Business Analytics and Emerging Trends

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Internet of Things

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Module 5

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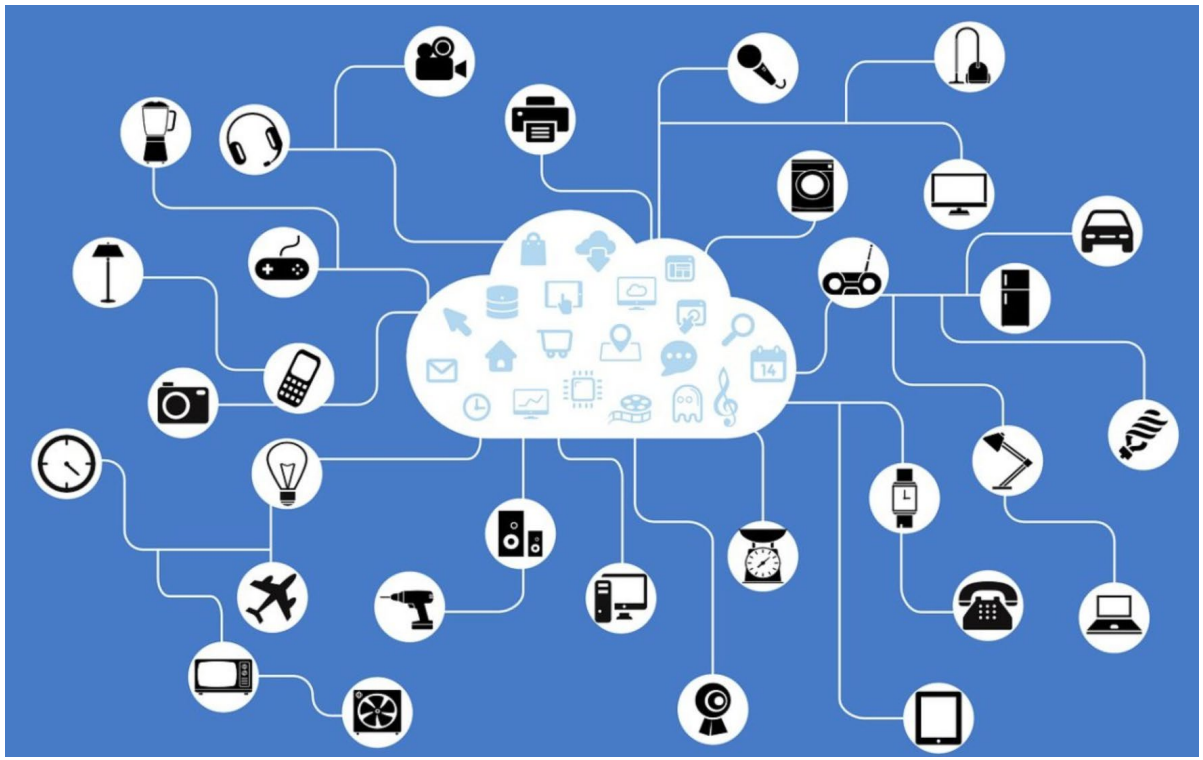
What is Internet of Things?

- A system involving **connected devices** that **gather data**, **connect** with the Internet, **generate analytics**, and **adapt behavior** based on the analytics



Internet of Things - Layers

Internet of Things Architecture

Data gathering

Connectivity

Data processing

User Interface

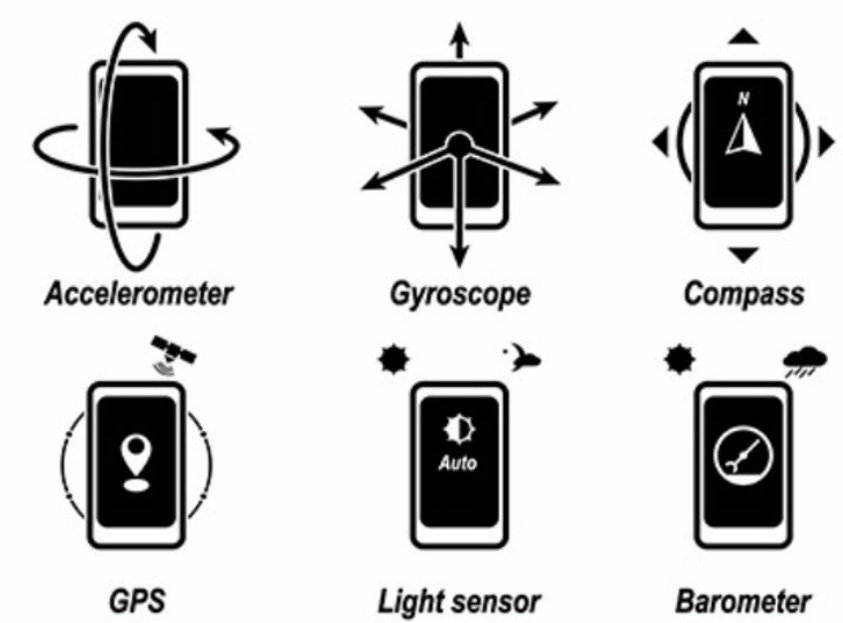
How do devices gather data?

- Sensors / Actuators
  - **Detect** the feature **quantity** of a measurement object and **convert** this quantity into a **readable signal**

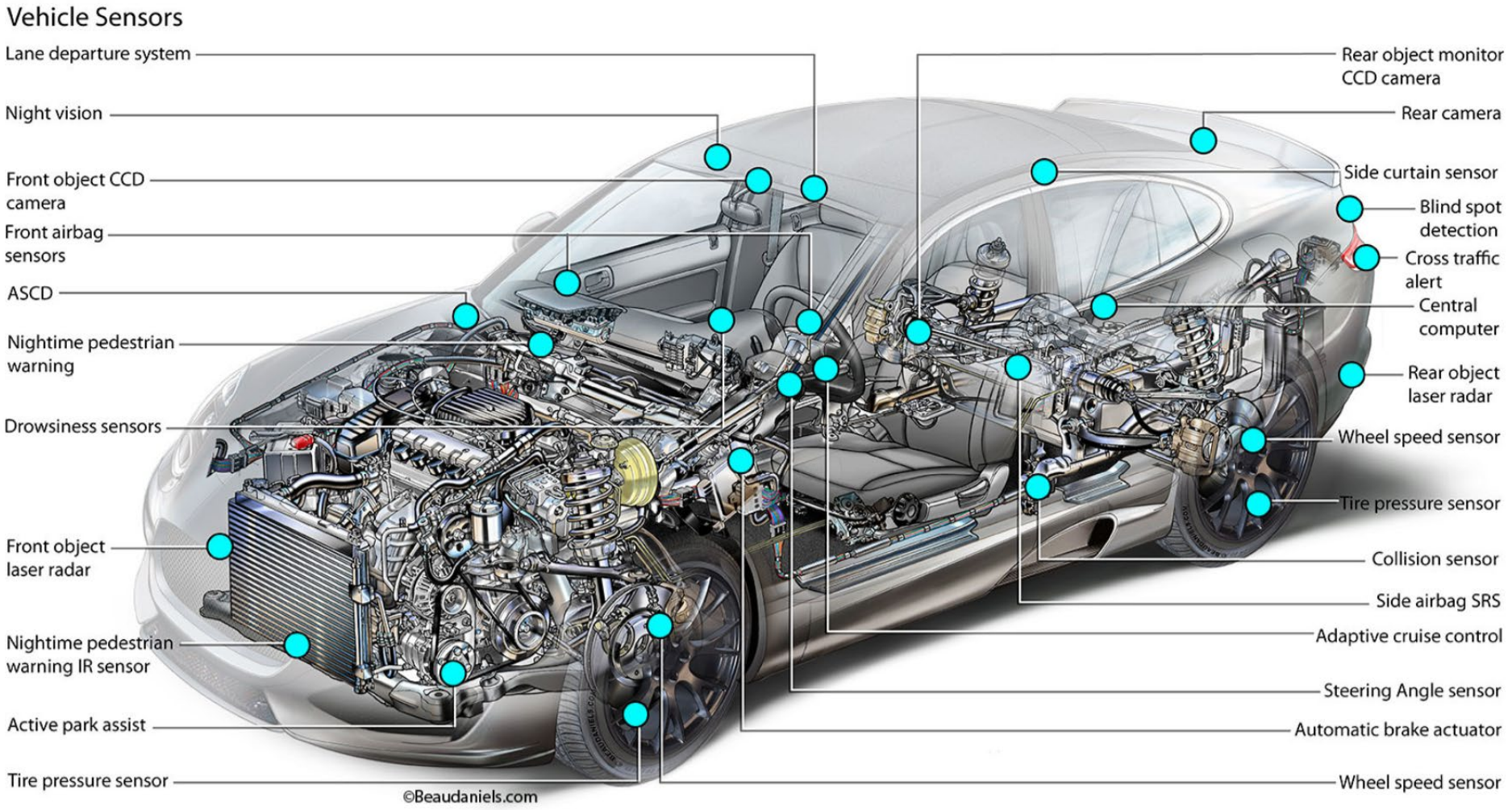
Five senses	Sight	Hearing	Smell	Taste	Touch
As behavior	-See the thing -Feel the light	-Listen the sound -Feel the shaking -Take the balance	-Smell the thing	-Feel the taste	-By touching, feel the heat, force, or texture
Sensory organ as human	Eye 	Ear 	Nose 	Tongue 	Skin 
Typical sensors as machinery	-Image sensor -Light intensity sensor	-Acoustic sensor -Ultrasonic sensor	-Gas component sensor	-Liquid component sensor	-Tactile sensor -Pressure sensor -Temperature sensor -Humidity sensor -Displacement sensor

