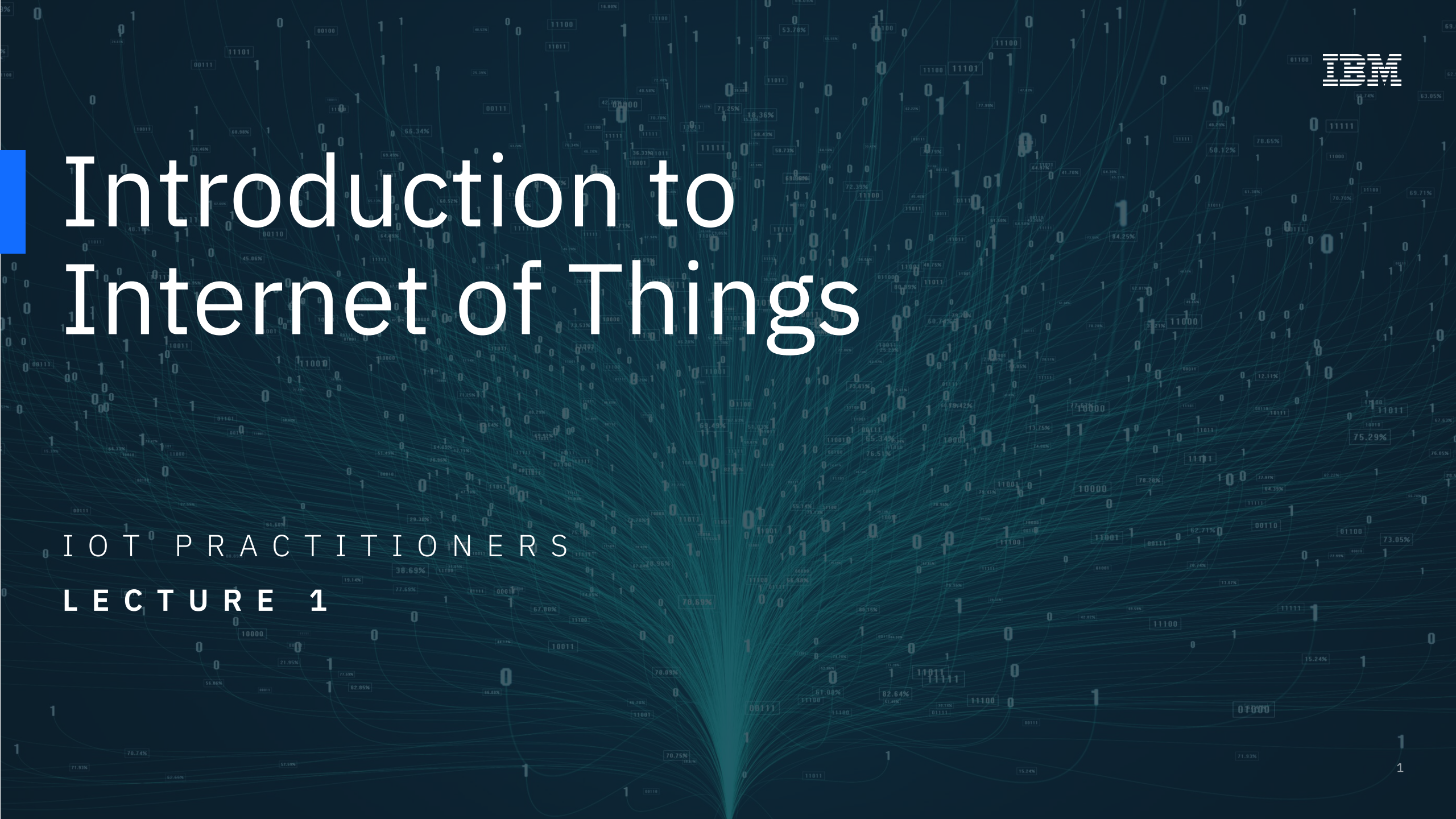


Introduction to Internet of Things

IOT PRACTITIONERS

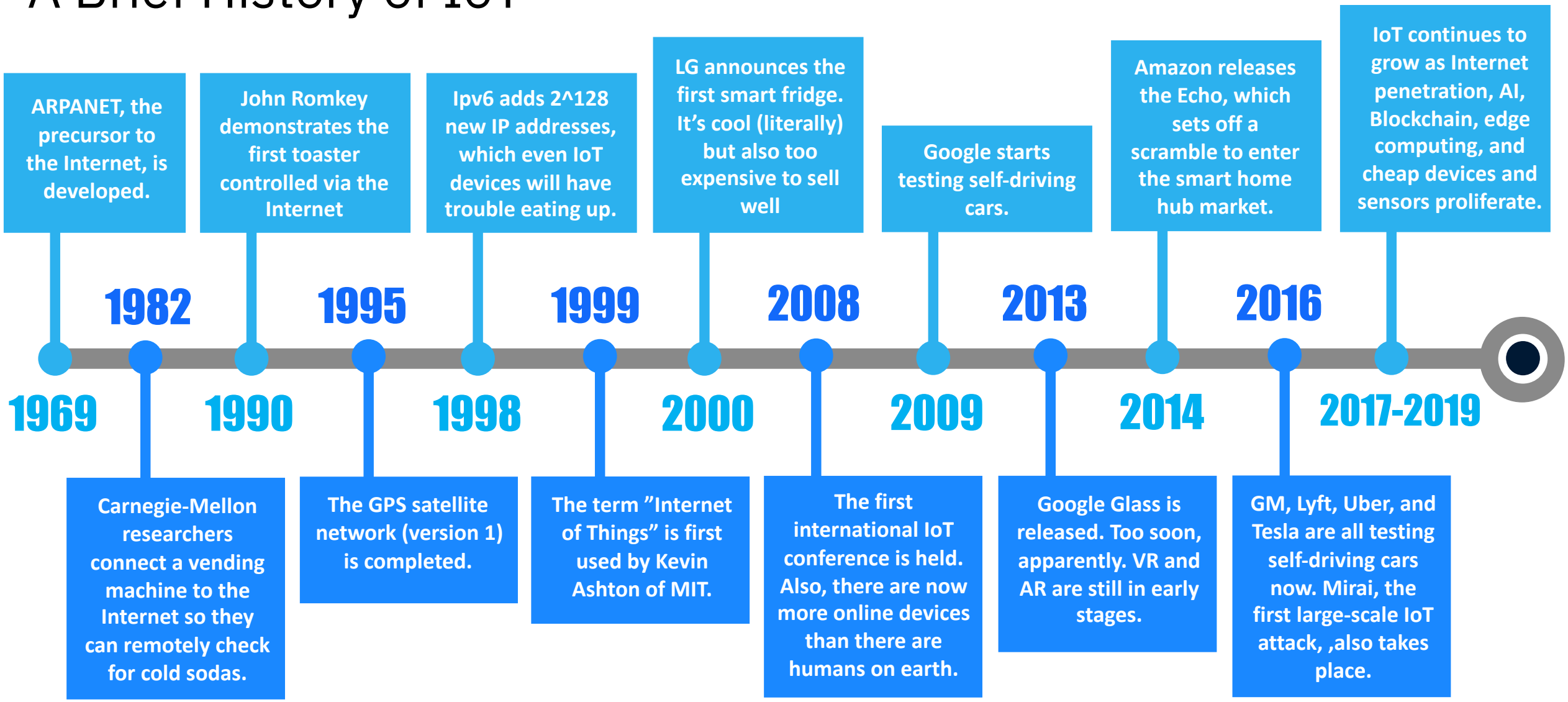
LECTURE 1

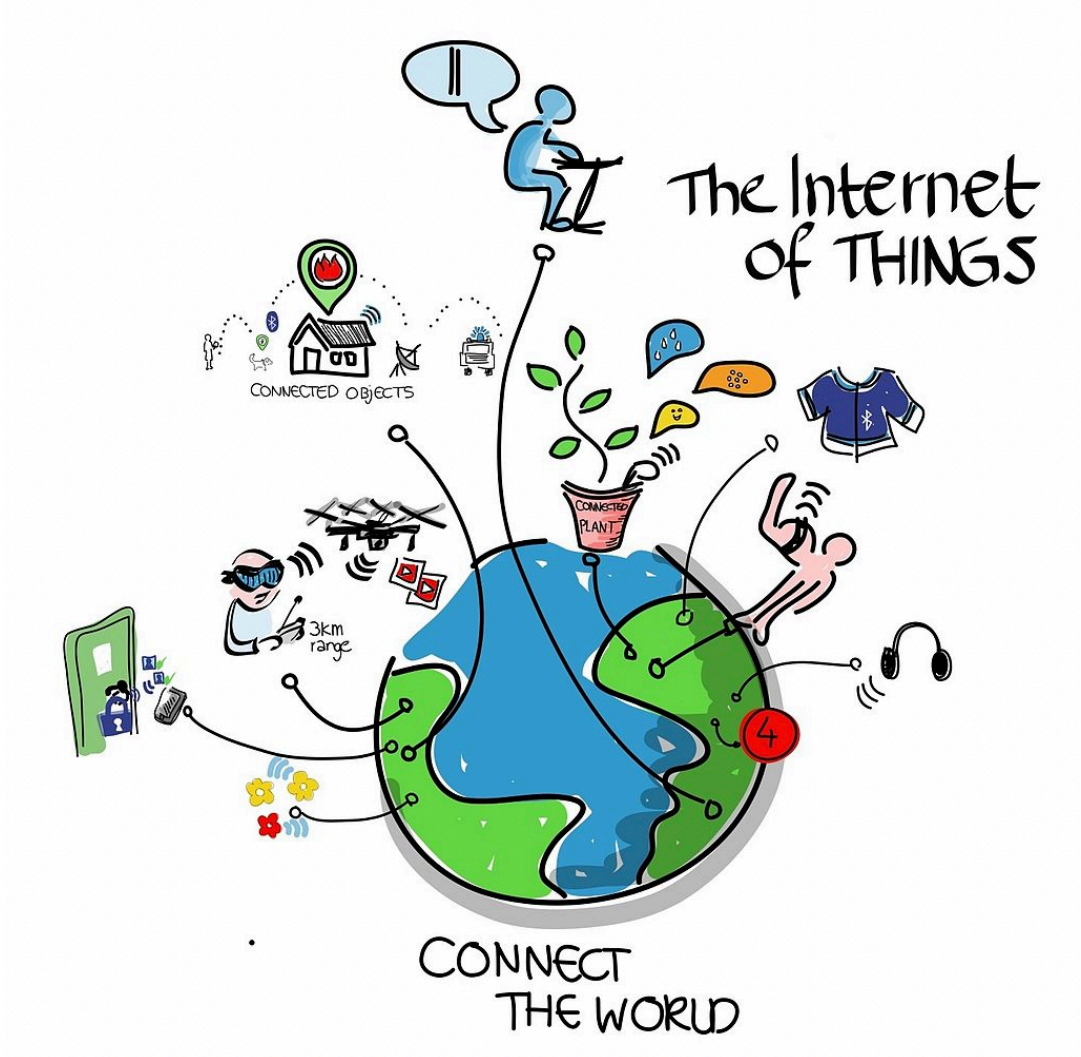
Contents

- What is Internet of Things
- How IoT works
- Why IoT
- Few Applications of IoT
- IoT Architecture

1. What is IoT?

A Brief History of IoT





What is IoT?

- The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data.
- A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

ITU definition

Physical Design of IoT

A “Thing” in the context of the Internet of things (IoT), is an entity or physical device that has a Unique identifier, an embedded system and the ability to perform remote sensing and actuating and have monitoring capabilities to transfer data over a network.

- IoT devices can:
  - Exchange data with other connected devices and applications (directly or indirectly)
  - Collect data from other devices and process the data locally,
  - Send the data to centralized servers or cloud-based application back-ends for processing the data
  - Perform some tasks locally and other tasks within the IoT infrastructure, based on temporal and space constraints

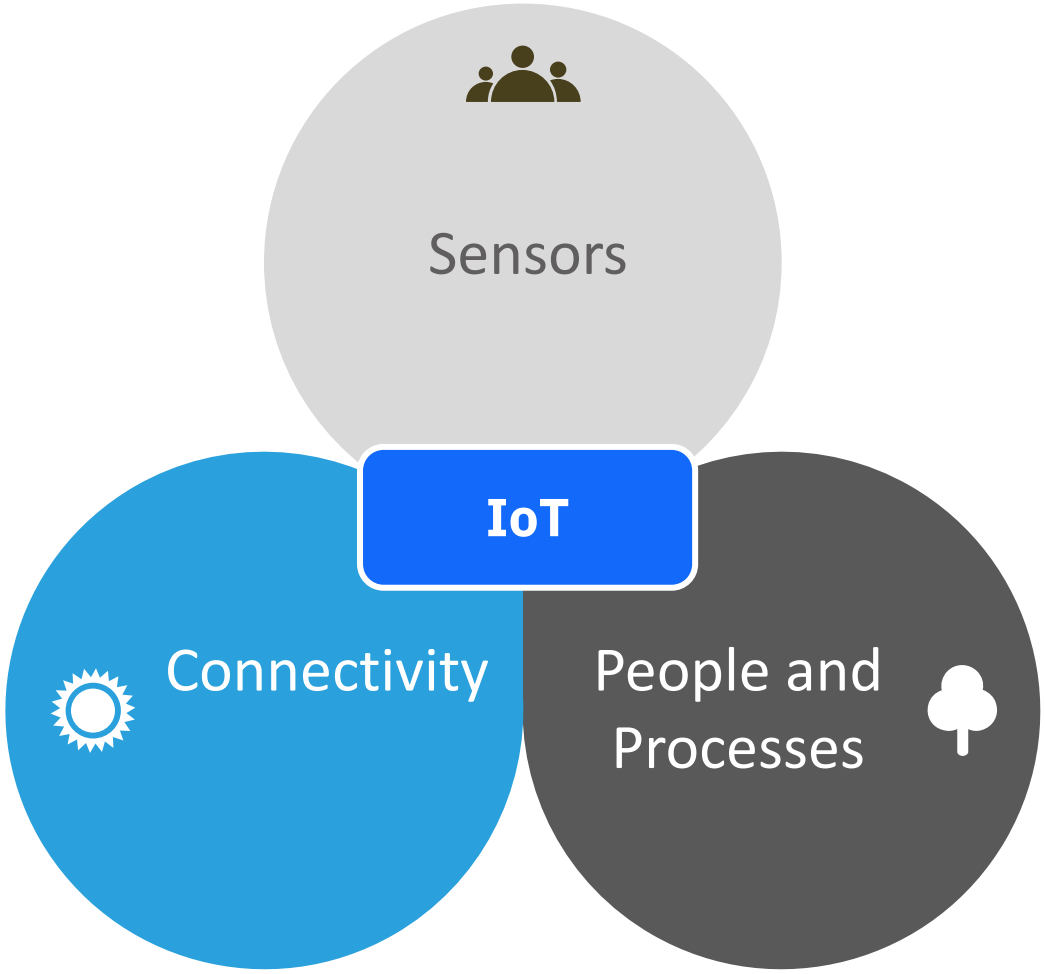
These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.

- ❖ Heart monitoring implants
- ❖ Biochip transponders on farm animals
- ❖ Automobiles with built-in sensors
- ❖ DNA analysis devices & OtherWearbles etc.

