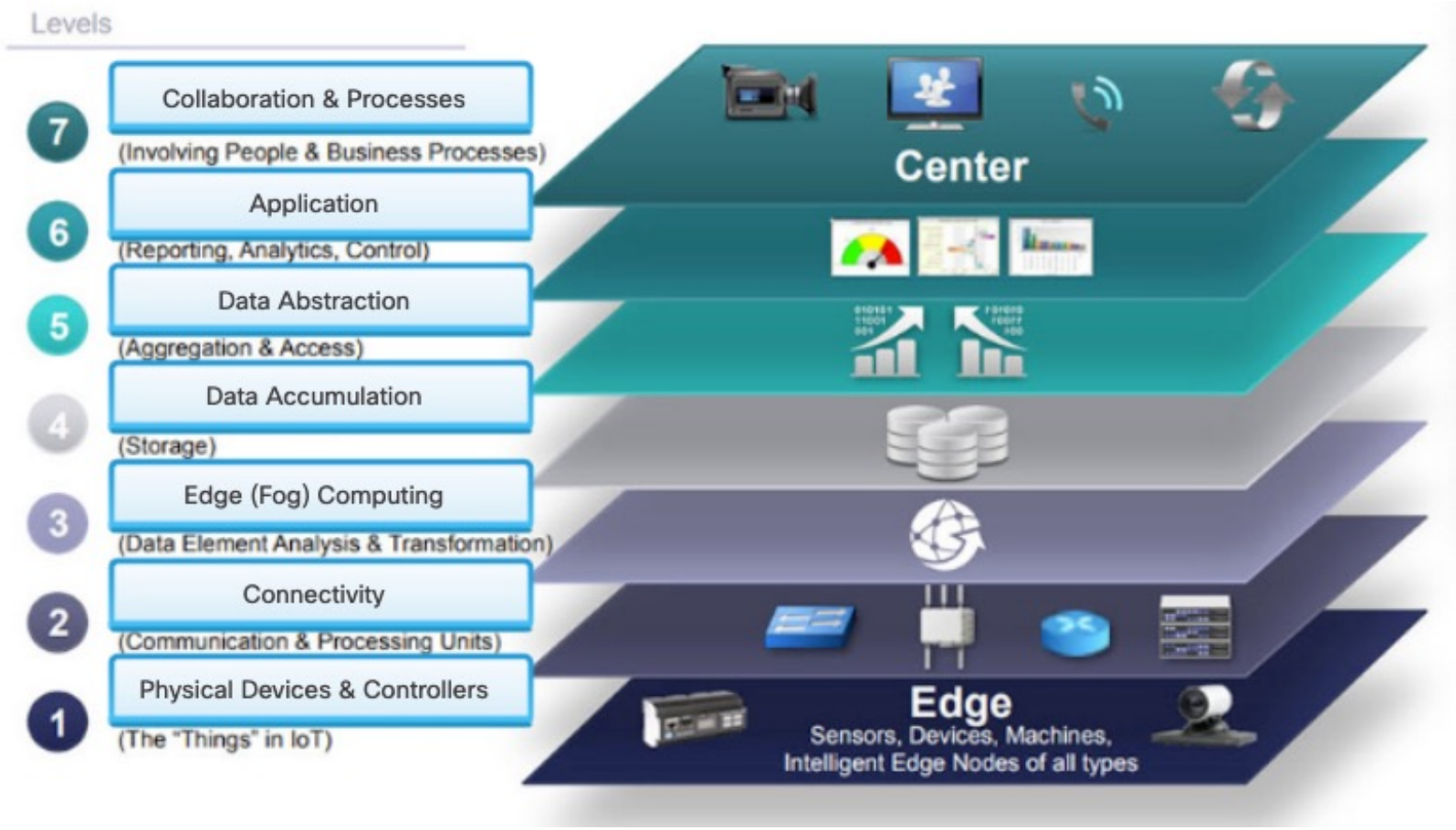

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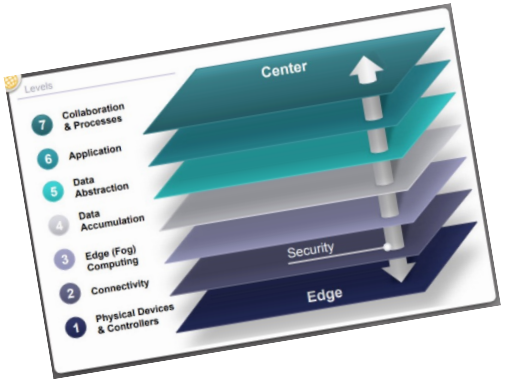