Sensors on smart phones

- **Accelerometer**
- **Gyroscope**
  - Measures orientation
- **Magnetometer**
  - Detects magnetic fields
- **GPS**
  - communicate with the satellites
  - determine our location on Earth
- **Light sensor**
  - Measures the light in the vicinity
  - Adjusts the display's brightness
- **Barometer**
  - measures atmospheric pressure
  - how high we are above the sea level
- **Thermometer, Microphone, Pedometer…**



Vehicle Sensors



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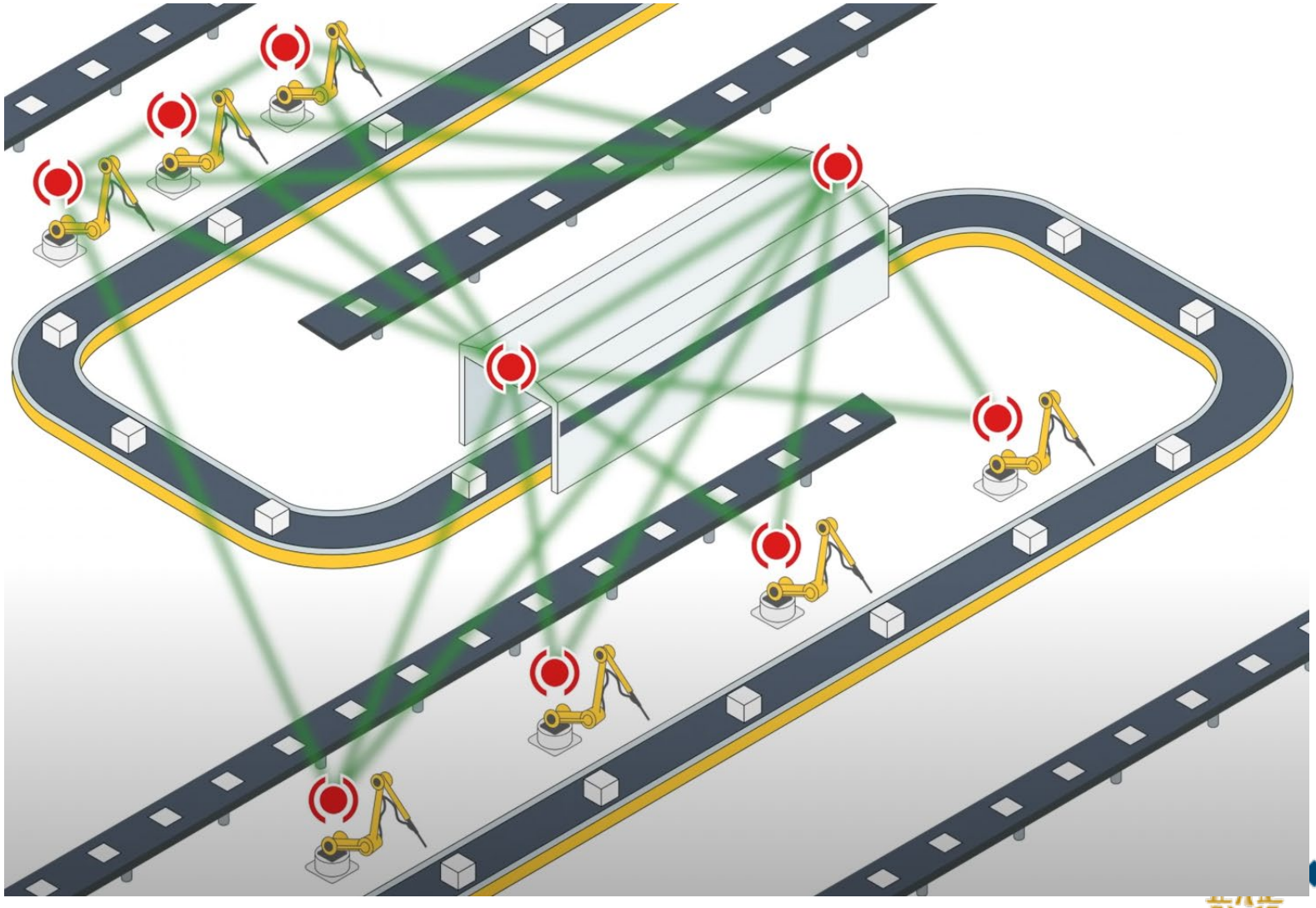
Wireless Sensor Networks



Communication Protocols

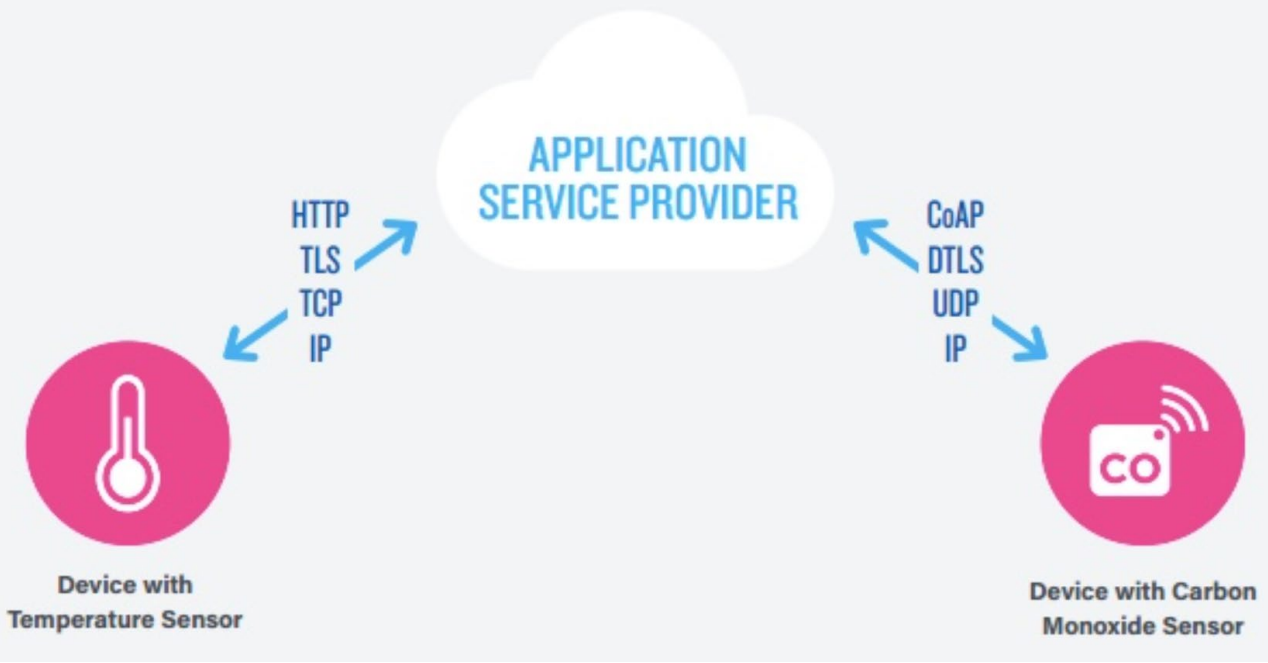
- Options for connectivity are **various**
  - Cellular, satellite, WiFi, Bluetooth, RFID, NFC, LPWAN, Zigbee
- Four **models** for connectivity
  - 1) Device to Device
  - 2) Device to Cloud
  - 3) Device to Gateway
  - 4) Backend Data Sharing