Components of IoT

Smart Systems and Internet of Things are driven by a combination of :

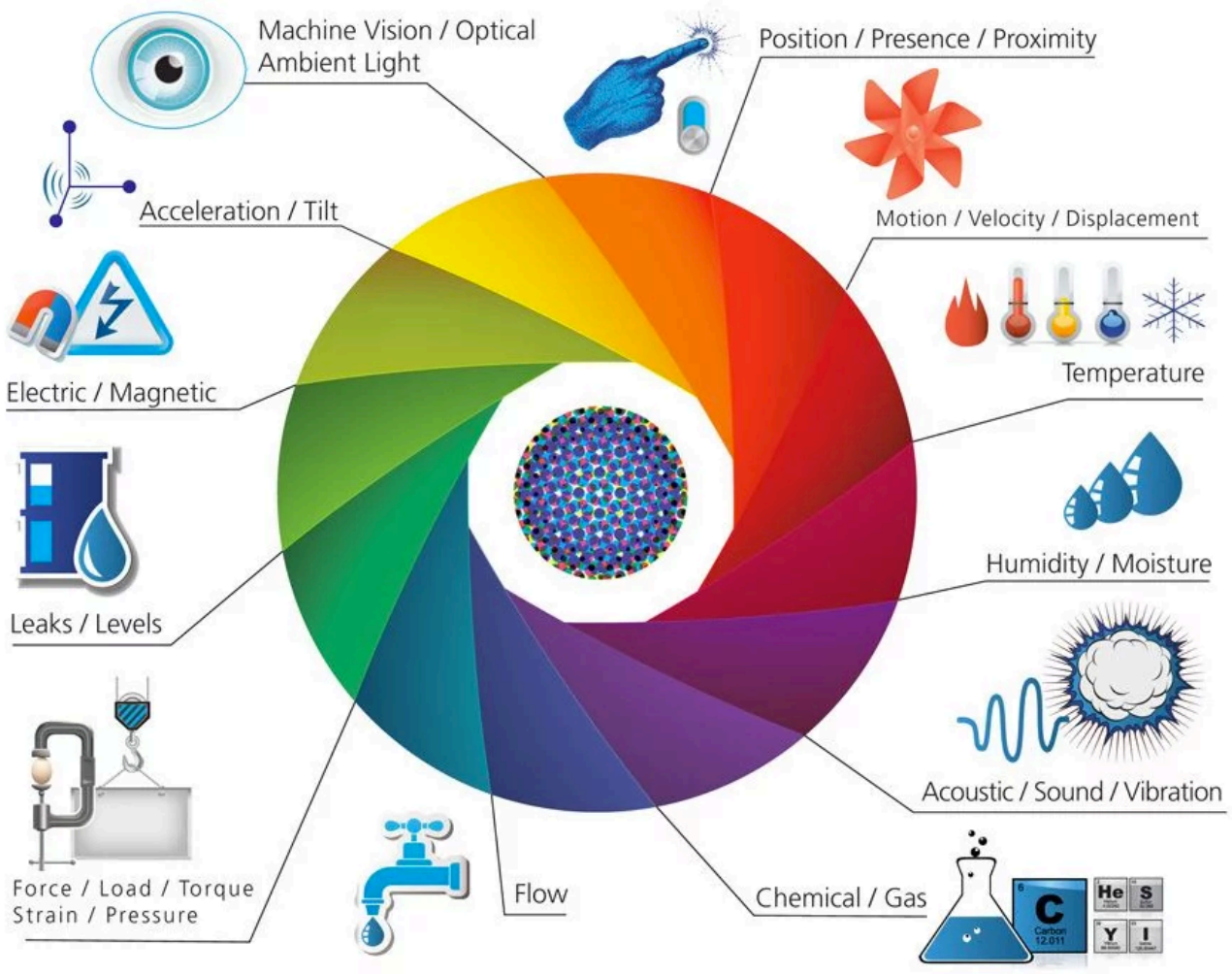
- Sensors & Actuators
- Connectivity
- People & Processes



1. Sensors & Actuators

We are giving our world a digital nervous system.

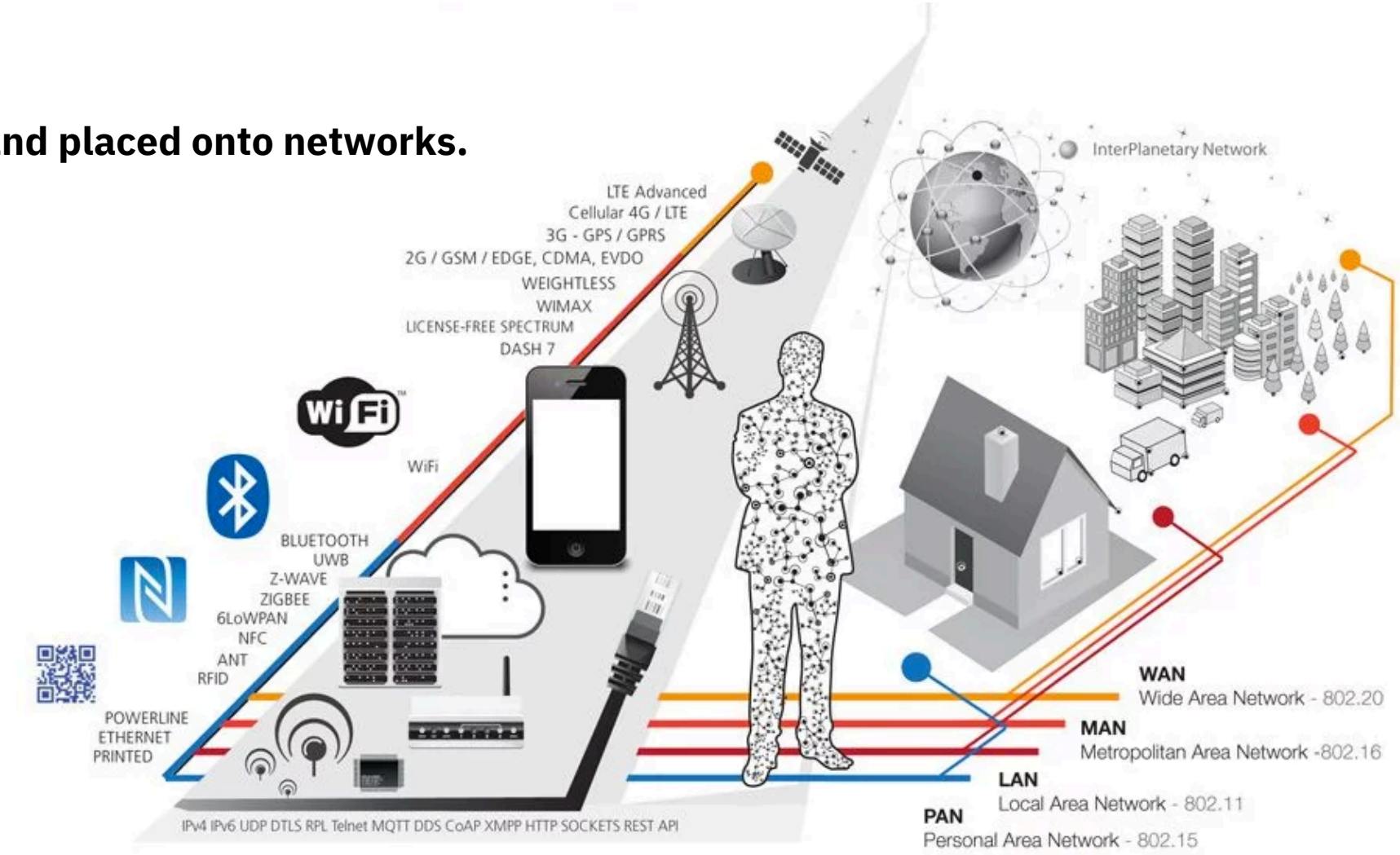
Location data using GPS sensors. Eyes and ears using cameras and microphones, along with sensory organs that can measure everything from temperature to pressure changes.



[Source: Postscape - http://postscapes.com/what-exactly-is-the-internet-of-things-infographic]

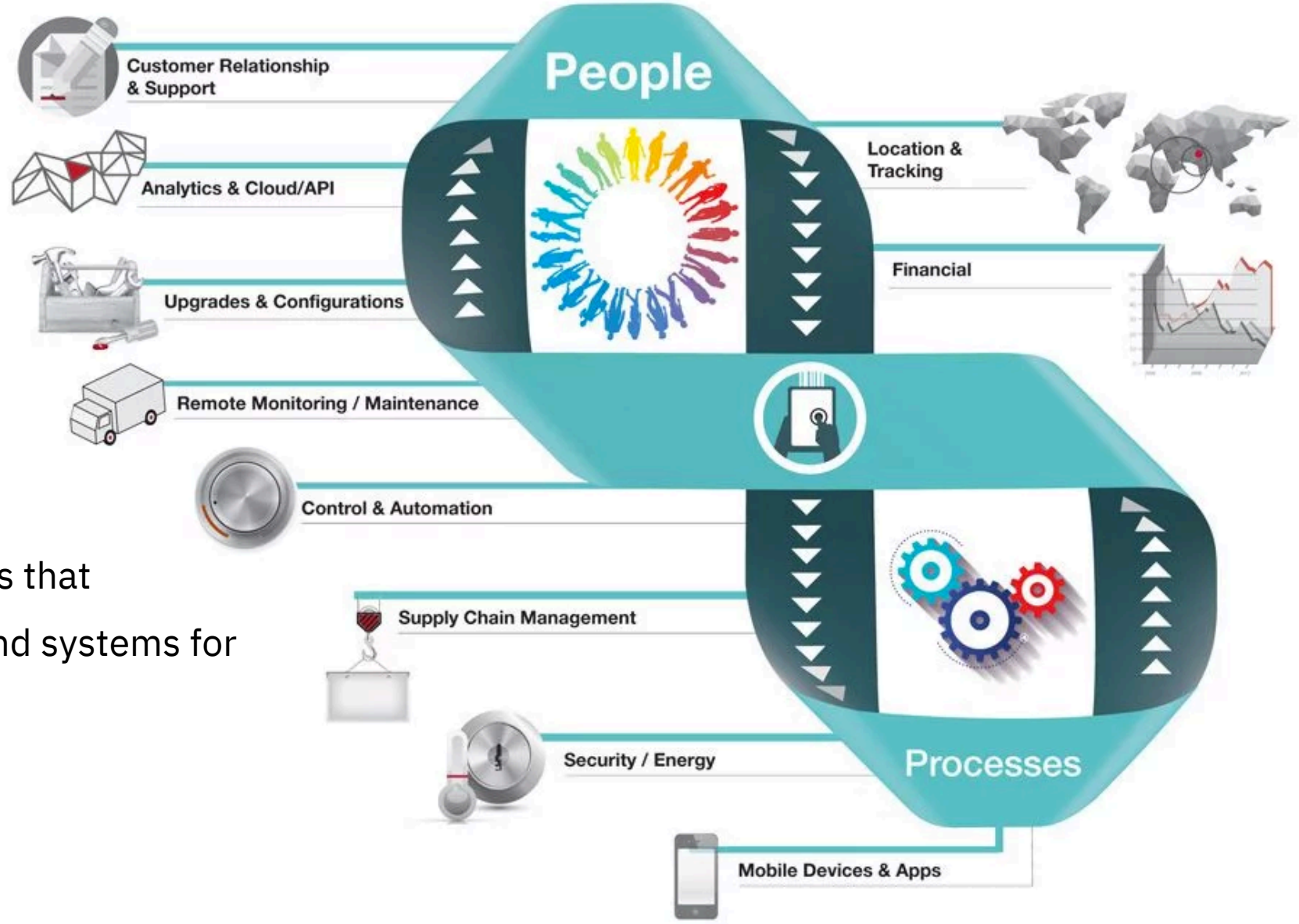
2. Connectivity

These inputs are digitized and placed onto networks.



[Source: Postscape - http://postscapes.com/what-exactly-is-the-internet-of-things-infographic]

3. People & Processes



These networked inputs can then be combined into bi-directional systems that integrate data, people, processes and systems for better decision making.

[Source: Postscape - http://postscapes.com/what-exactly-is-the-internet-of-things-infographic]

2. How IoT Works?

The Internet of Things Lifecycle

Devices and **Sensors** are collection data everywhere.

- At your home
- At your office
- In your car
- In the Manufacturing plant

Sending **Data** and events through **Network** to some destination.

- A cloud platform
- Private data center
- Home network

Creating **Information** from the data

- Visualizing the data
- Building Reports
- Filtering Data

Taking **Action** based on the information and data

- Communicate with other machine (m2m)
- Send notification (sms, email, text)
- Talk to another system

The Structure of IoT

The IoT can be viewed as a gigantic network consisting of networks of devices and computers connected through a series of intermediate technologies where numerous technologies like RFIDs, wireless connections may act as enablers of this connectivity.

- **Tagging Things**: Real-time item traceability and addressability by **RFIDs.**
- **Feeling Things**: **Sensors** act as primary devices to collect data from the environment.
- **Shrinking Things**: Miniaturization and **Nanotechnology** has provoked the ability of smaller things to interact and connect within the "things" or "smart devices."
- **Thinking Things**: **Embedded intelligence** in devices through sensors has formed the network connection to the Internet. It can make the "things" realizing the intelligent control.

3. Why is it relevant?

Why IoT?

- Dynamic control of industry and daily life.
- Improves the resource utilization ratio.
- Integrating human society and physical systems.
- Acts as technology integrator.
- Universal inter-networking.

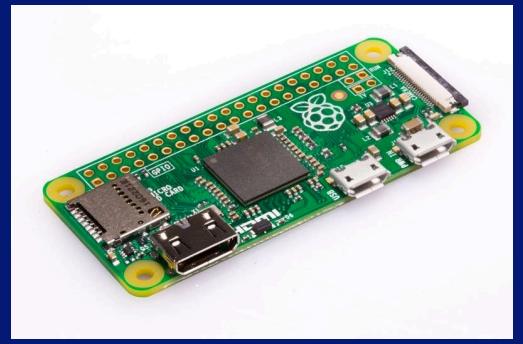
Importance of IoT

- Health care - cost reduction and service quality improvement
- Energy – more efficient usage (management) and cost reduction
- City infrastructure – efficiency, costs, quality of life
- Security – automated, accessible from anywhere
- Industry – automated factories
- Agriculture – livestock and crop monitoring

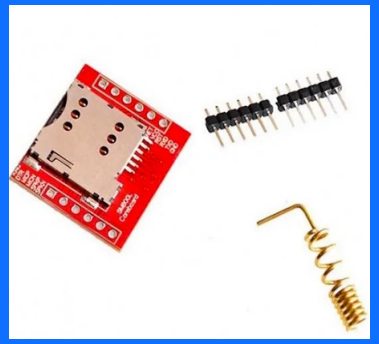
Why now IoT?