4- Put data at rest and possibly transform it to be consumed by higher-levels

3- Converts data into information that is suitable for storage and higher-level processing

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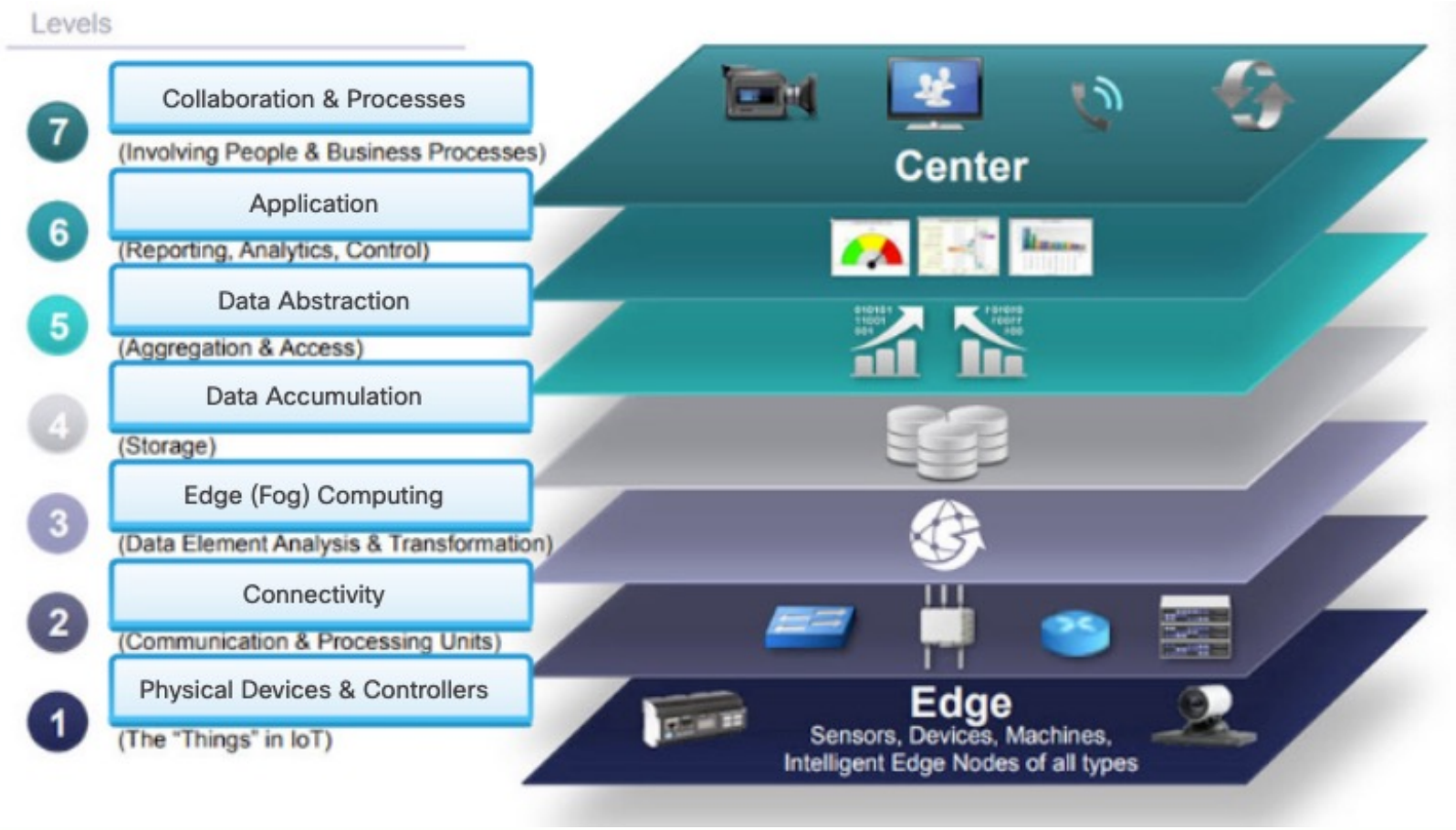