Device to Device

- **Direct** communication with each other
  - Via IP network, hardwire or bluetooth
  - **Example**: Smart watch and pacemaker
- **Low power** consumption
  - Ideal for products to have a long battery life

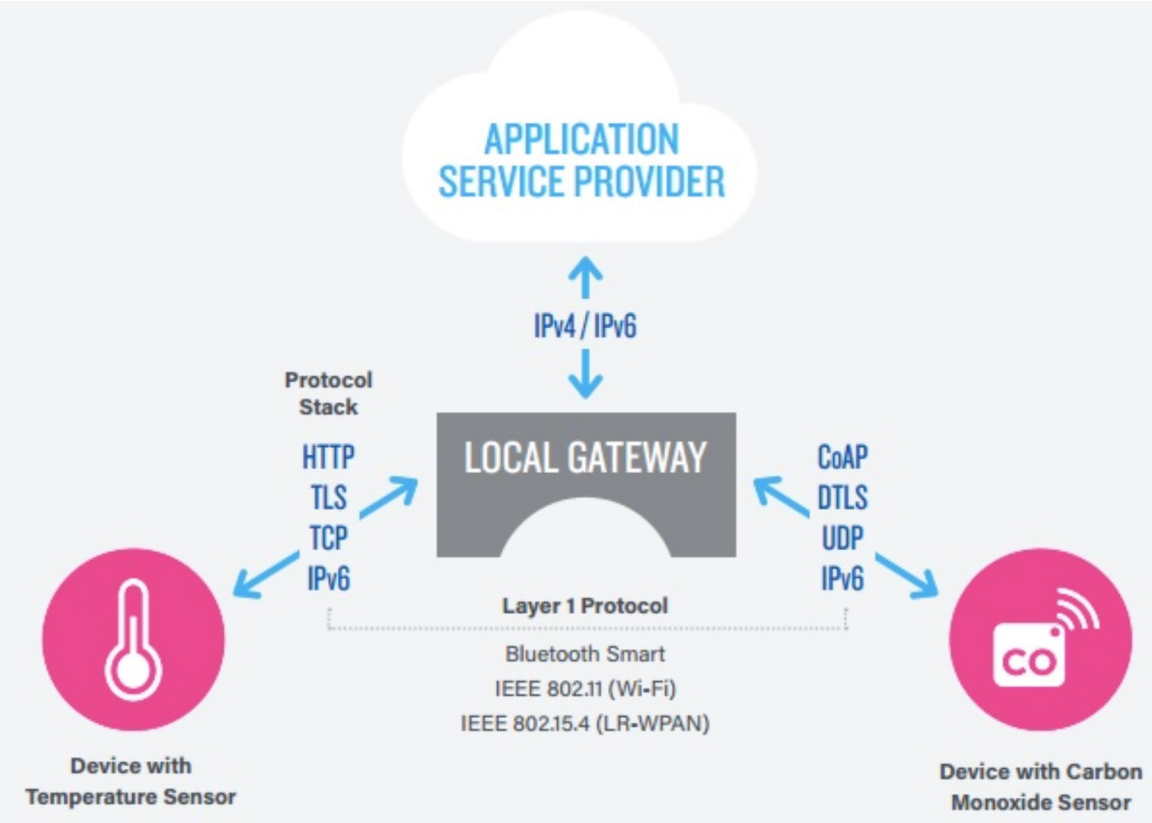
Device to Cloud

- Via ethernet, WiFi or cellular
  - **Example:** Webcams to watch home while on vacation
  - Tag on an animal to find where it is
- Difficulty for inter product **compatibility**
  - Due to the differences in manufacturer design



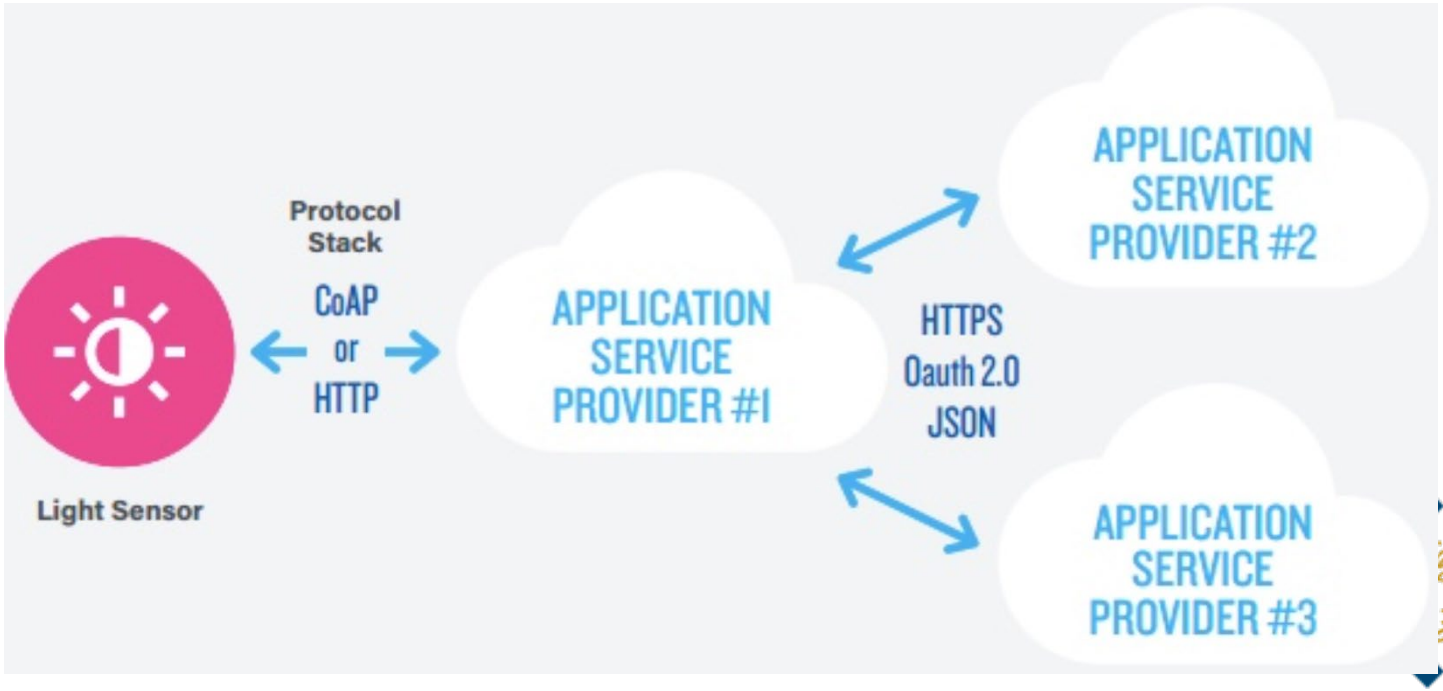
Device to Gateway

- **Intermediary** between IoT device and a cloud service
  - Fitness device connects to the cloud **through** Nike+ app
  - Home appliance connects to a **hub** like Samsung SmartThings