- Cost effective hardware, manufacturing and devices
- Cost effective communication medium
- Automation and process efficiency
- Market competition (e.g. real-time analytics)

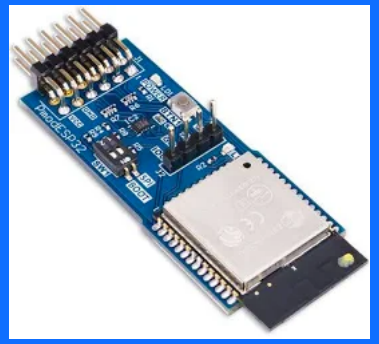
Raspberry Pi Zero USD$5



Communication Modules

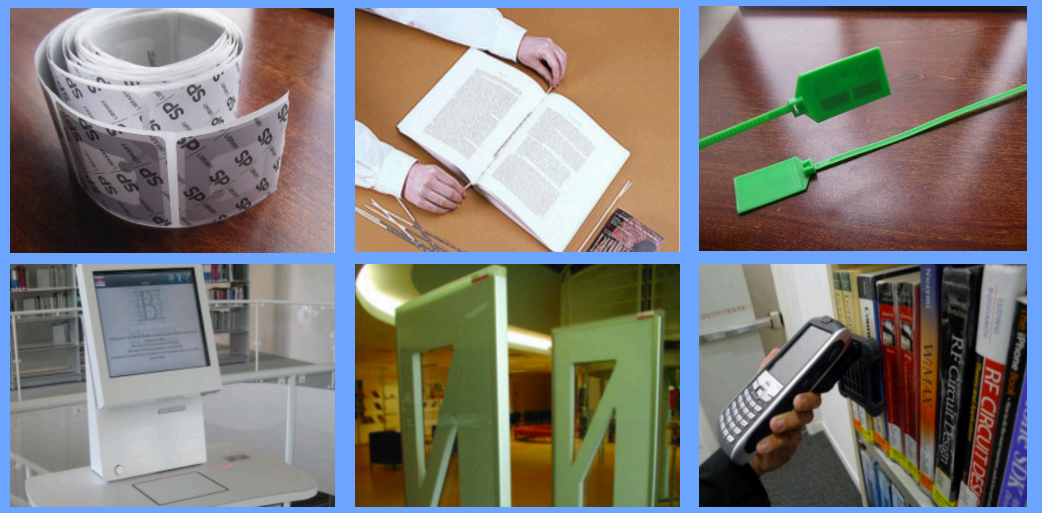


GSM Module

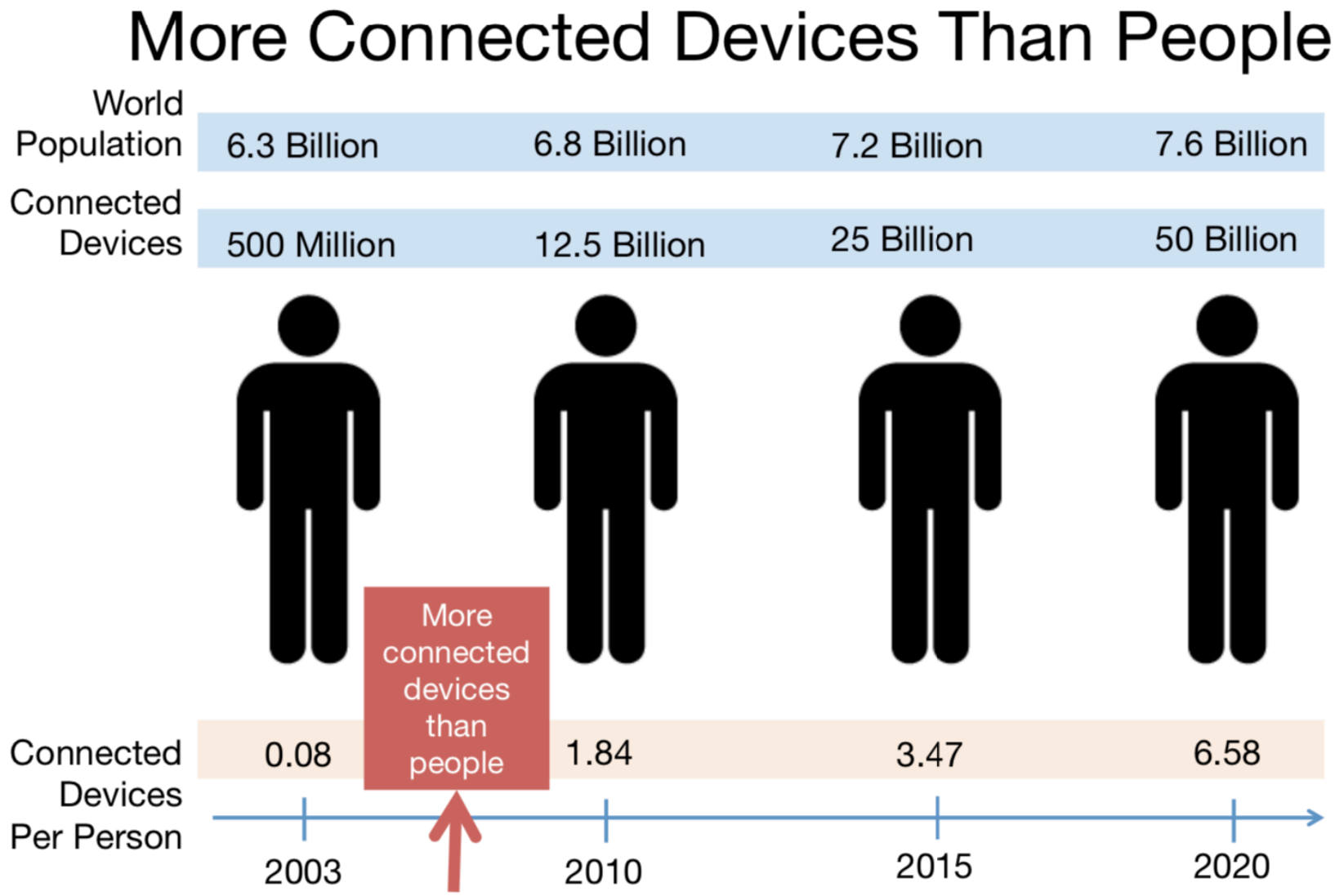


Wi-Fi/Bluetooth Module

RFID for Automation

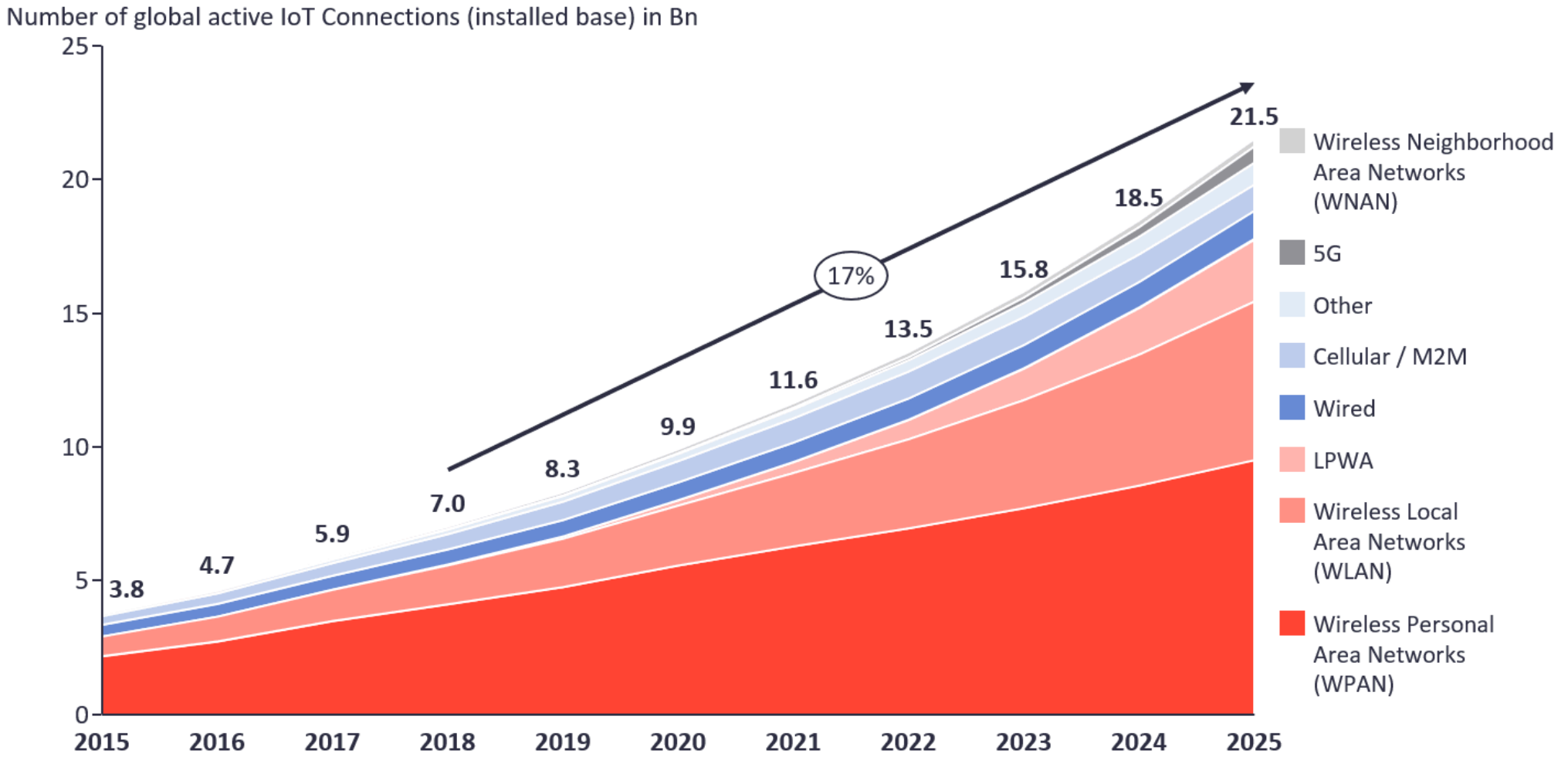


Current Status & Future Prospect of IoT



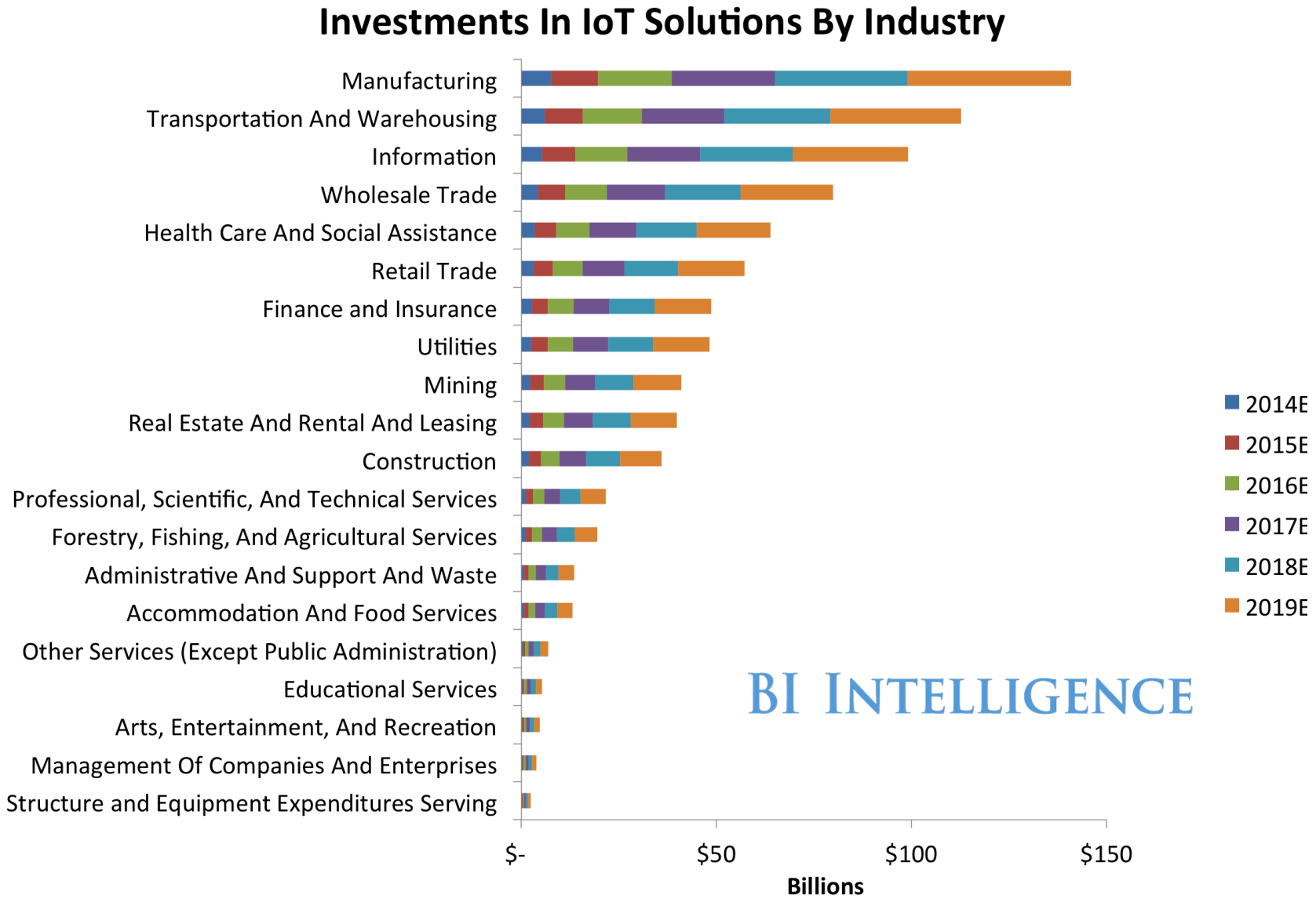
[Source: Cisco IBSG, April 2011]