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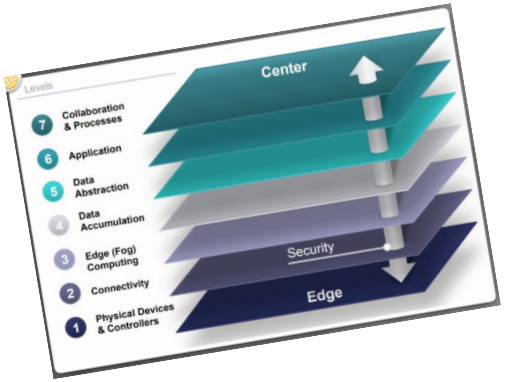

5- Render data and its storage to enable application development

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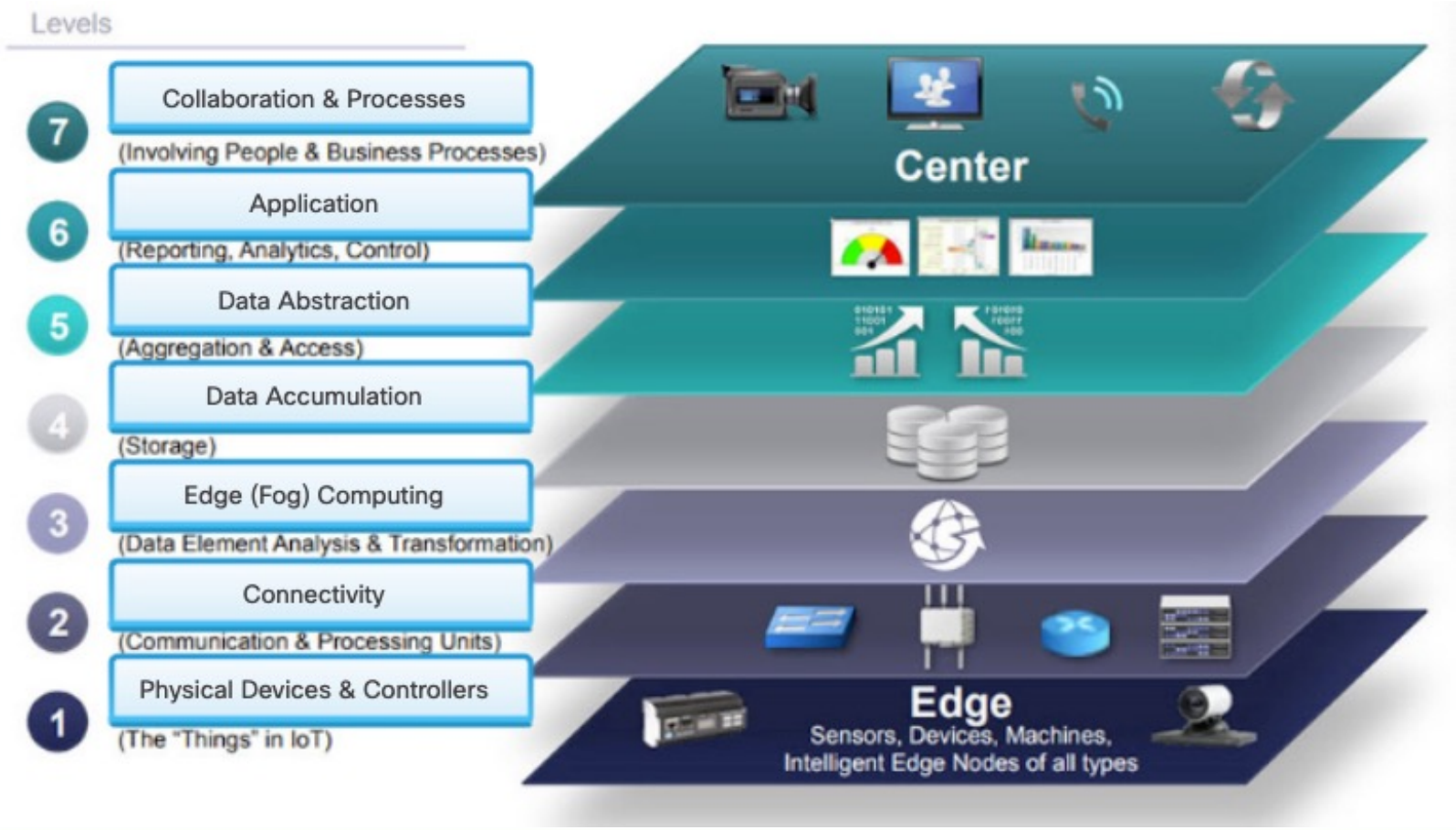