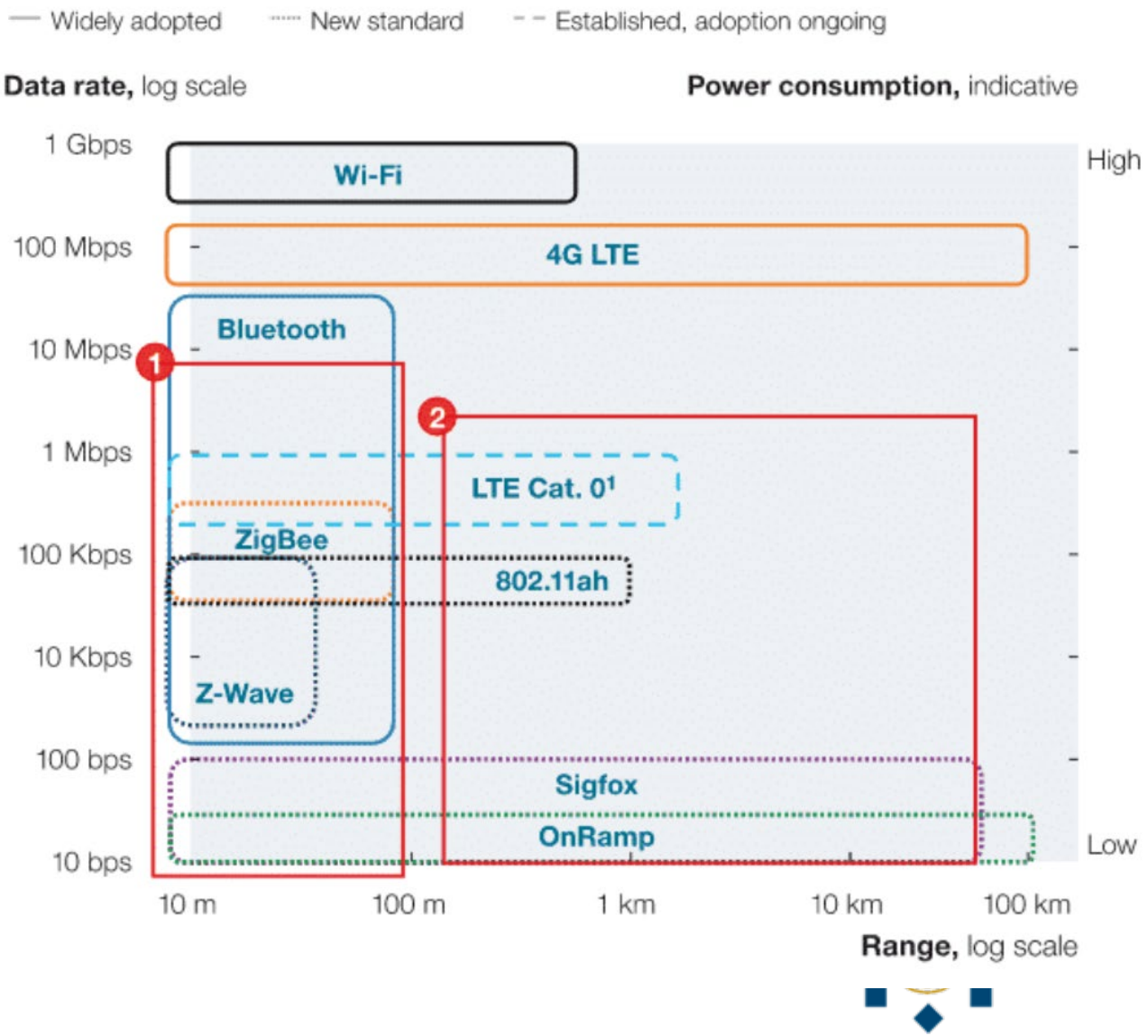
Backend Data Sharing

- **Extends** single device to cloud model
  - Sensor data can be accessed by authorized **third parties**
- Export, analyze smart object data from a cloud service
  - Combine with data from other sources
  - **Map My Fitness**: Data from Fitbit, Adidas miCoach, etc.