Global Number of Connected IoT Devices



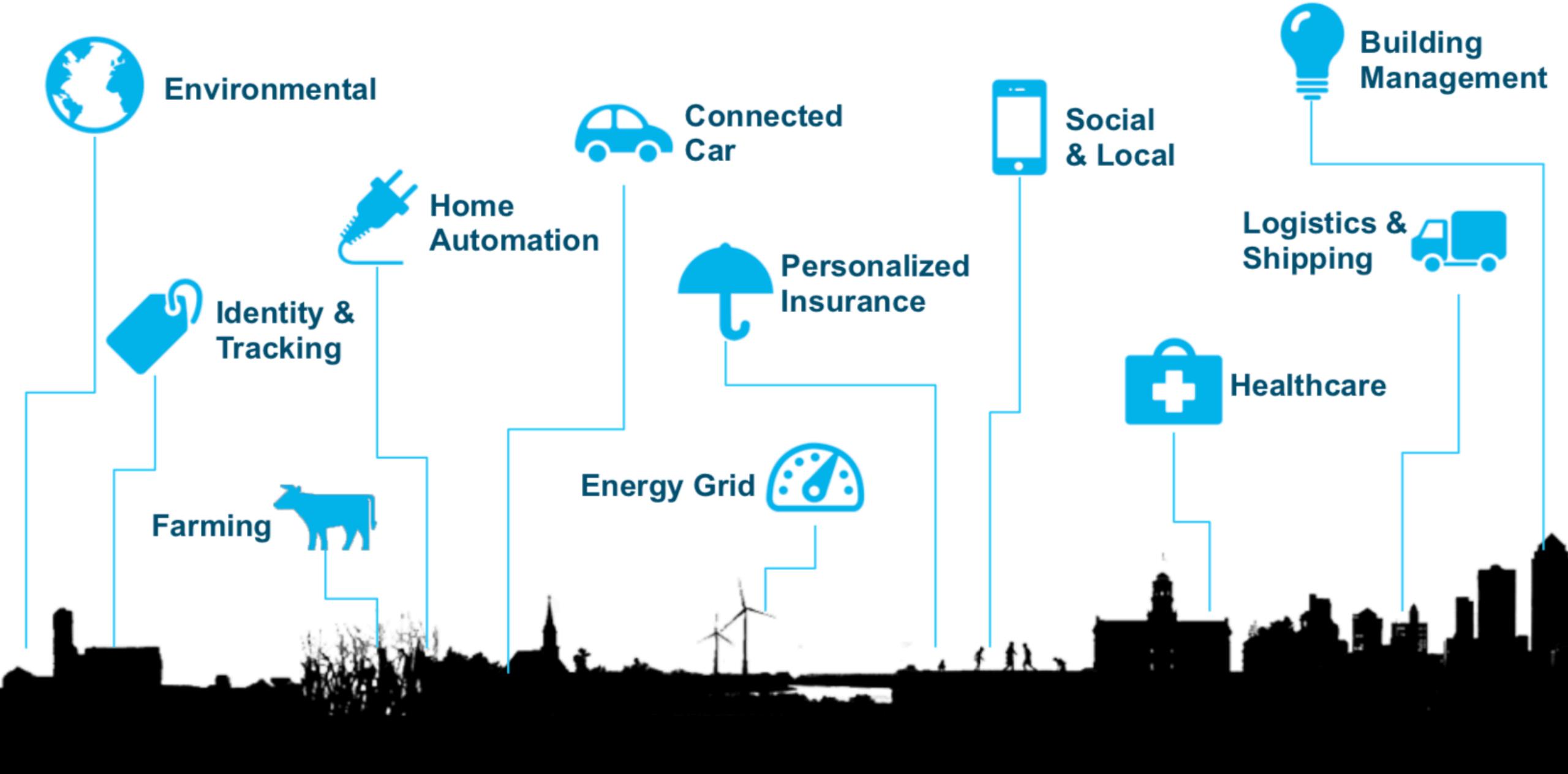
Note: IoT Connections do not include any computers, laptops, fixed phones, cellphones or tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology not considered (e.g., RFID, NFC). Wired includes Ethernet and Fieldbuses (e.g., connected industrial PLCs or I/O modules); Cellular includes 2G, 3G, 4G; LPWAN includes unlicensed and licensed low-power networks; WPAN includes Bluetooth, Zigbee, Z-Wave or similar; WLAN includes Wi-fi and related protocols; WNAN includes non-short range mesh; Other includes satellite and unclassified proprietary networks with any range.
Source: IoT Analytics Research 2018

Economic Aspect of IoT



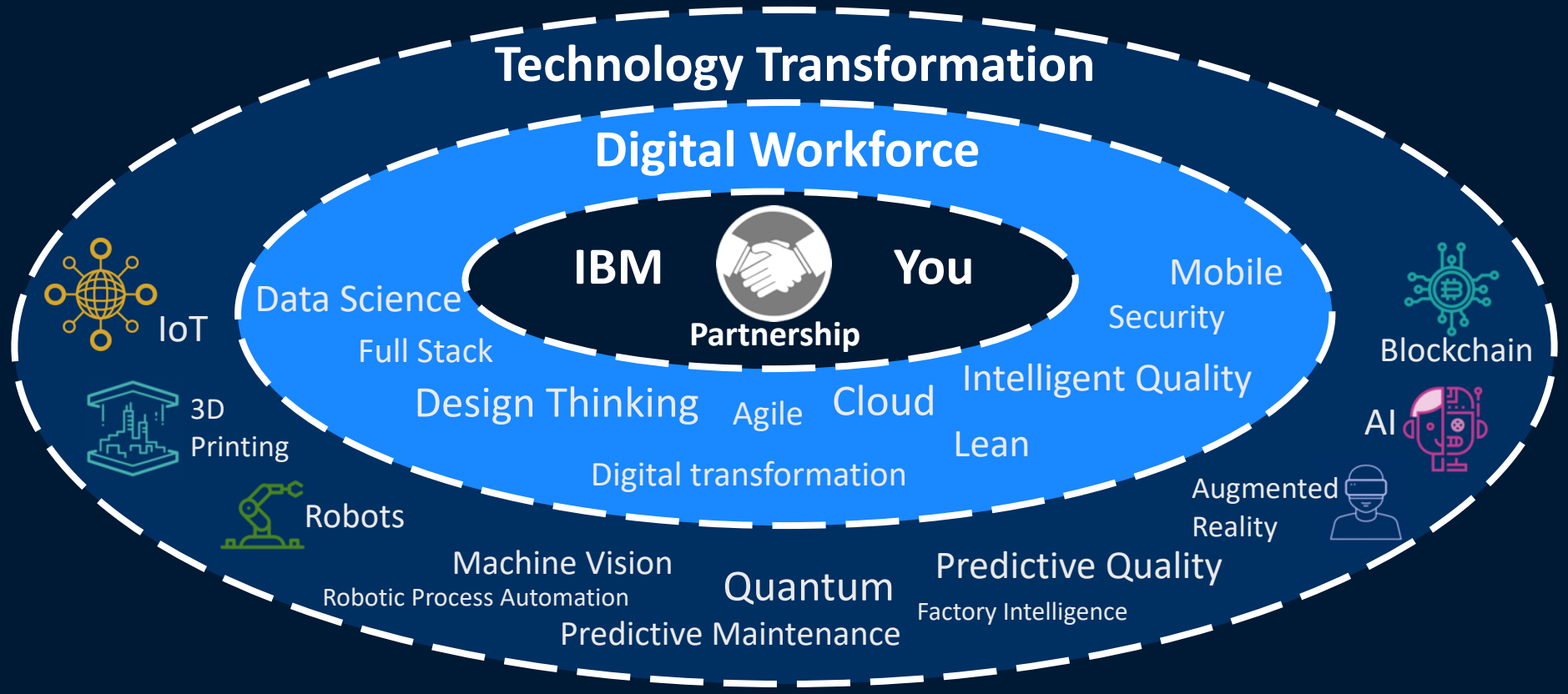
Source: BI Intelligence Estimates

Connecting the physical world to the Web

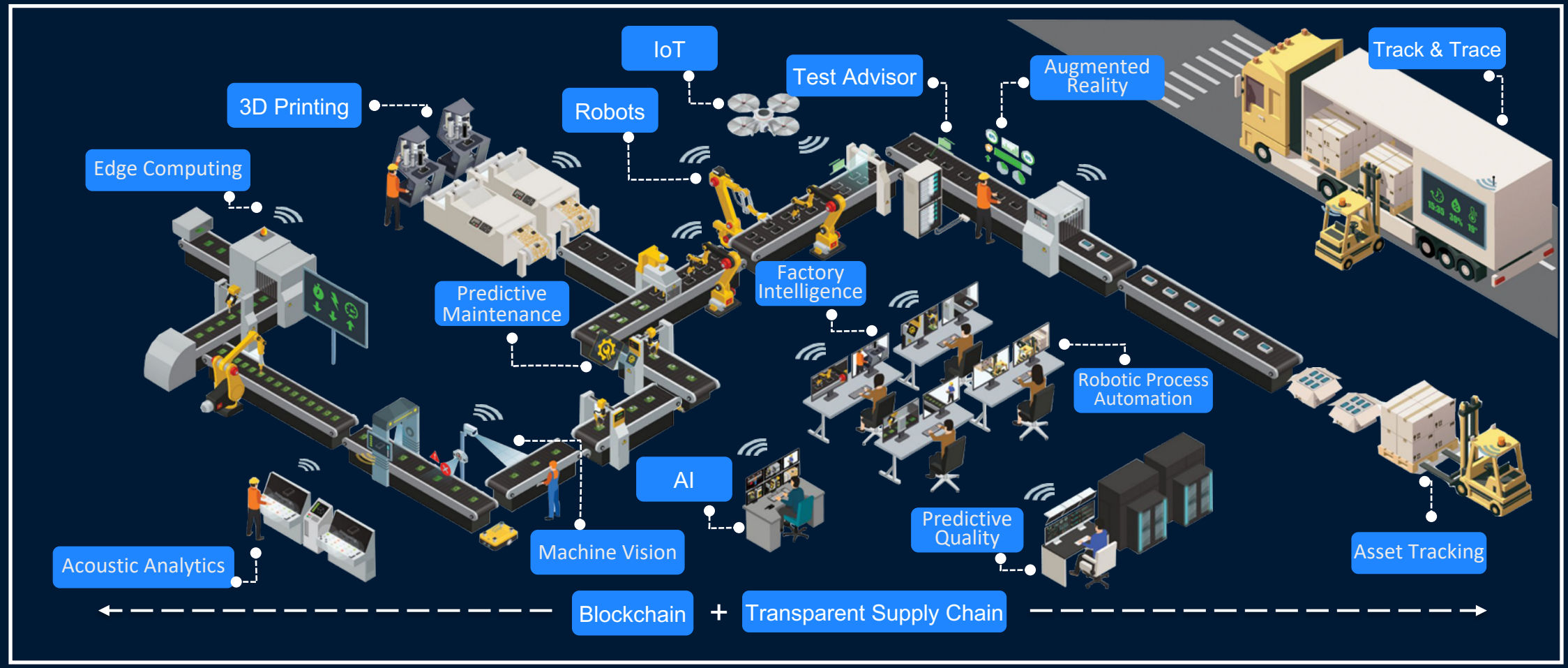


4. Applications of IoT

Industry 4.0 Transformation



Cognitive Factory

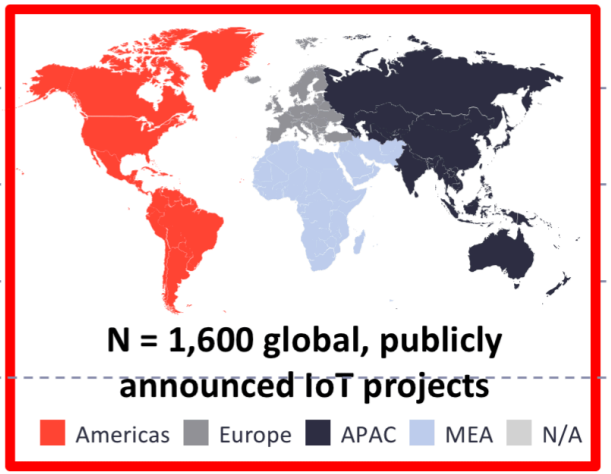


IoT Segment

Global share of IoT projects[1]

Details

	IoT Segment	Global share of IoT projects[1]	Americas	Europe	APAC	Trend[2]
1	Smart City	23%	34%	45%	18%	↗
2	Connected Industry	17%	45%	31%	20%	↘
3	Connected Building	12%	53%	33%	13%	↑
4	Connected Car	11%	54%	30%	12%	→
5	Smart Energy	10%	42%	35%	19%	→
6	Other	8%	50%	34%	11%	→
7	Connected Health	6%	55%	29%	15%	→
8	Smart Supply Chain	5%	49%	36%	12%	↗
9	Smart Agriculture	4%	39%	26%	31%	→
10	Smart Retail	4%	53%	35%	9%	→



1.Based on 1,600 publicly known enterprise IoT projects (Not including consumer IoT projects e.g., Wearables, Smart Home). 2.Trend based on comparison with % of projects in the 2016 IoT Analytics Enterprise IoT Projects List. A downward arrow means the relative share of all projects has declined, not the overall number of projects 3. Not including Consumer Smart Home Solutions. **Source**: IoT Analytics 2018 Global overview of 1,600 enterprise IoT use cases (Jan 2018)

Source: IoT Analytics, Jan 2018

Industrial Equipment

Manufacturing

- **Enterprise asset management -** ***Shenzhen China Star Optoelectronics Technology Co., Ltd.***

LCD manufacturer partnered with IBM to accelerate and automate product inspections — boosting production quality and throughput, while cutting costs.

- **System engineering -** ***Mahindra & Mahindra Ltd***

Automobile manufacturer gains the ability to manage product innovations throughout the development process, reduces redundant work and enhances governance of projects.

- **Worker safety -** ***Bragi Gmbh***

With wearables to assist maintenance crews and field operations with real-time insights.

Processing

- **Enterprise asset management -** ***Velenje Coal Mine***

By analyzing in near-real time the status of the mine's equipment, the solution can detect and report potential failures, enable to take action with predictive maintenance before faults occur.

- **System engineering -** ***Petrobras***

Track suppliers' progress on software development tasks, and automatically calculate key performance indicators – streamlining payment processes and saving manual work.

- **Worker safety -** ***Northstar Bluescope Steel***

Boost worker safety in extreme environments that could include toxic gas, open flames and high heat.

Power generation and transmission

- **Enterprise asset management -** ***Fingrid***

Using IBM EAM solutions and advanced analytics to manage the grid, monitor asset health and predict equipment failure.

- **System engineering -** ***NuScale Power***

Using IBM Rational DOORS to create a collaborative work environment for continuous engineering that meets detailed, complex and evolving management requirements to design the next generation of nuclear reactors.

- **Worker safety -** ***Woodside Energy***

Using IBM Watson™ to design a cognitive system that consumes, learns and applies data from millions of sources to make smarter decisions across the enterprise.

Buildings

Commercial buildings

- **Assets and facilities - *Ferrovial***

Save lifecycle costs, improve collaboration and eliminate excess hours of manual work for large-scale projects.

- **IoT Connectivity - *Tyréns AB***

Tyréns is revolutionizing building management and boosting efficiency by deploying IoT sensors at its headquarters and linking them to its building information models and asset management systems, enabling smarter decision making across their facilities.

- **Buildings Insights - *IBM TRIRIGA***

Using real-time energy use data to take smarter decisions and make the building more energy efficient.

Industrial facilities

- **Assets and facilities - *Dow Chemical***

To support over 20 million square feet of space, Dow Chemical had to overcome disconnected, manual facilities management processes. By deploying the IoT solution, facility use increased by 20%, saving approximately $4 million a year.

- **IoT Connectivity - *Port of Rotterdam***

The Port of Rotterdam, Europe's largest port by cargo tonnage, is utilizing IBM IoT Connection Service to digitize port operations, delivering a centralized view of the entire ecosystem.

- **Worker Safety - *Nation Waste, Inc.***

Nation Waste, Inc. is lunching the Nation Safety Net to leverage a solution powered by IBM Watson IoT to keep workers safe and mitigate the cost of workplace injuries.

Hotels

- **Assets and facilities - *KONE***

KONE uses IBM solutions to connect, remotely monitor and optimize millions of elevators, escalators, doors and turnstiles in buildings worldwide.

- **IoT Connectivity - *Pebble Beach***

Pebble Beach and 17-Mile Drive aim to attract a new generation of younger and more tech savvy travelers with a more engaging and personalized journey. The solution was a virtual concierge in the form of a mobile app, with the power of Watson's cognitive capabilities.

Vehicles

Automobiles

- **Systems Engineering – *Jaguar Land Rover***

Using a suite of connected engineering solutions to quickly and cost-effectively deliver vehicle features that meet marketplace demands.

- **Enterprise Asset Management - *Golden State Foods***

IoT-enabled vehicles are easier to track and maintain as issues are automatically report and address before they cause bigger problems down the line to avoid spoiled produce.