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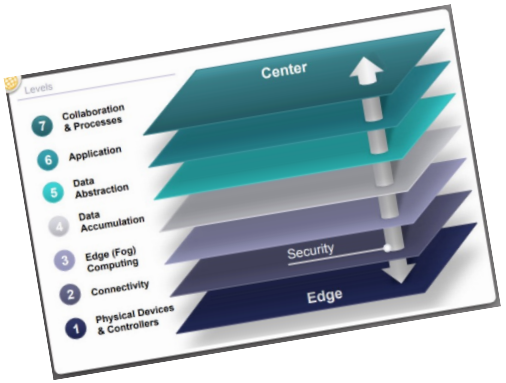

6- Information interpretation based on the nature of the device and business needs

5- Render data and its storage to enable application development

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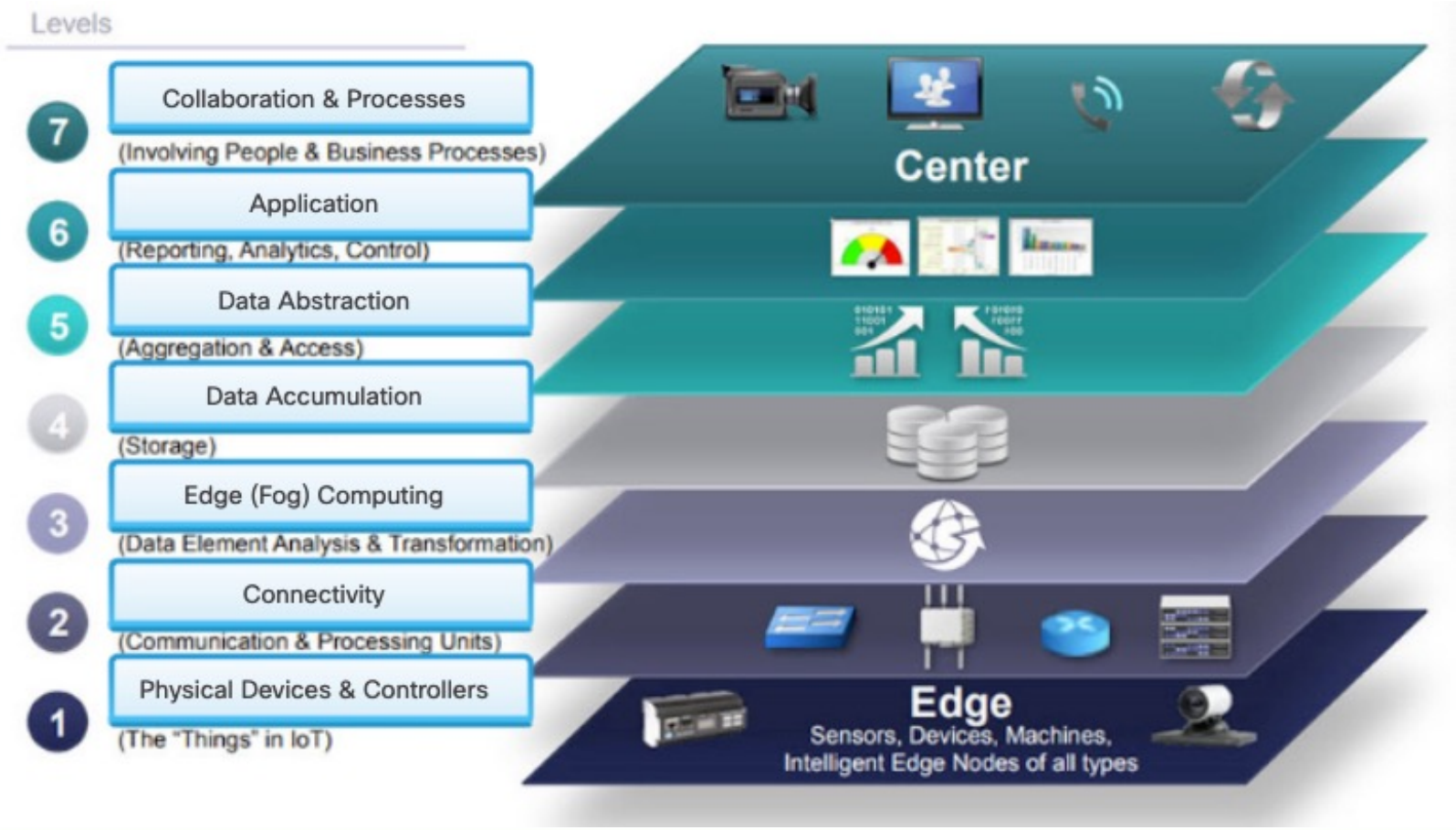