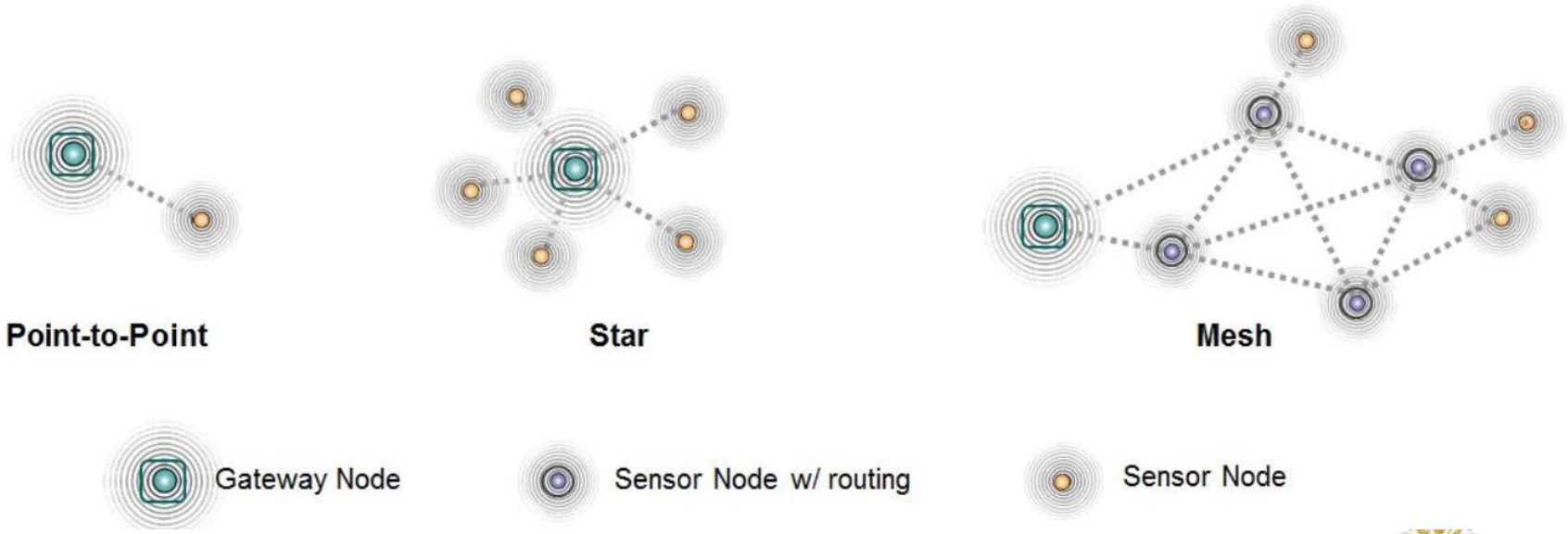
Communication Protocols

- **Tradeoff** between
  - Power consumption
  - Range
  - Bandwidth



IoT Network Topology

- IoT Network Topology
  - Point-to-Point
  - Star
  - Mesh
  - Hybrid



Internet of Things Architecture

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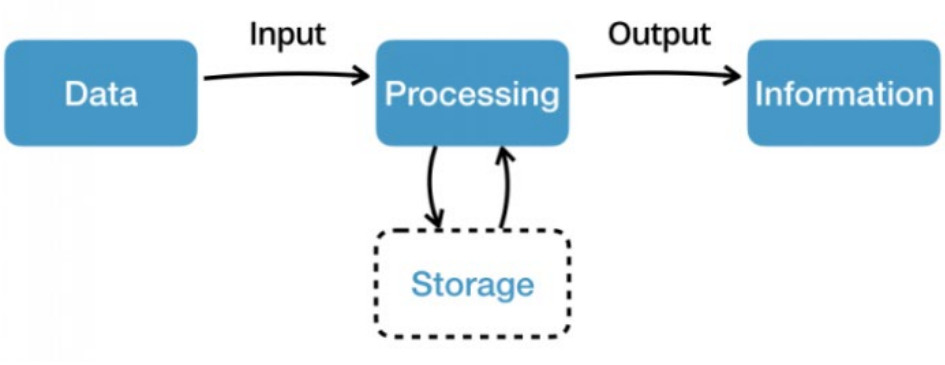
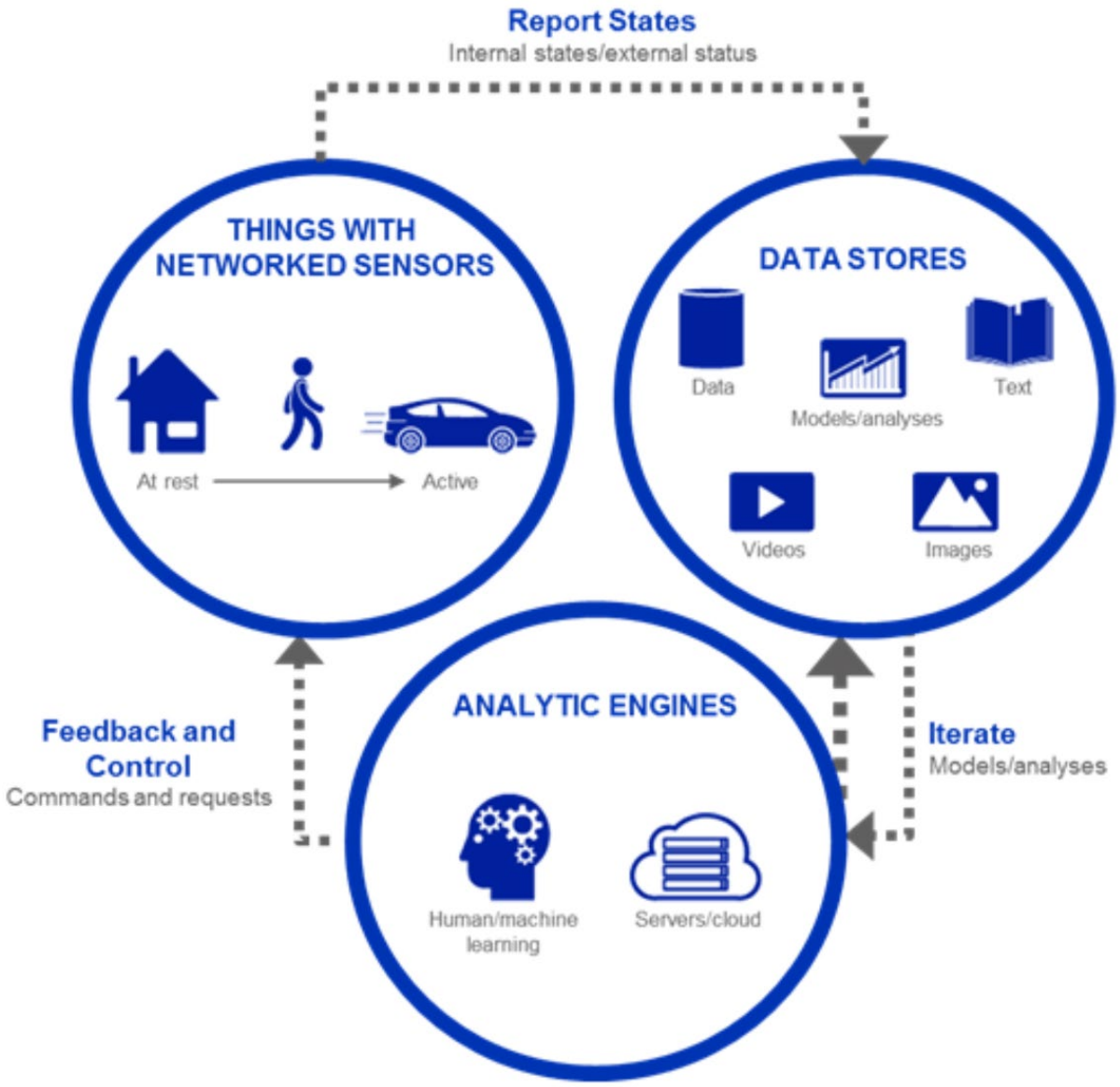
Data Processing

- Once the sensor data gets to the cloud
  - Software performs **processing** on data
- Numerous algorithms and data processing elements
  - Ultimately become **information**
- Considerations
  - Storage
  - Frequency of updates
  - Desired output type