- **Connectivity and IoT - *Groupama***

An IoT-based, connected insurance experience enables Groupama to create new business models with customers in the driver's seat.

Aircraft

- **Systems Engineering - *Crane***

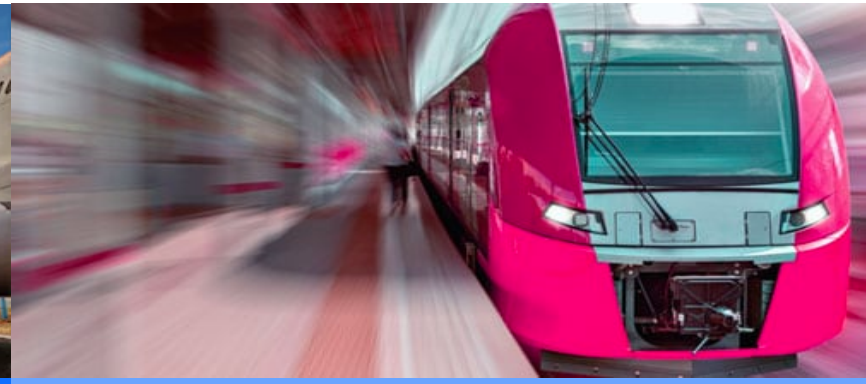
IBM connected engineering solutions help Crane enhance collaboration among development teams and automate application development, testing and reporting lifecycles.

- **Enterprise Asset Management - *Arrow***

Using IBM Maximo, Watson IoT, and Arrow sensors & gateways to improve the maintenance and performance of airport equipment to eliminate the inconveniences for travelers.

- **Weather Insights - *Boeing***

Boeing enables airlines to provide their operation centers with access to the same weather information which facilitates collaboration and builds confidence in operational decisions, resulting in fewer flight delays and a better flying experience.



Railcars

- **Systems Engineering – *Invensys Rail Dimetronic***

IBM connected engineering solutions were used to automate code generation and speed response to frequent changes in traffic signal requirements.

- **Enterprise Asset Management - *CSX***

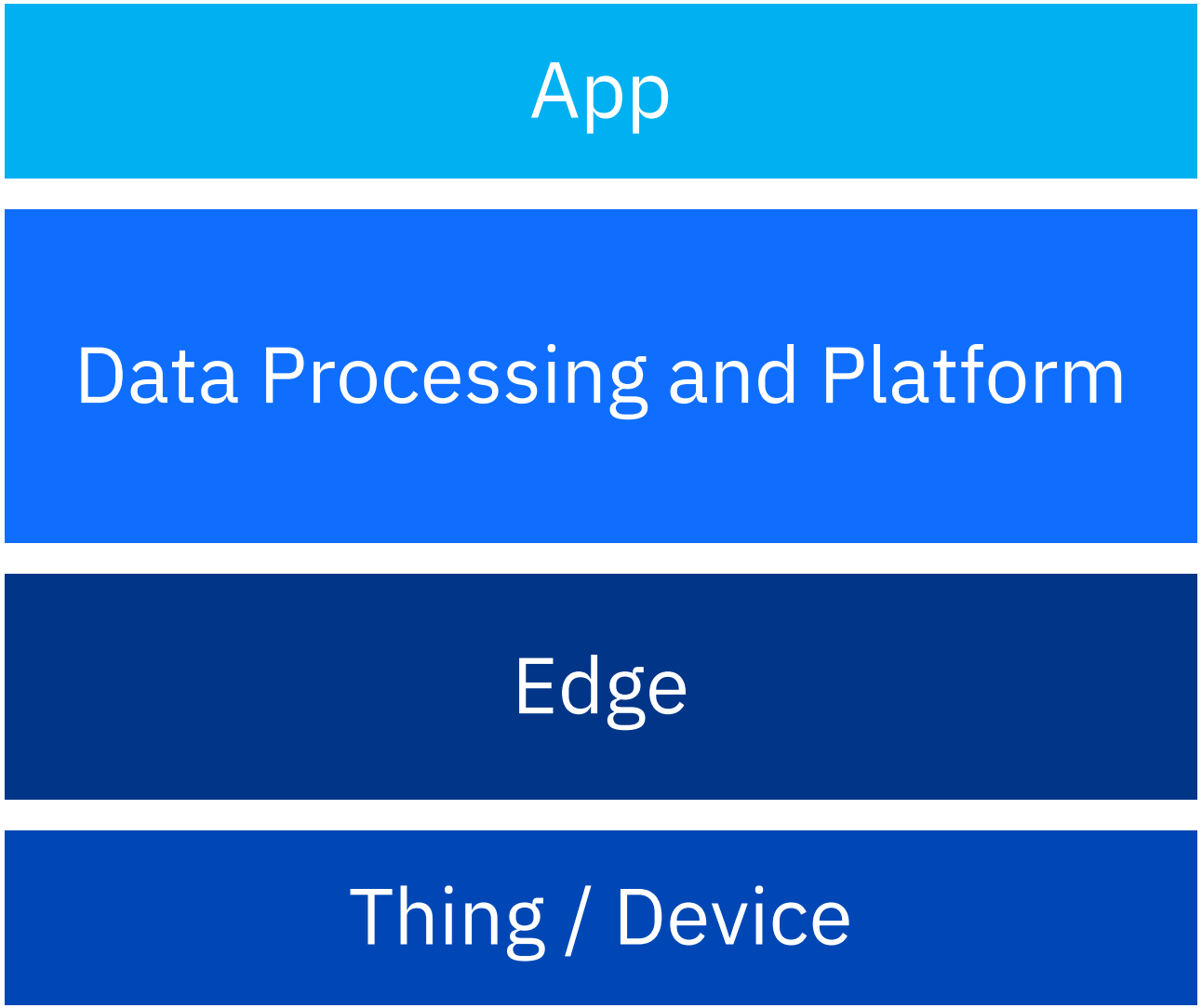
By using IBM's enterprise asset management solutions for inventory, service requests and work orders, CSX is able to manage its equipment, reducing downtime and disruption of service.

- **Connectivity and IoT - *SNCF***

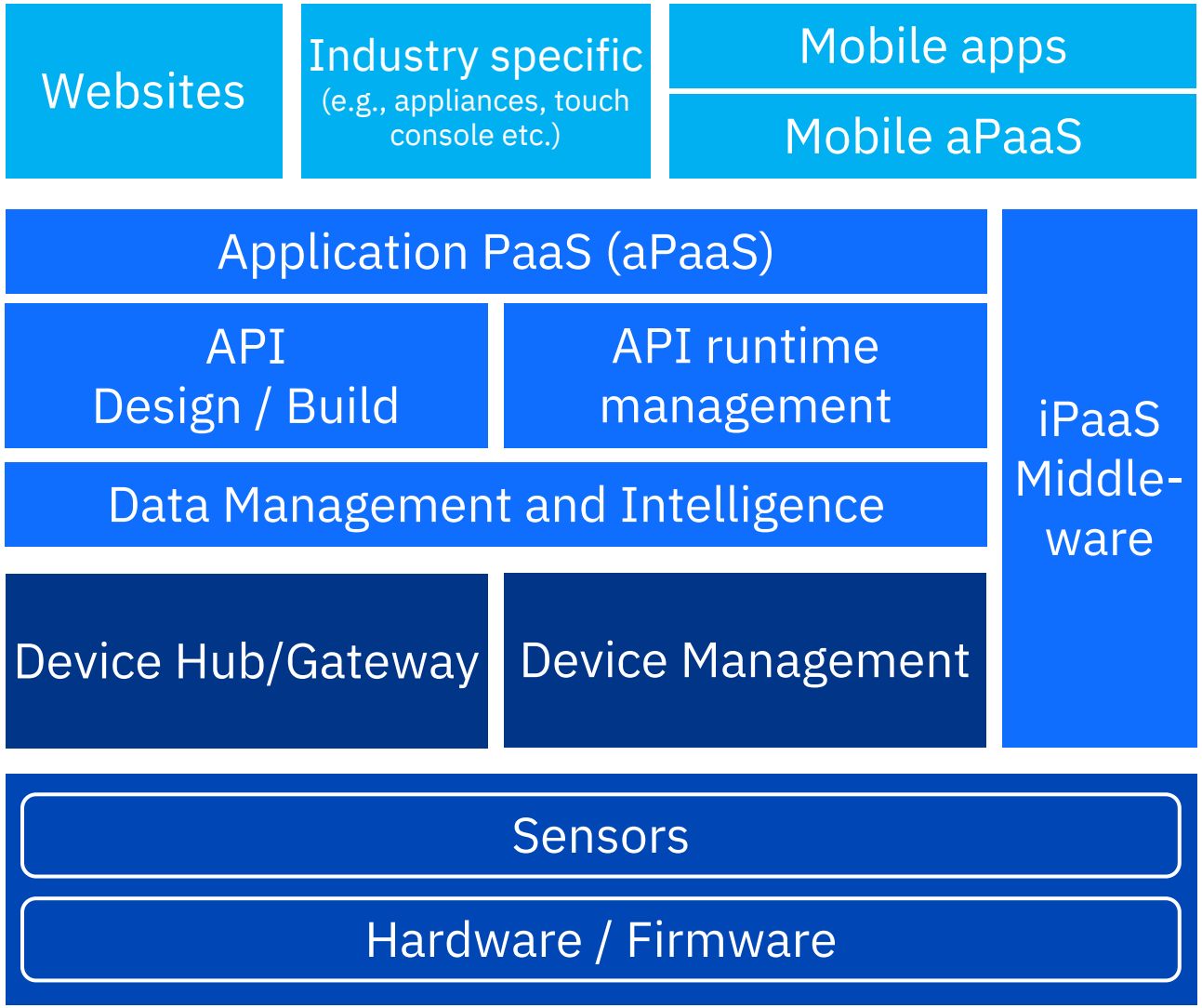
With Watson IoT Platform gathering insights from real-time information on data, SNCF improves the quality, security and availability of its trains.

4. IoT Stack

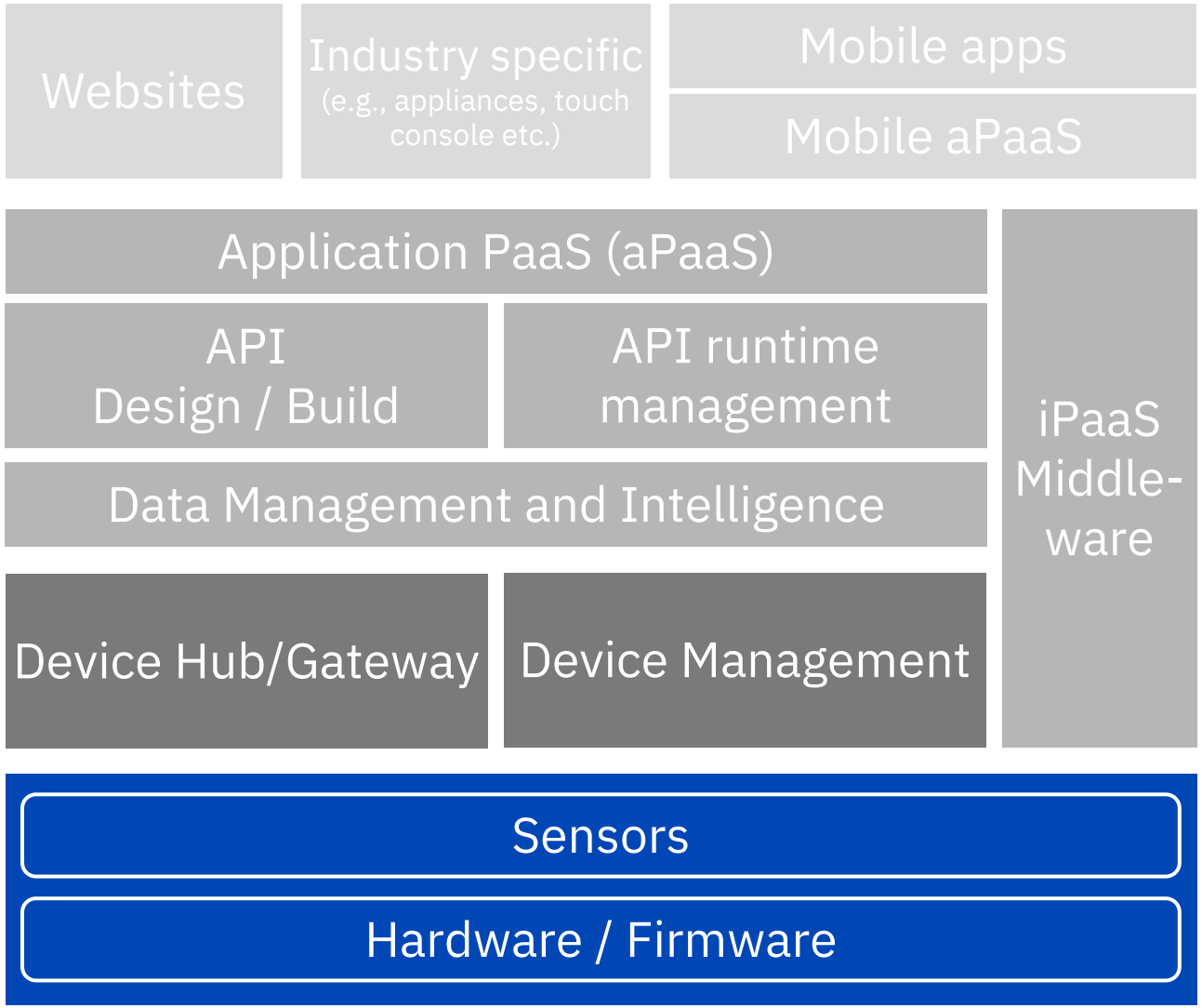
General IoT Stack – High level



The IoT Stack



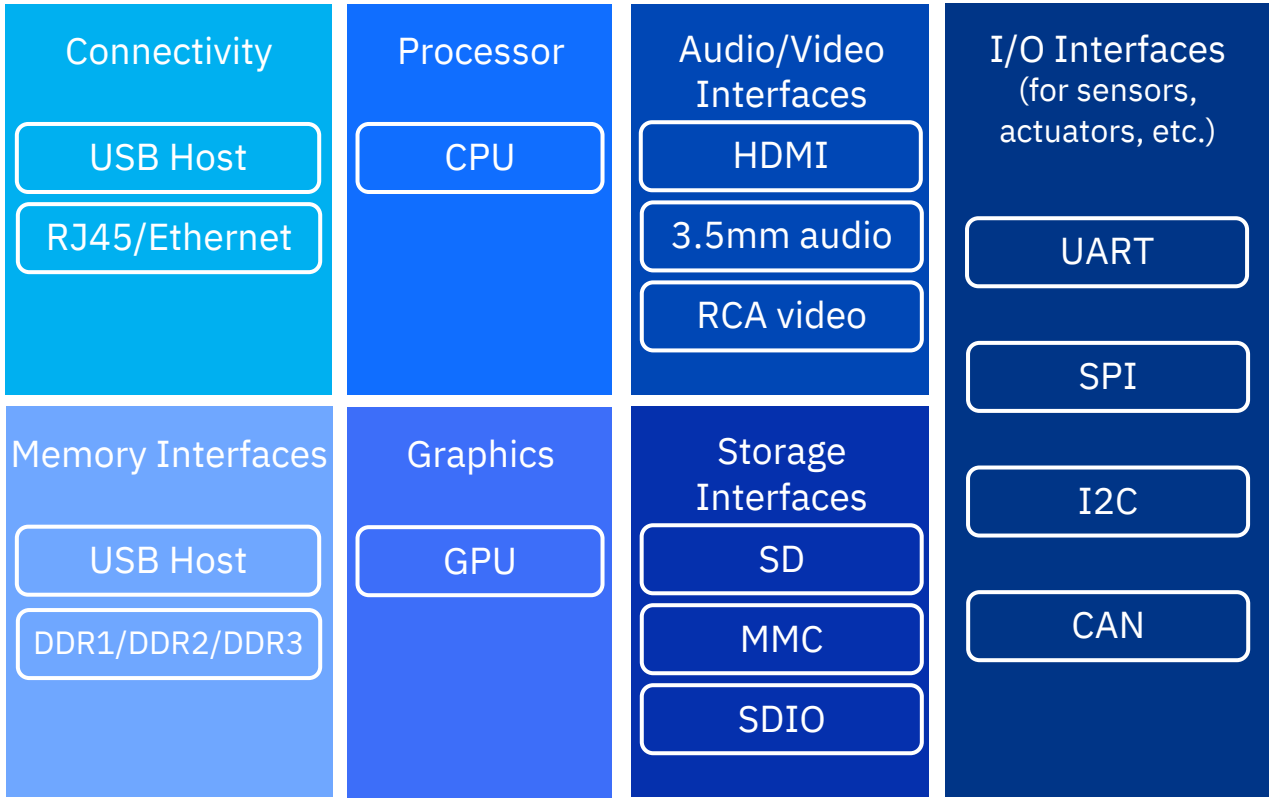
IoT Stack: Devices / Things



Generic Block Diagram of an IoT Device

An IoT device may consist of several interfaces for connections to other devices, both wired and wireless.