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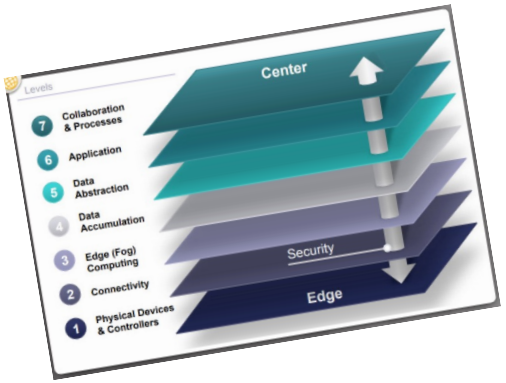

7- Include communication and collaboration required between people and business processes

6- Information interpretation based on the nature of the device and business needs

5- Render data and its storage to enable application development

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The IoT Reference Model

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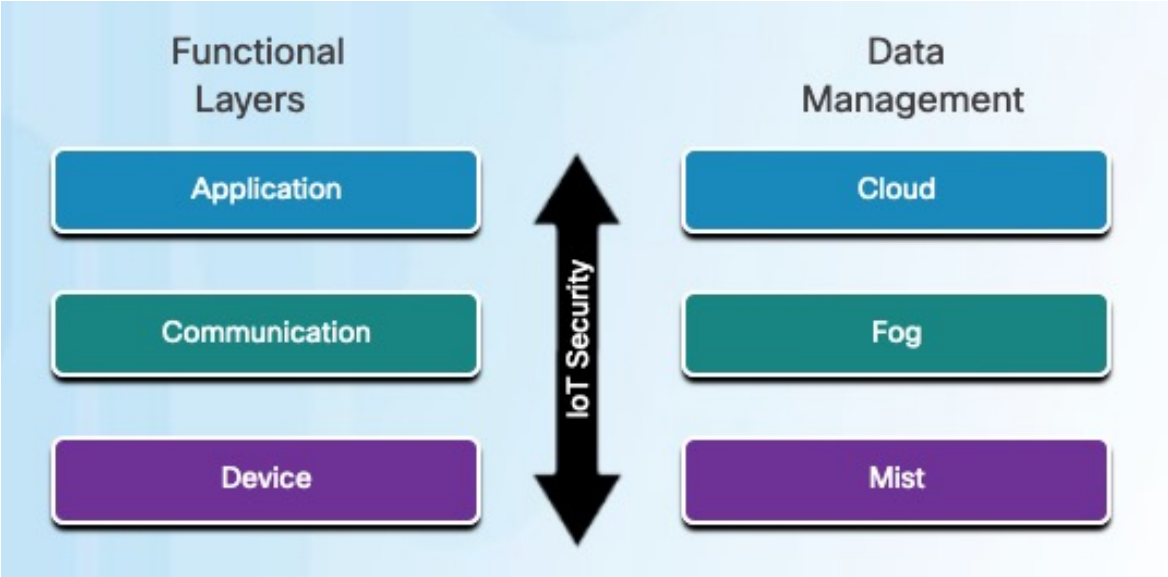
- This is just one of the standard models
- Others exist and can be more ”field” oriented
  - In the manufacturing industry: Purdue Model for Control Hierarchy
  - For industrial systems: Industrial Internet Reference Architecture (IIRA)
  - Internet of Things - Architecture (IoT-A) maintained by the IoT Forum ; previously known as the Architectural Reference Model (ARM) for the Internet of Things