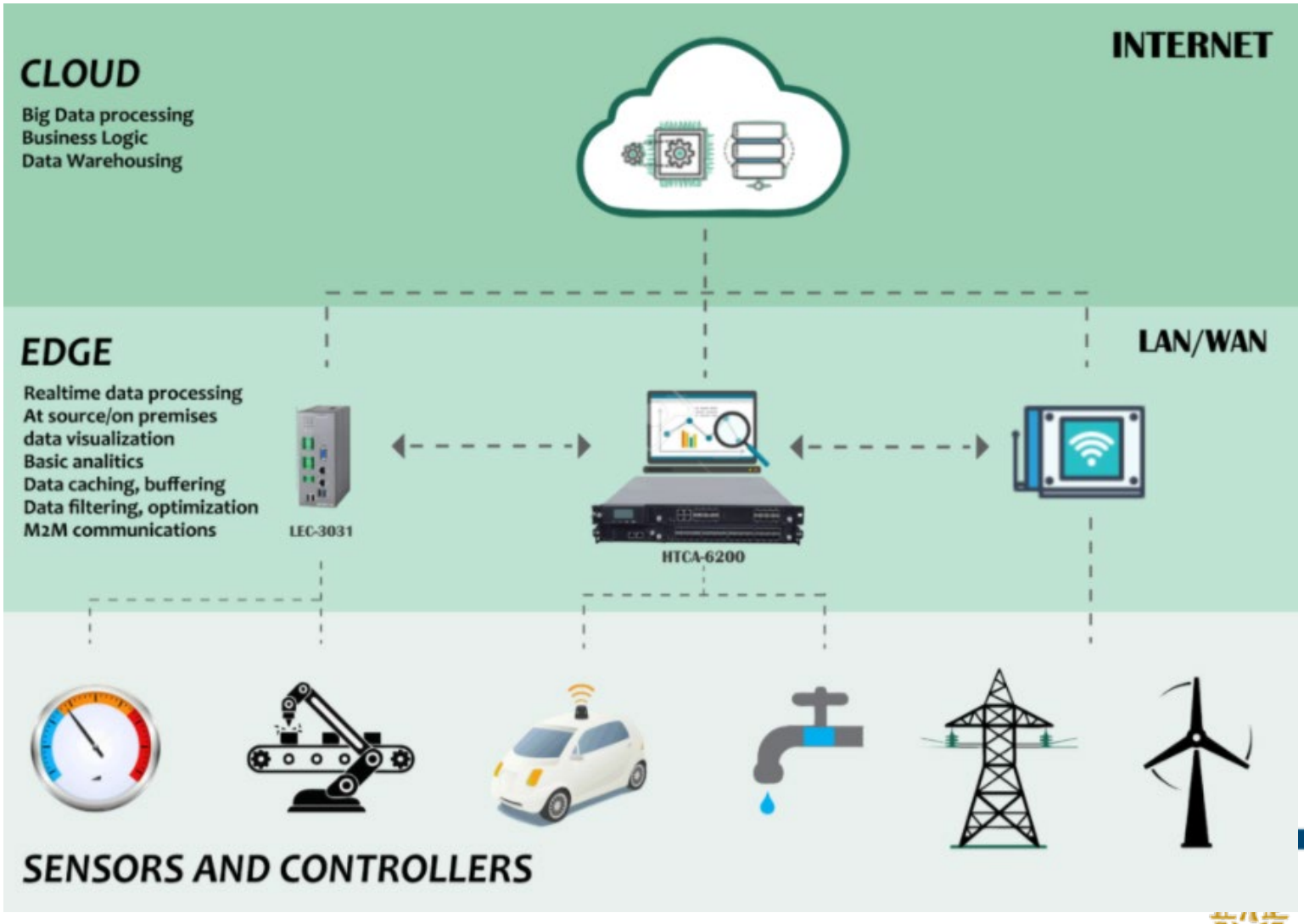
Data Processing



Edge Computing

- The round-trip time can take **too long**
  - Sending data, processing, analyzing, returning instructions
- Edge computing
  - A smart edge device
  - Aggregate data, analyze it and fashion responses if necessary
  - All within **relatively close physical distance**
  - Reducing delay
- Edge devices also have upstream connectivity for sending data to be further processed and stored

Edge Computing



Internet of Things Architecture

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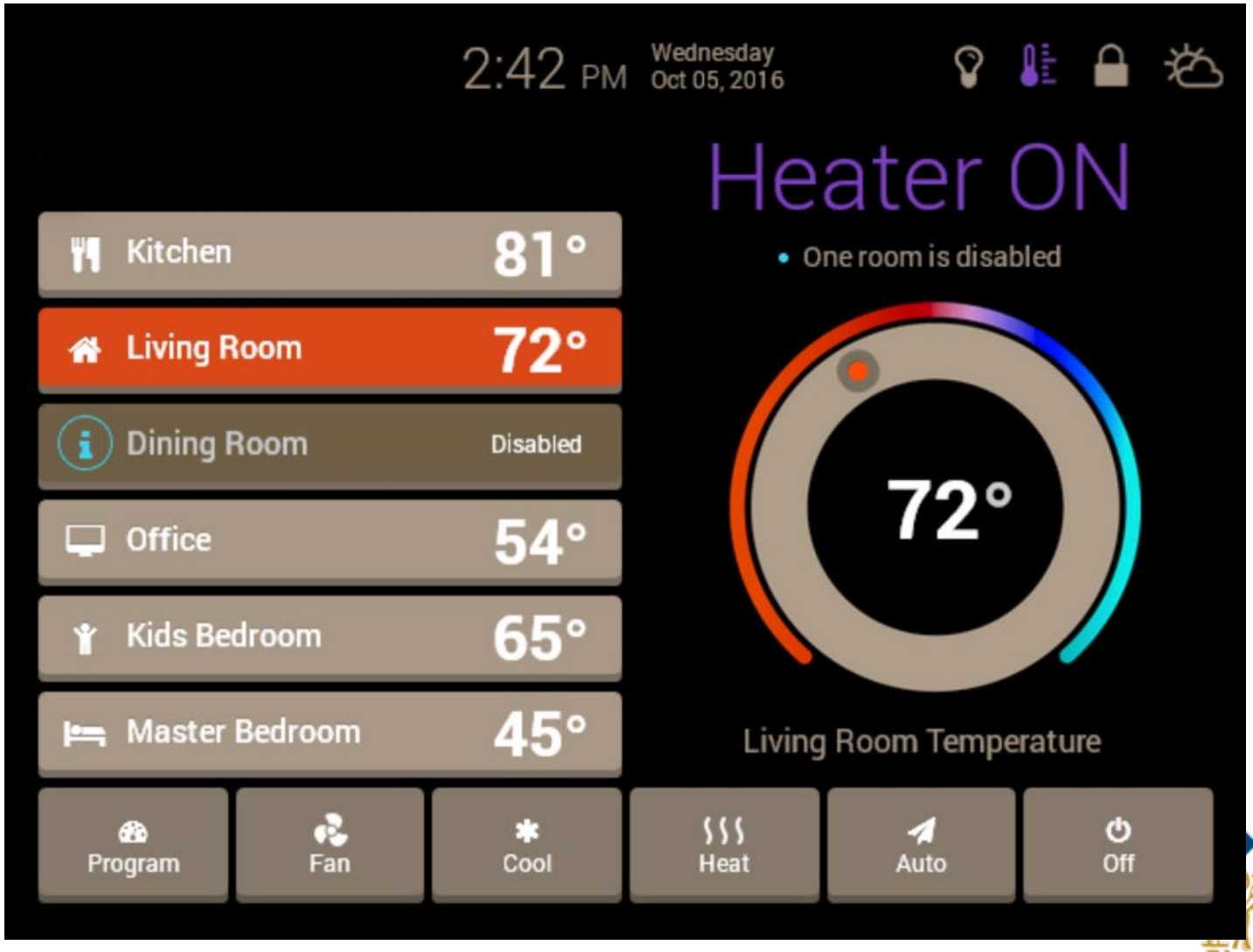
User Interface

User Interface

- Information is made useful to the **end-user**
- Ways to interact
  - Alert (email, text)
  - Automatic **notifications**
  - Monitoring information proactively
  - Controlling system remotely
- Considerations
  - Connectivity
    - Real-time information or not, when the last update was received
  - Performance
    - Massive data to be presented, pagination (only a part of the data is loaded)
  - Simplicity
    - What the user needs to see, visualization