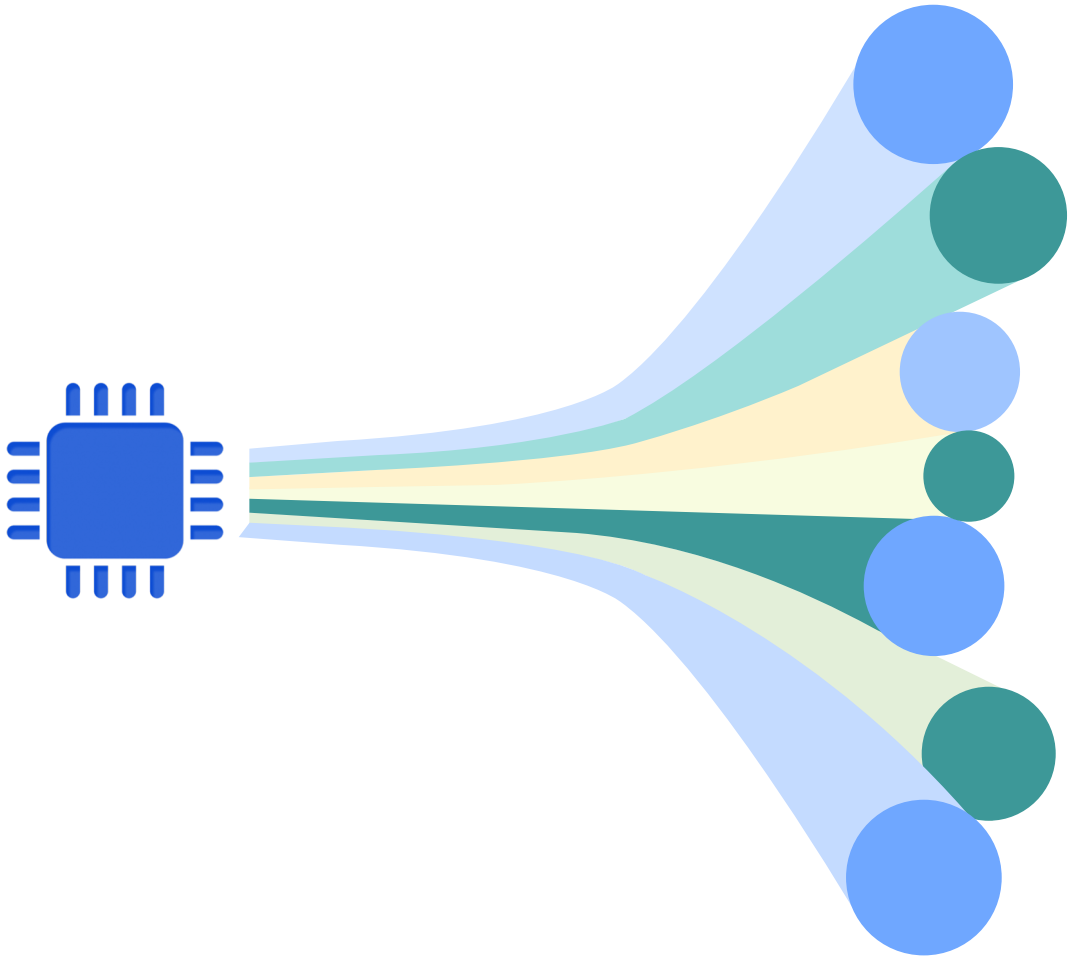
- I/O interfaces for sensors
- Interfaces for internet connectivity
- Memory and storage interfaces
- Audio/video interfaces

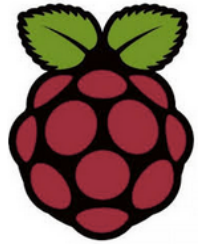


Devices

Many chipsets platforms to choose from.

(Becoming more and more vertically integrated with software stacks.)