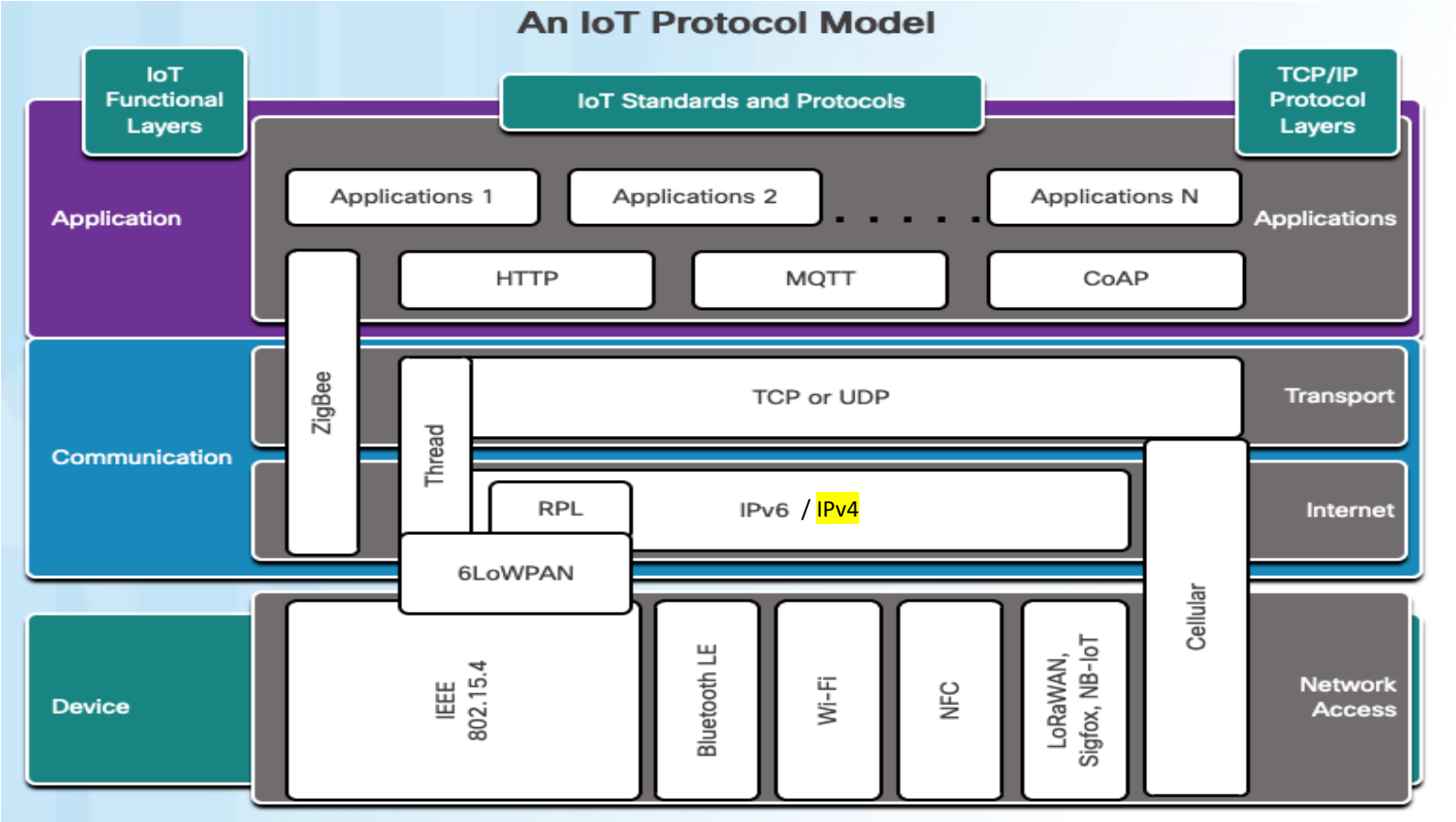
The IoT Security Model

- To ease things, a simplified model can be used:



- **Function Layers:** how things are connected to the network and to one another
- **Data Management:** when & where data is produced, processed

The IoT Security Model



An IoT Protocol Model
Application Layer

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- **Zigbee**
  - This includes a suite of protocols and uses low-power digital radios based on the IEEE 802.15.4 wireless standard. It includes protocols at the Application and Communication layers. The majority of components in the Zigbee specification exist at the application layer.
- **Message Queuing Telemetry Transport (MQTT)**
  - This is a lightweight publish and subscribe messaging protocol designed for resource-constrained devices that use TCP.
- **Constrained Application Protocol (CoAP)**
  - A specialized application protocol designed for transmission of data by constrained devices on M2M networks.