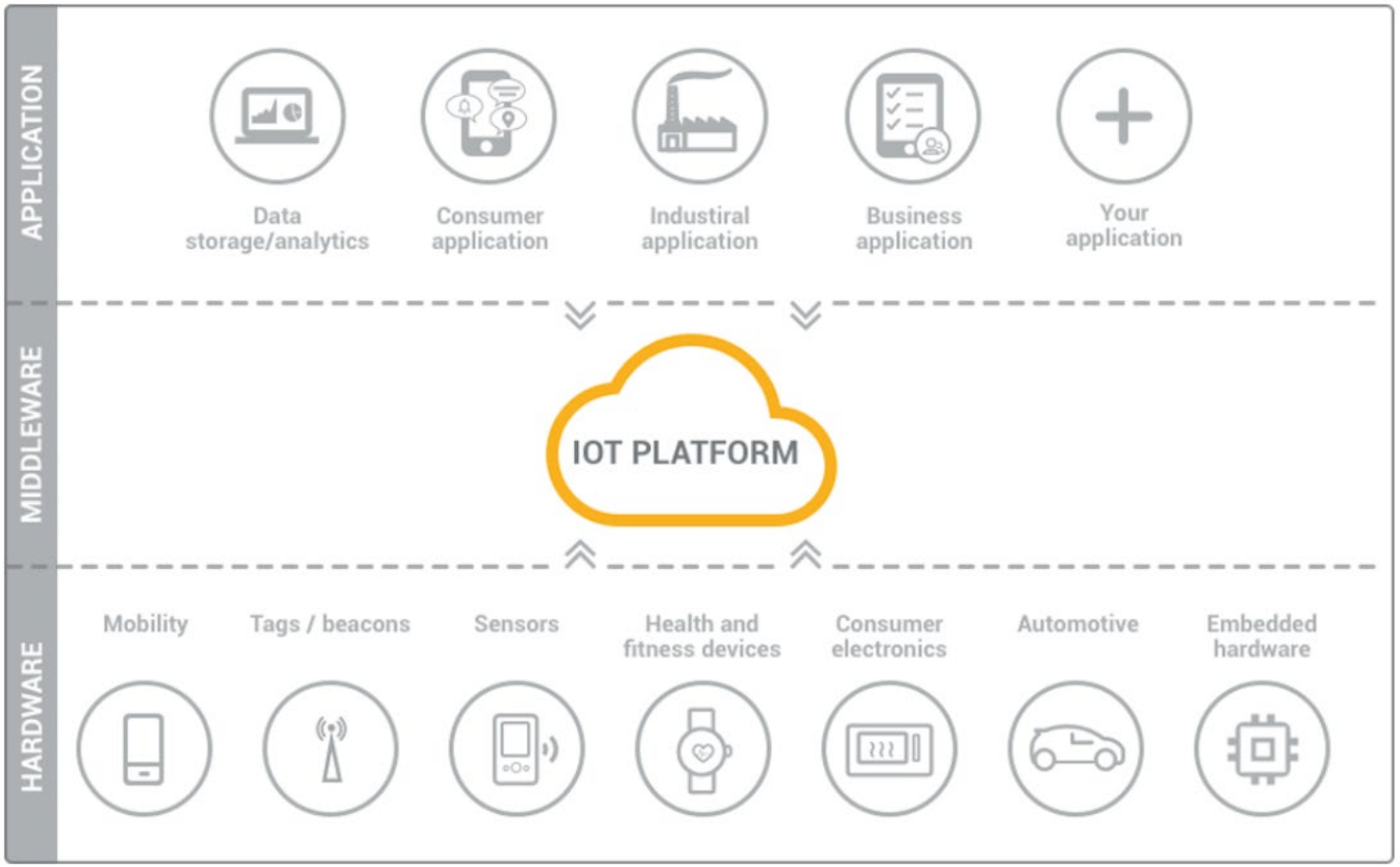
User Interface



IoT Platforms

What is an IoT Platform?

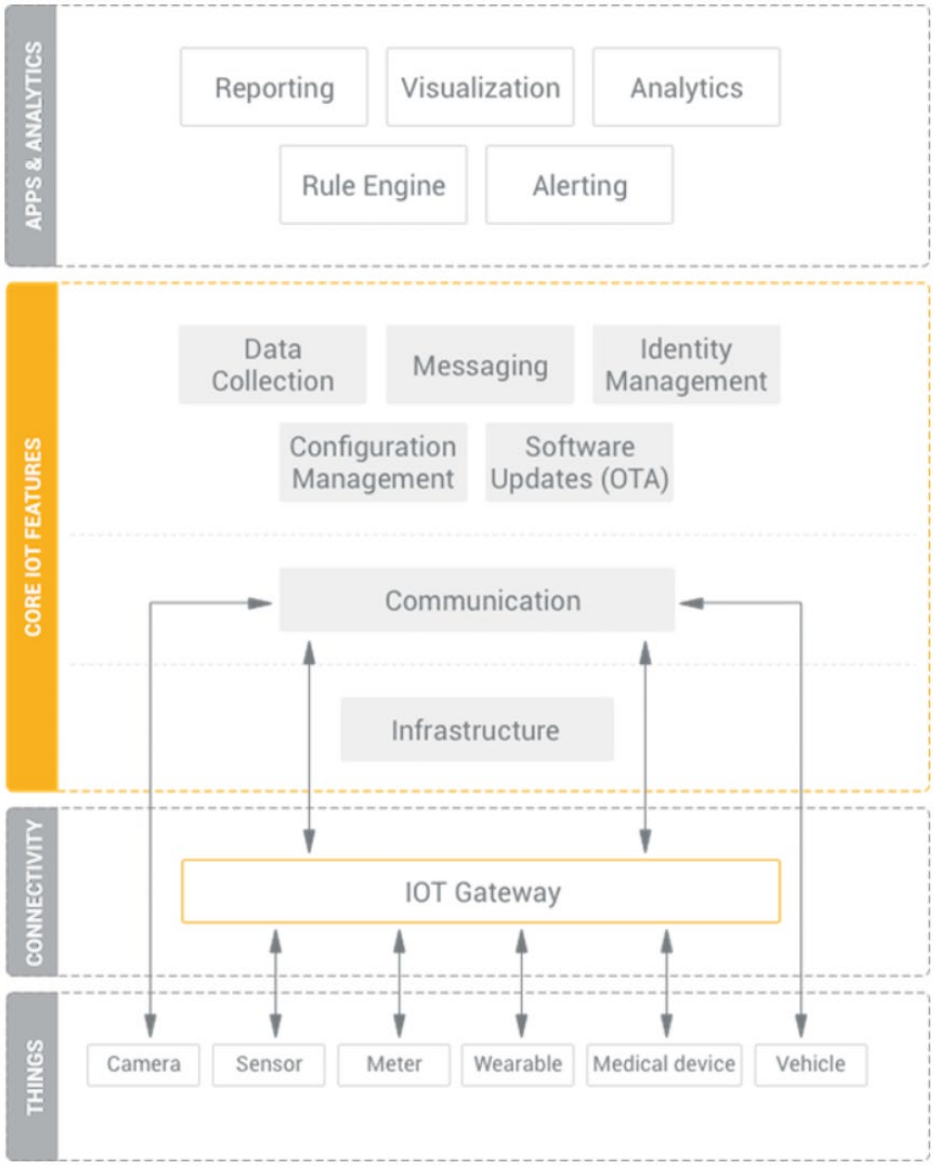
- **Middlemen** that connects the hardware to the cloud