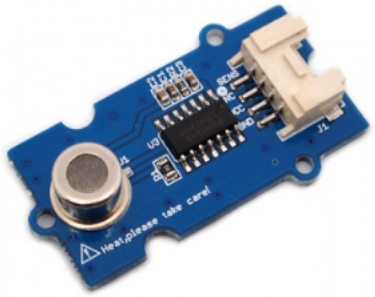
Sensors

Grove – Light Sensor

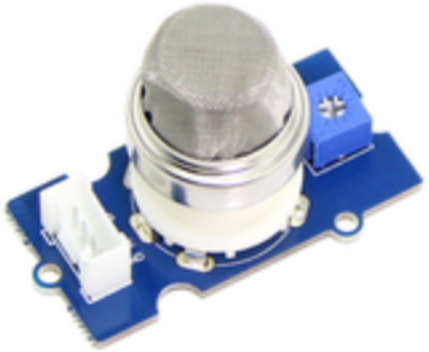
Grove – Sound Sensor

Grove – Touch Sensor

Grove – Temperature and Humidity Sensor



Grove – Air Quality Sensor

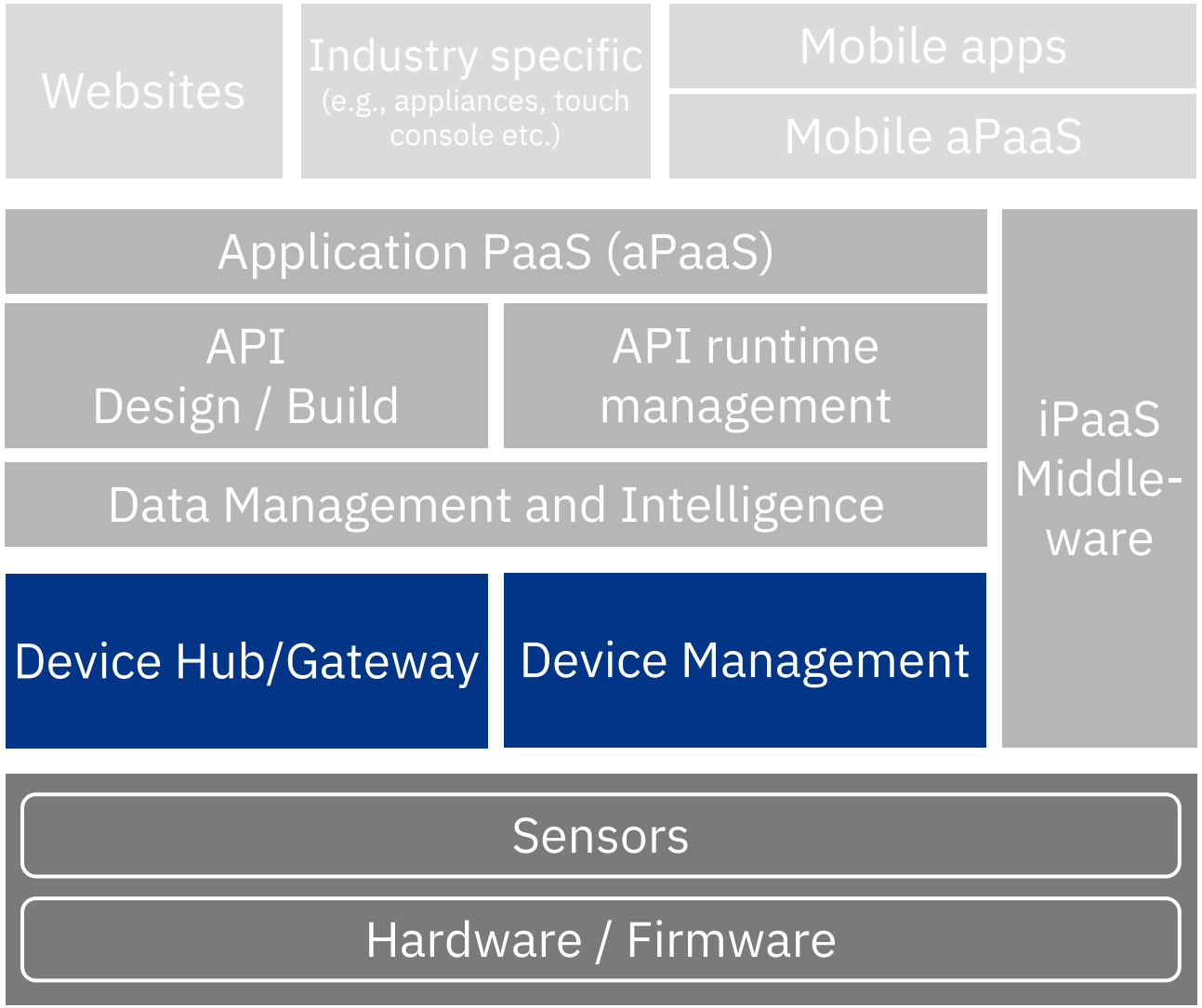


Grove – Gas Sensor

Grove – Alcohol Sensor

Grove – Water Sensor

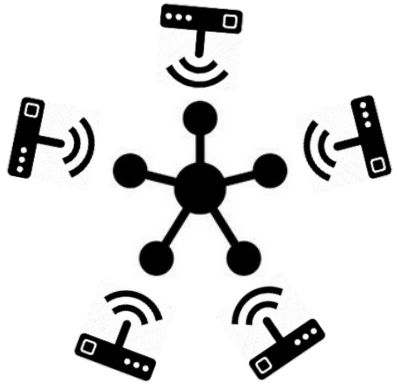
IoT Stack: Device Edge

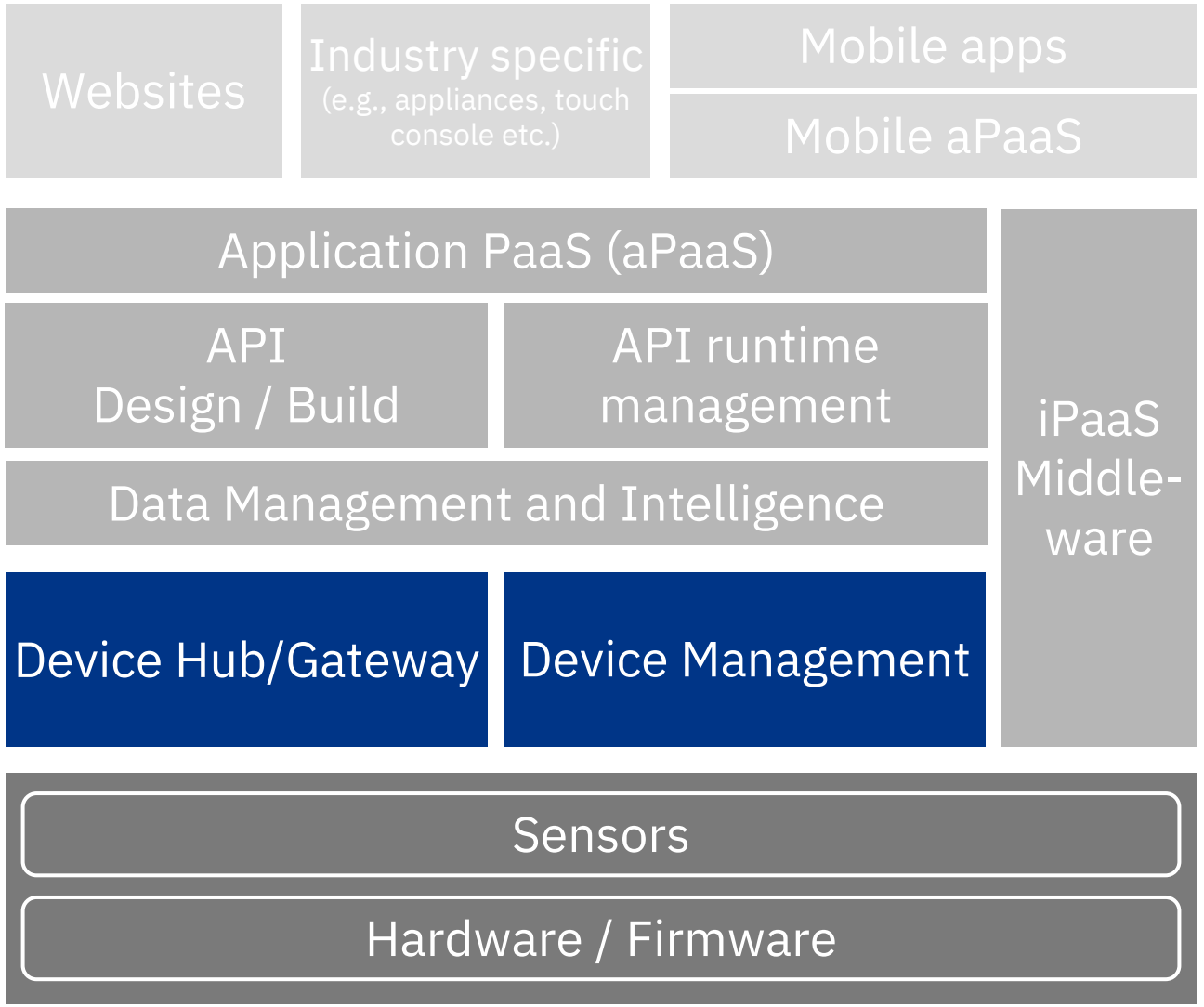


IoT Stack: Device Edge

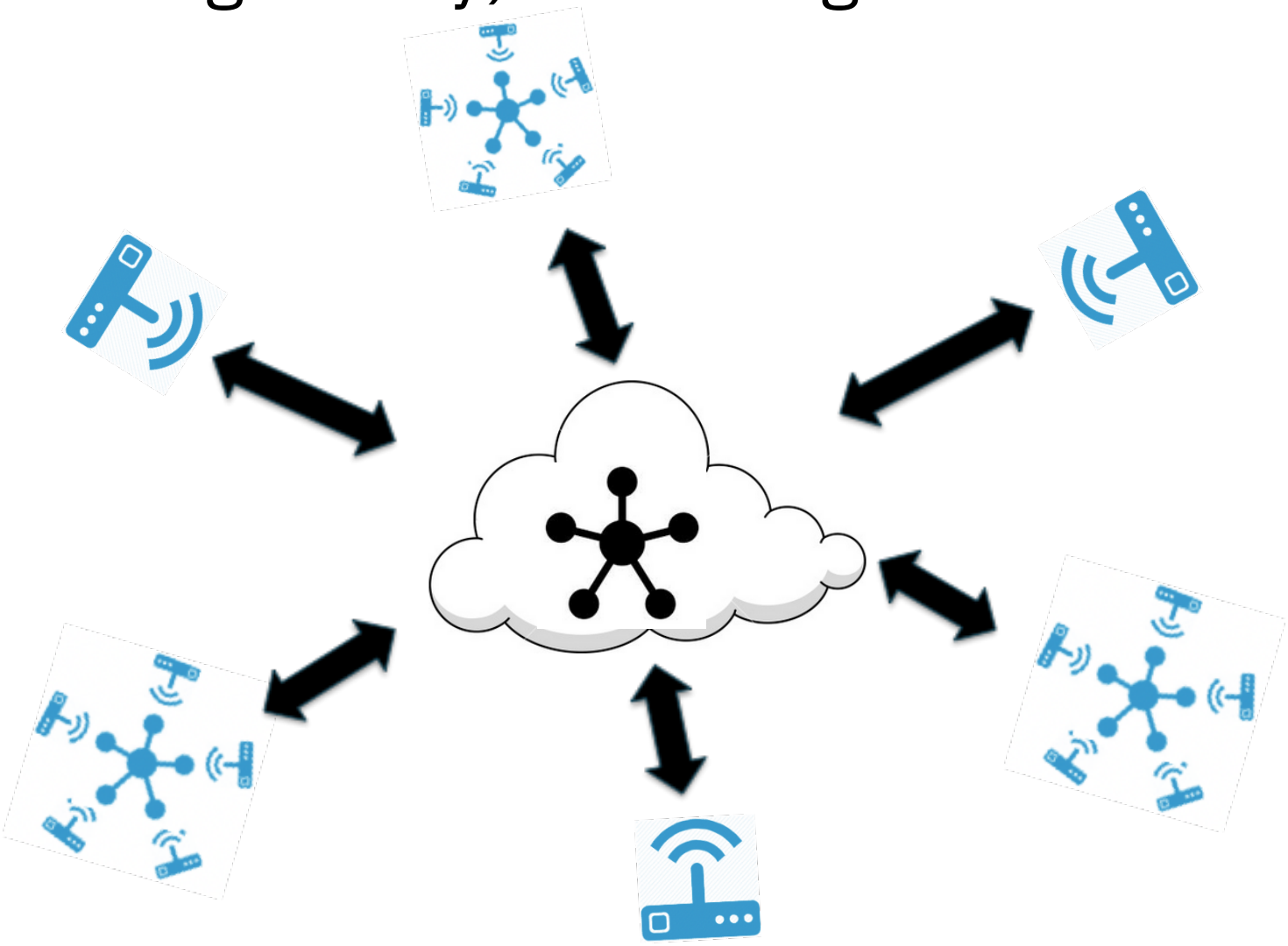
Key charter is to establish and maintain a secure, robust, fault-tolerant connection between the cloud and the edge devices in order to:

- Collect and aggregate device data
- Manage the device



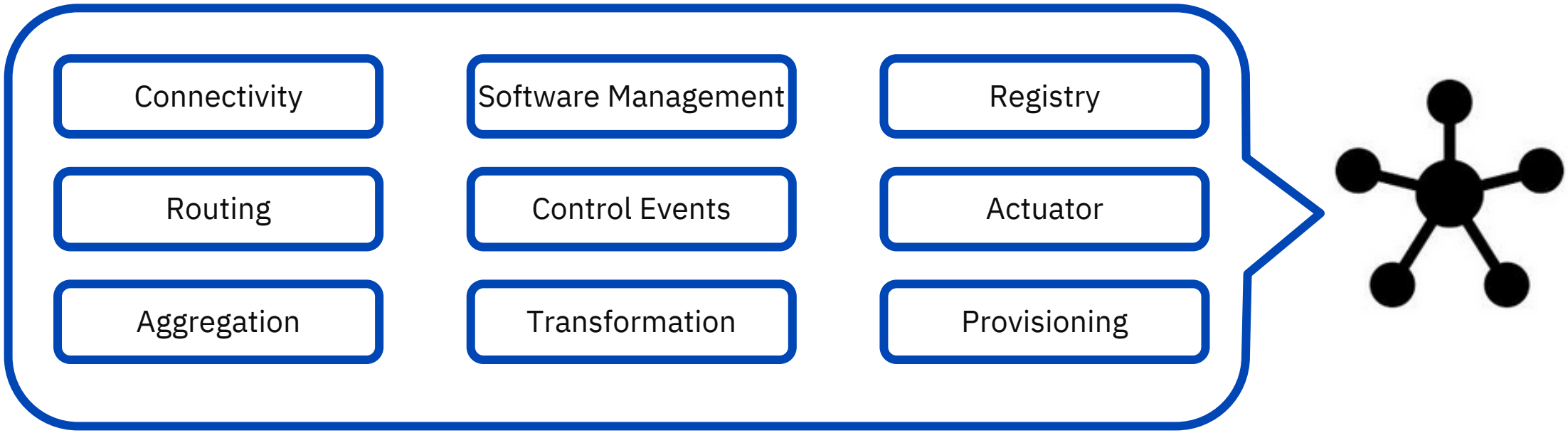


Typically a combination of a localized gateway, and a cloud based gateway, at the edge

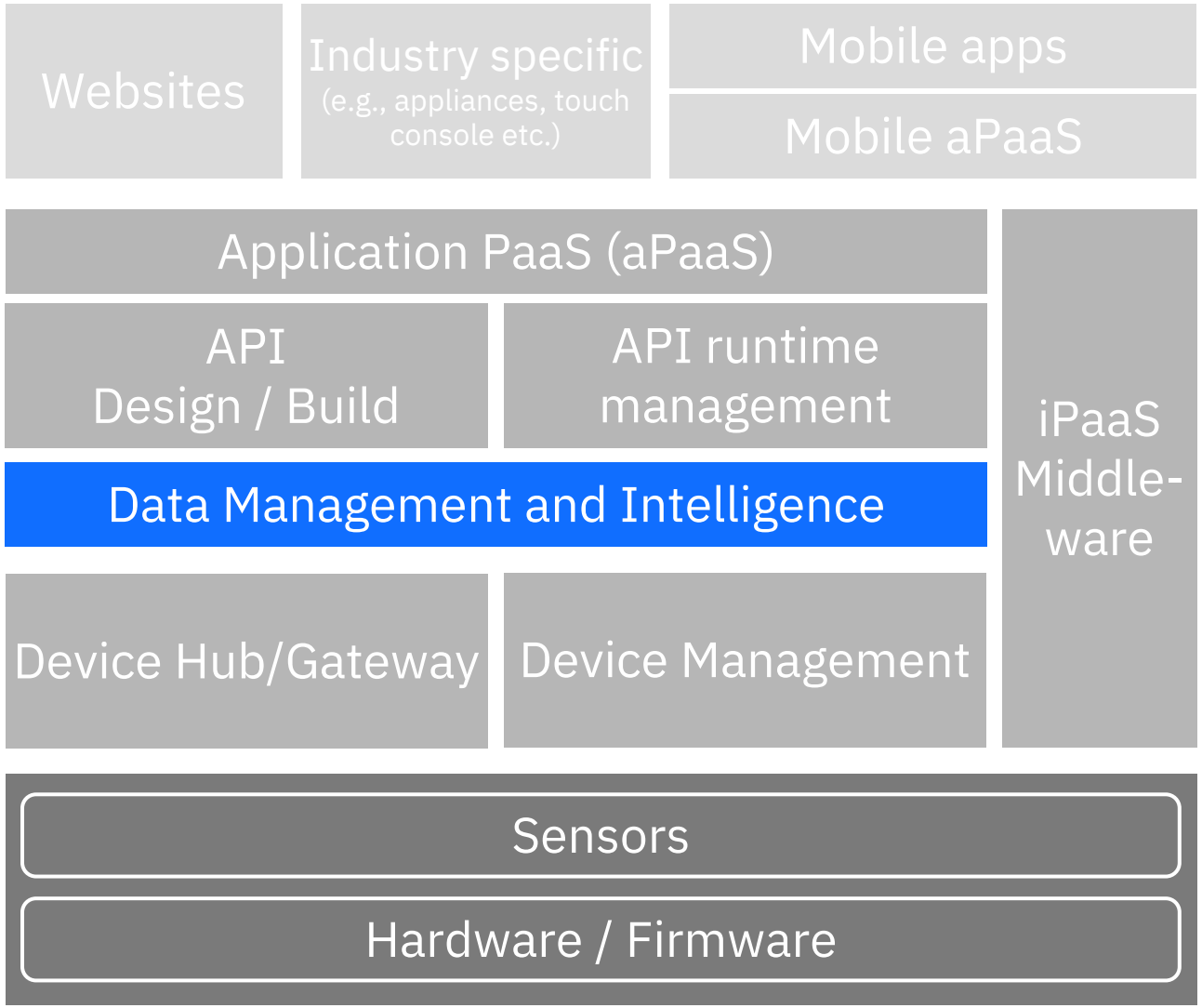


Reference Capabilities for a Gateway

Enable scalable, real-time, dependable, high- performance and interoperable data and device management related exchanges between publishers and subscribers

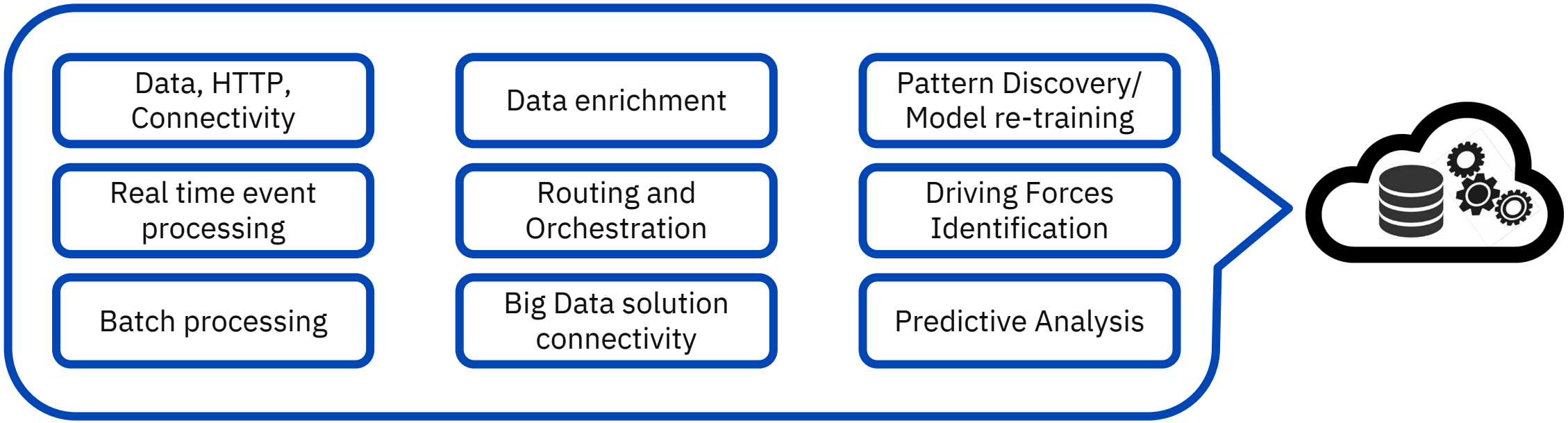


IoT Stack: Data management and intelligence

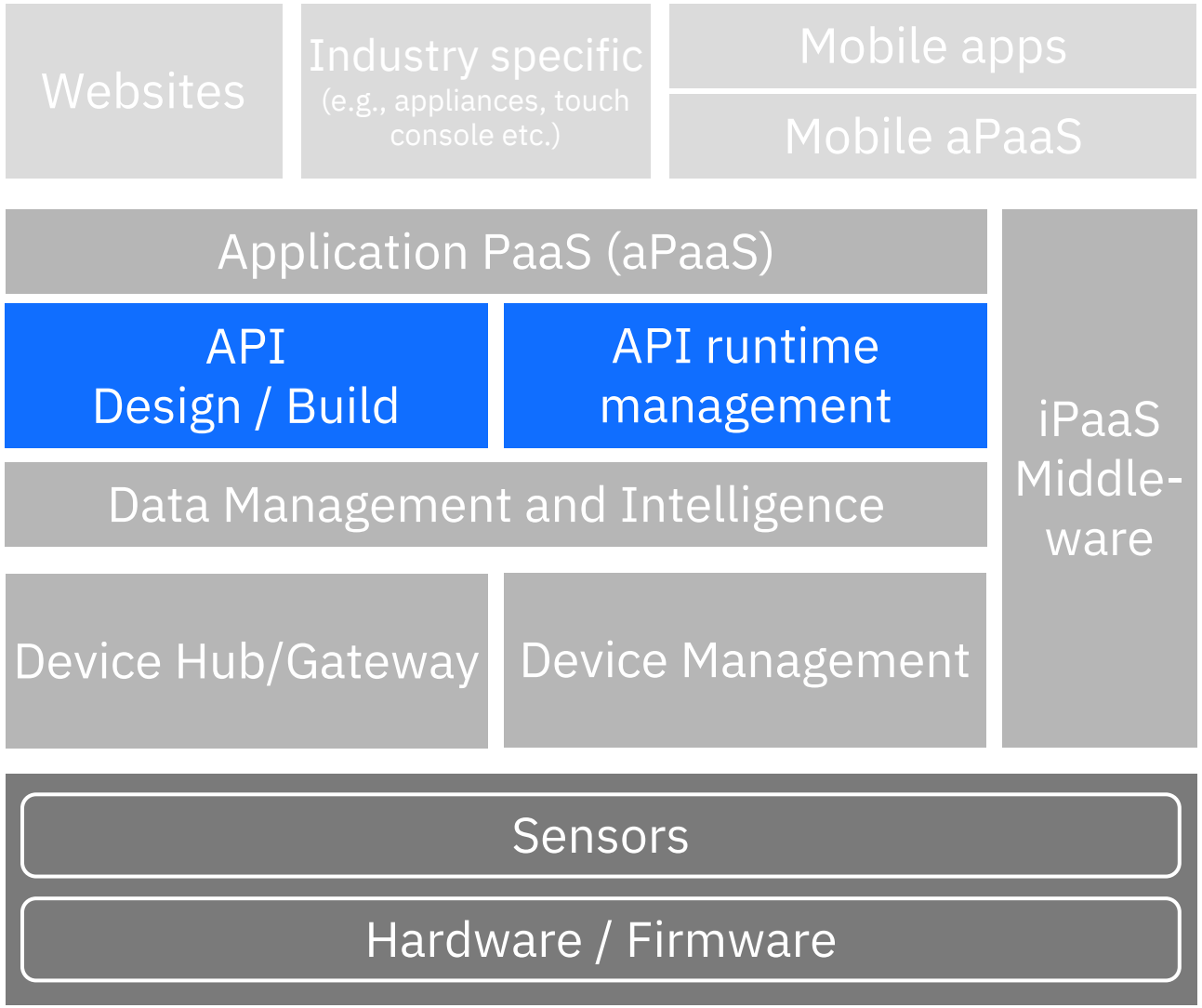


Capabilities required for Data Management and Intelligence

- Data collection, storage, and analysis of sensor data
- Run rules on data streams
- Trigger alerts
- Advanced analytics/machine learning
- Expose HTTP (REST) APIs