An IoT Protocol Model Communication Layer

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- **Thread**
  - This is a standard for home automation that uses Internet Protocol version 6 (IPv6) for routing on top of an IEEE 802.15.4 wireless network.
- **RPL**
  - This is a **R**outing **P**rotocol for **L**ow-Power and Lossy Networks that uses IPv6. Lossy networks are classified as those with devices that typically have high loss rates, low data rates, and instability.
- **6LoWPAN**
  - This is an Internet Engineering Task Force (IETF) standard for IPv6 Low-power Wireless devices in a Personal Area Network that provides a way for IPv6 to conform to the IEEE 802.15.4 standard.

An IoT Protocol Model
Device Layer

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- **IEEE 802.15.4**
  - This is the Institute of Electrical and Electronic Engineers standard for low-rate wireless personal area networks (LR-WPANs) that is meant to be used by low-cost, low-speed devices.
- **Bluetooth Low Energy (BLE)**
  - This is a wireless personal area network (WPAN) protocol that uses the 2.4 GHz radio frequency. The LE version provides much-reduced power consumption without sacrificing range.
- **Near Field Communication (NFC)**
  - This is a collection of protocols for device-to-device communications when the devices are very close to one another (within 4 cm).
- **LoRaWAN, Sigfox, NB-IoT**
  - Low-power wide-area network (LPWAN) protocols designed to carry small data payloads over long distances at low transfer rates.

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Security & IoT

The CIA Triad

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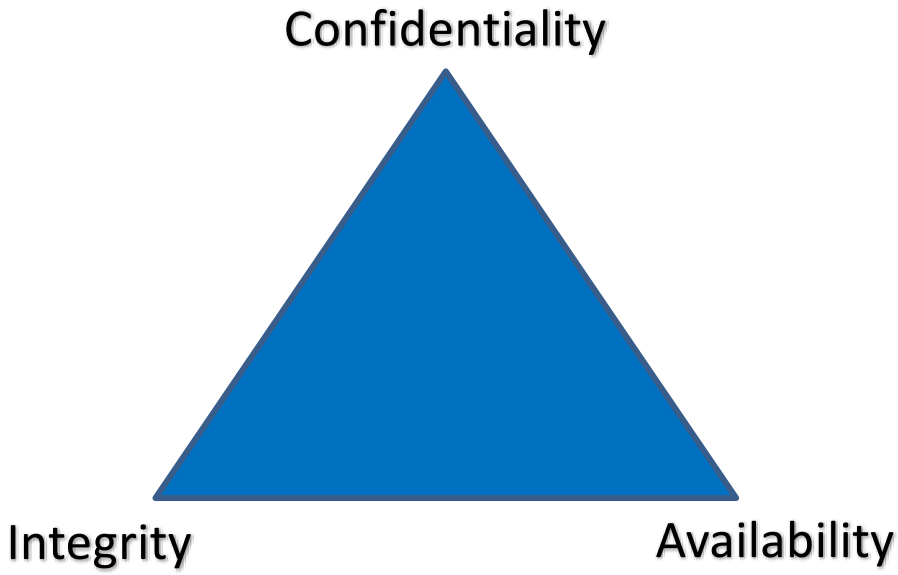
- Security is globally organized around the CIA Triad