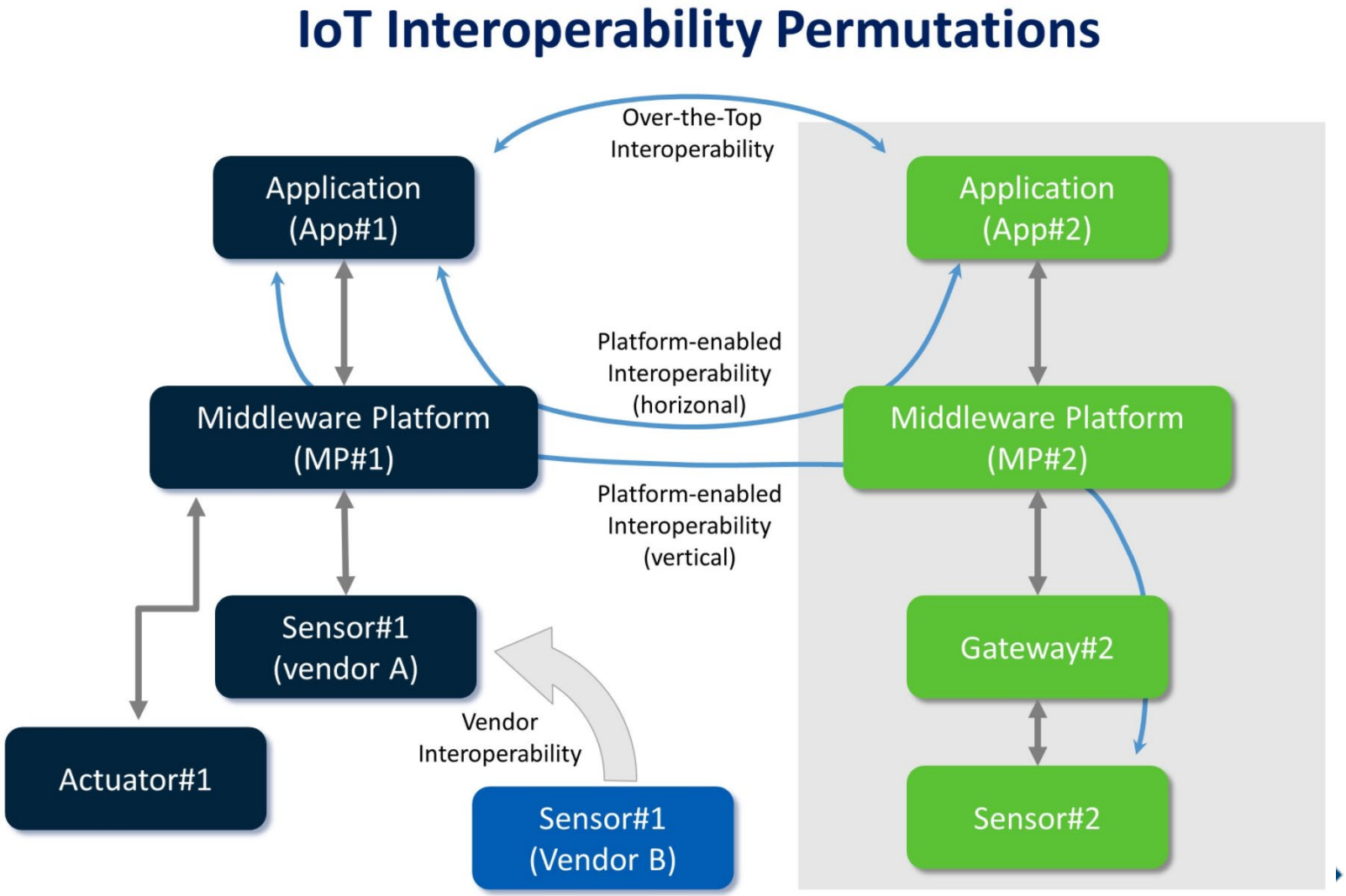
Elements of IoT Platform

- An IoT platform can be decomposed into several **layers**
- **Infrastructure** level
  - Enables the functioning of the platform
  - Internal messaging, orchestration of IoT solution clusters
- **Communication** layer
  - Where devices connect to the cloud
- **Core layer** for IoT features
  - Data collection, device management, configuration management, messaging
- **Analytics** layer
  - Data processing, visualization, rule engine, reporting

Elements of IoT Platform



Interoperability Issues in IoT Platforms



Interoperability Issues in IoT Platforms

- **Horizontal** interoperability
- App #1 can improve the performance by using **data from sensor #2**
  - 3 possibilities
- 1) App #1 might be able to **access App #2**
  - **a)** Over-the-top interoperability (horizontal)
  - Via an external data exchange
  - **b)** Platform enabled interoperability (horizontal)
  - Through the middleware platform
- 2) App #1 might be able to **access Sensor #2**
  - Platform enable interoperability (vertical)
  - Through the middleware platform

Interoperability Issues in IoT Platforms

- **Horizontal** interoperability
  - Apps able to discover **other resources**
    - Other apps, other middleware platforms, other sensors, etc.
  - Apps able to discover **other services**
    - Published data stream, usage tracking, etc.

Interoperability Issues in IoT Platforms

- **Vertical (quality)** interoperability
- App #1 can improve the performance by finding **a better sensor #1** from another vendor
- Better sensor #1
  - Better **performance**
  - Low **cost**
  - Greater **reliability**
- Technology and **vendor** interoperability
  - In the vertical sense (replace with a **higher quality sensor**)

Now and beyond

Applications

- **Household** appliances
  - Smart washing machine, dryer
- **Automobiles**
  - Autonomous vehicles
- Factories
  - Efficient production lines
- **Healthcare**
  - Heart-rate tracking, fitness, smartwatches
- Cities
  - Traffic control

IoT Distrupting Traditional Business

THE INTERNET OF THINGS REQUIRES A MINDSET SHIFT
Because you'll create and capture value differently.

		TRADITIONAL PRODUCT MINDSET	INTERNET OF THINGS MINDSET
VALUE CREATION	Customer needs	Solve for existing needs and lifestyle in a reactive manner	Address real-time and emergent needs in a predictive manner
	Offering	Stand alone product that becomes obsolete over time	Product refreshes through over-the-air updates and has synergy value
	Role of data	Single point data is used for future product requirements	Information convergence creates the experience for current products and enables services
VALUE CAPTURE	Path to profit	Sell the next product or device	Enable recurring revenue
	Control points	Potentially includes commodity advantages, IP ownership, & brand	Adds personalization and context; network effects between products
	Capability development	Leverage core competencies, existing resources & processes	Understand how other ecosystem partners make money

SOURCE SMART DESIGN

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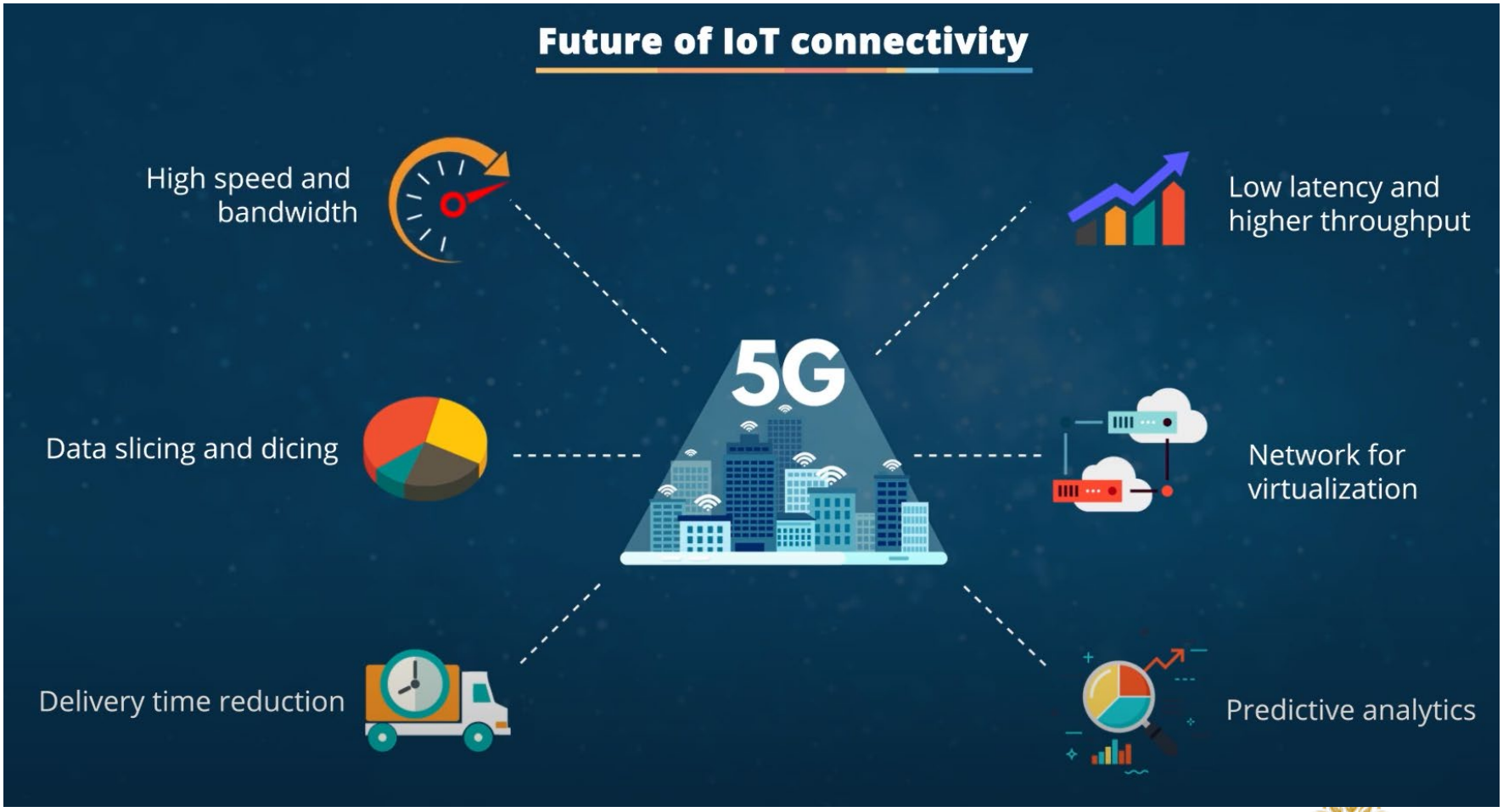
Current Issues

- Standards and Regulations
- **Privacy**
- Security
- Interoperability

Future of IoT – 5G



Readings

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