The CIA Triad

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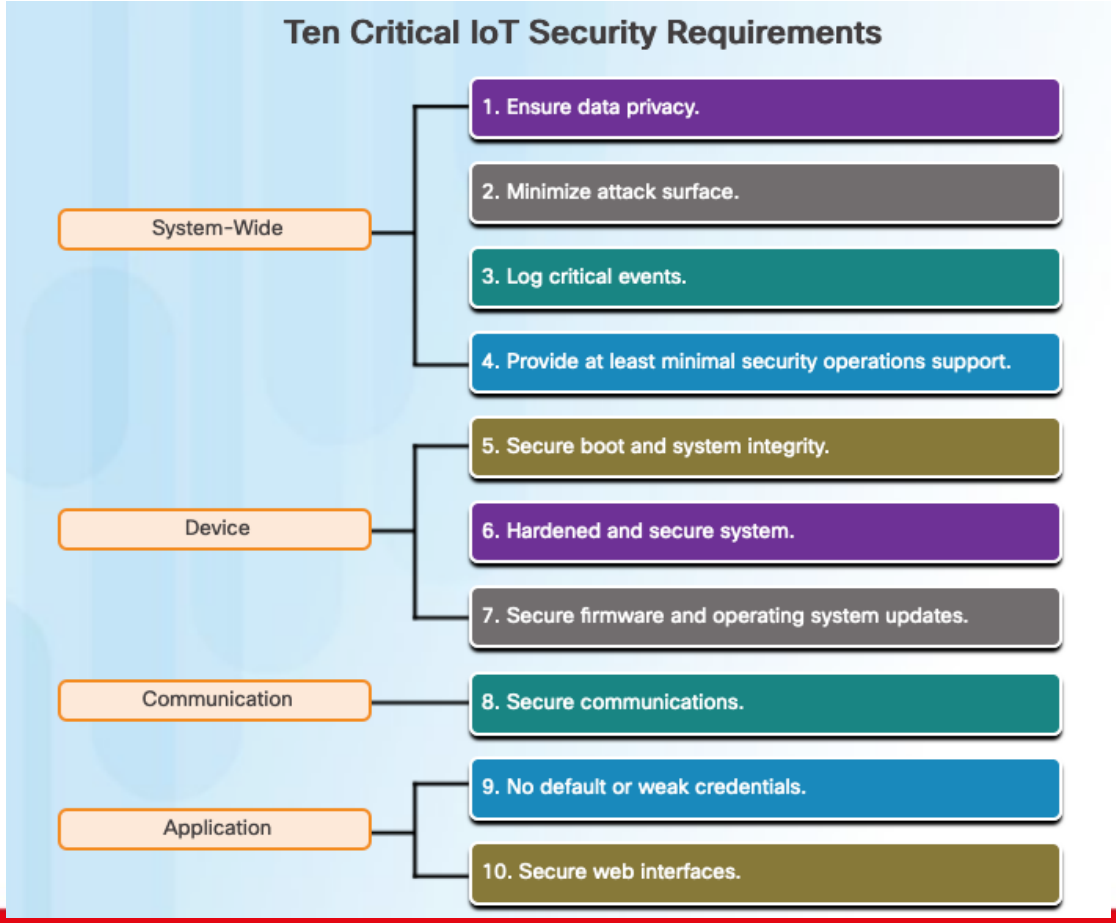
- **Confidentiality**
  - Maintaining control on information access and disclosure. Transmitting and storing data encrypted for privacy.
- **Integrity**
  - Preventing improper addition, modification, or destruction of data and information.
- **Availability**
  - Ensuring information can be accessed when it is required. This means that the IoT devices can communicate on the network so that they can submit data to and can be controlled by IoT applications. This also means that devices can not be damaged or tampered with.

Security Requirements



System-Wide Security Requirements

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- Ensuring data privacy:
  - Including functional, business & personal data alike
  - In transit & in storage

- Minimizing the attack surface:
  - Including all possible entry points that might be exploited
    - All potential entry points are secured
    - All unnecessary entry points are deactivated

System-Wide Security Requirements

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- Log critical events:
  - All critical events should be monitored and protected including unusual & normal activities

- Minimal security operations support:
  - Trained staff should be able to
    - Monitor systems for security incidents,
    - Address newly discovered vulnerabilities,
    - Investigate security breaches.

Device Security Requirements

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- Secure boot & system integrity
  - Ensuring that the operating system & the software cannot be altered
- Hardened and secure system
  - All unnecessary services should be deactivated
- Secure firmware and operating system updates
  - The updating process should be addressed
  - OTA updates should be considered for devices on the field

Communication Security Requirements

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- Secure communications
  - Prevent interception
  - Prevent falsification
  - Prevent spoofing

Application Security Requirements

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- No default or weak credentials
  - Use strong authentication process
  - When default passwords are set, they must be changed at first boot
  - Hard coded credentials must be avoided
- Secure Web interfaces
  - Applications and API must be securely defined and programmed