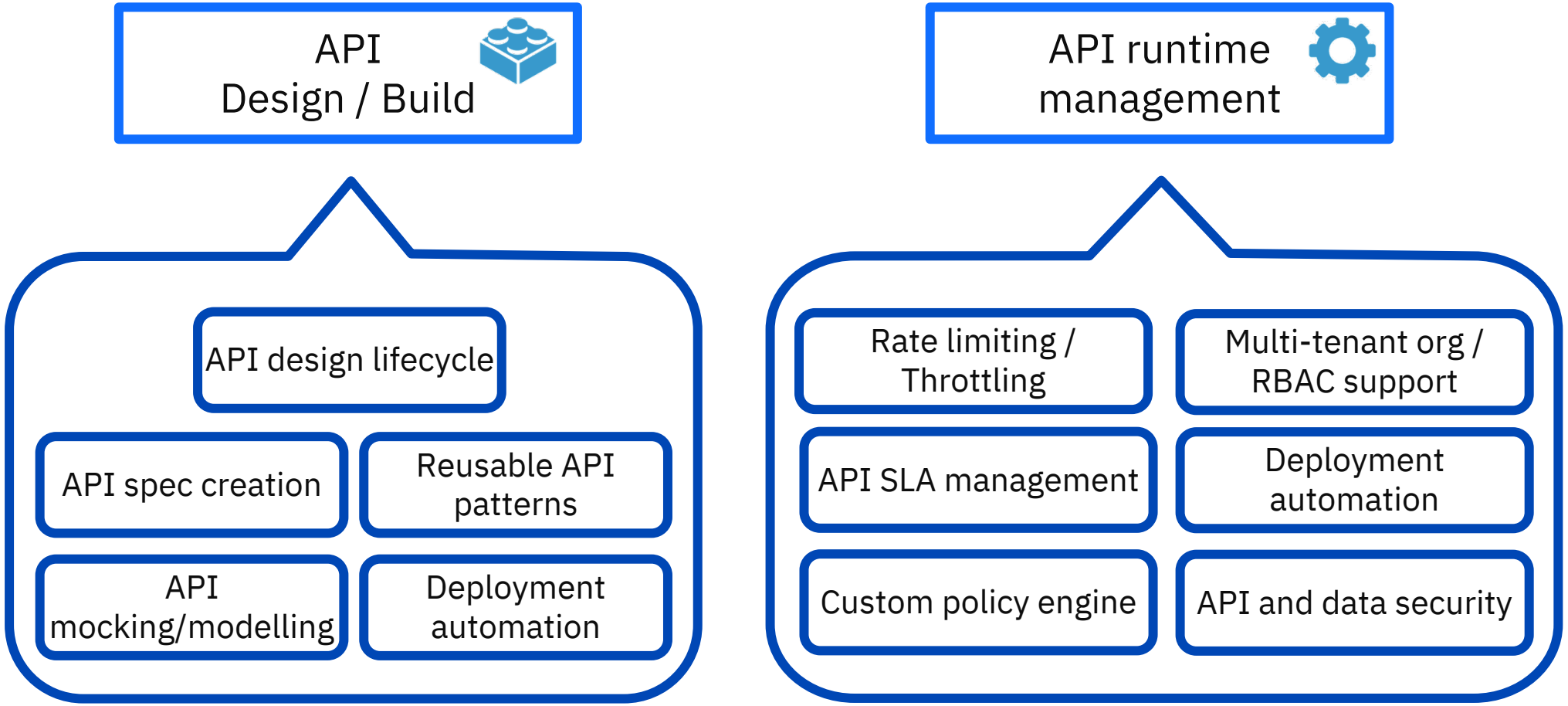


IoT Stack: API lifecycle tooling and platform

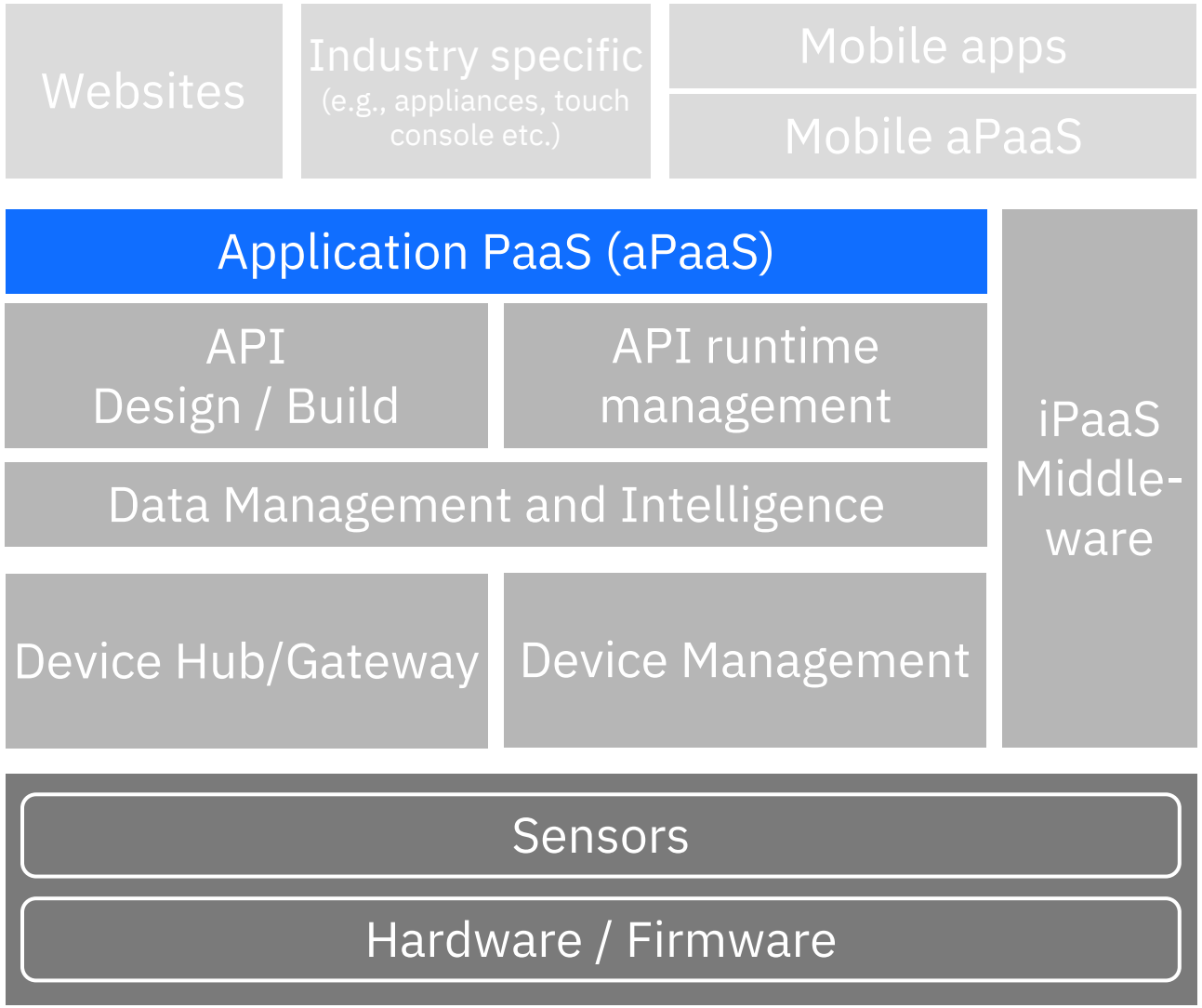


API Lifecycle: Design time and runtime

- Rapidly Design, deploy and publish APIs

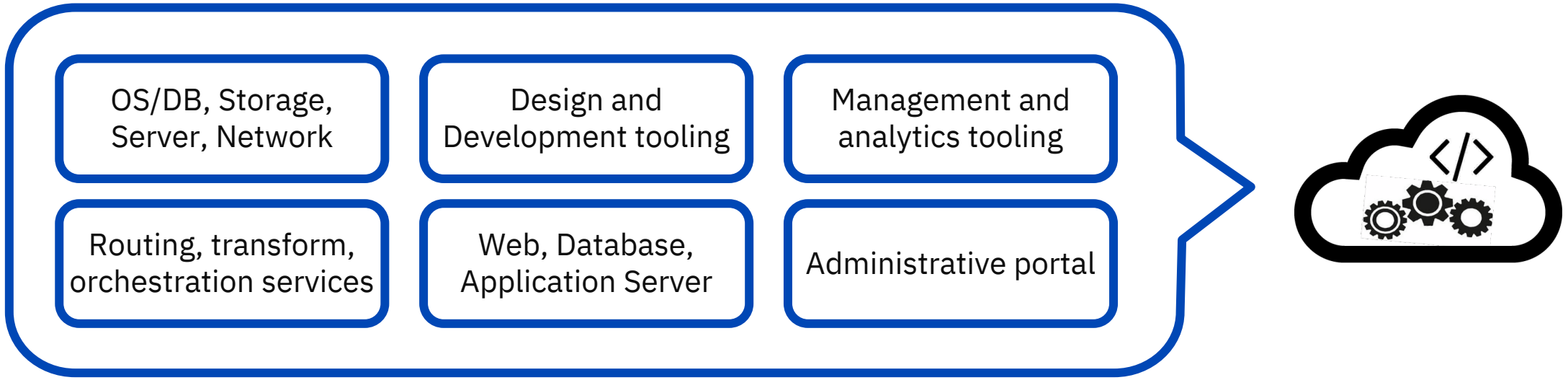


IoT Stack: Application PaaS (aPaaS)

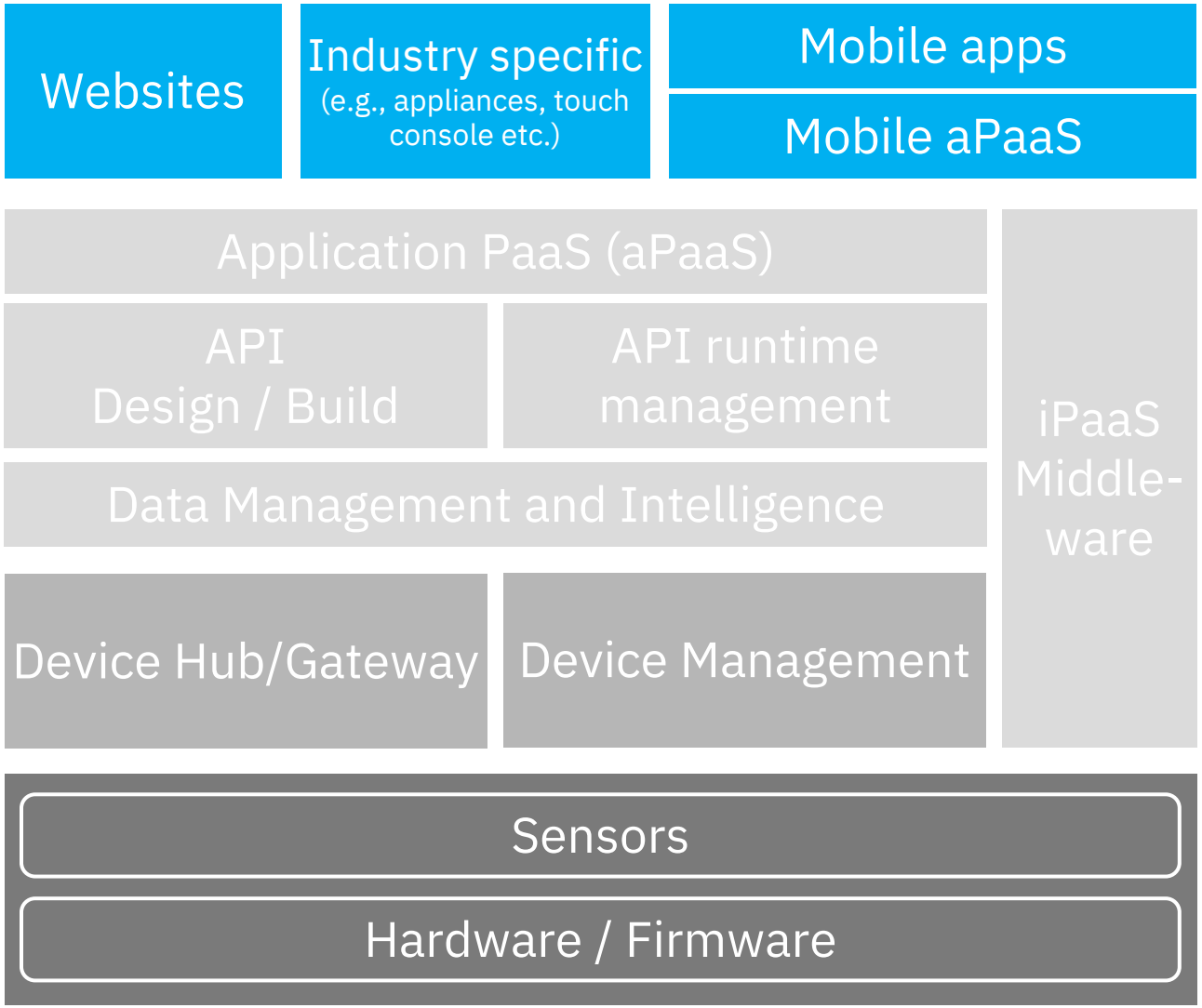


aPaaS Capabilities

- Hosted in the cloud
- Provides platform to build applications.

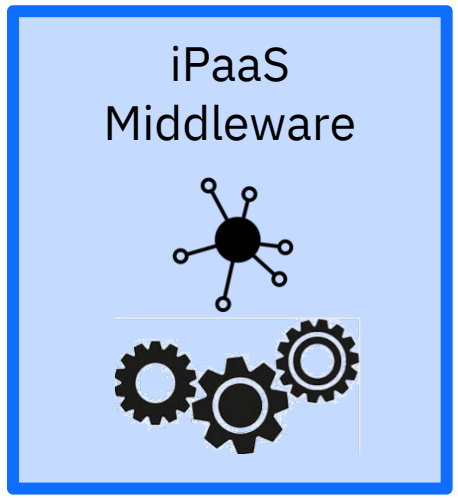


IoT Stack: End applications



IoT/IoE is a driver of mobile / tablet interfaces

IoT Stack: iPaaS integration – middleware



Websites

Industry specific
(e.g., appliances, touch console etc.)

Mobile apps

Mobile aPaaS

Application PaaS (aPaaS)

API
Design / Build

API runtime
management

Data Management and Intelligence

Device Hub/Gateway

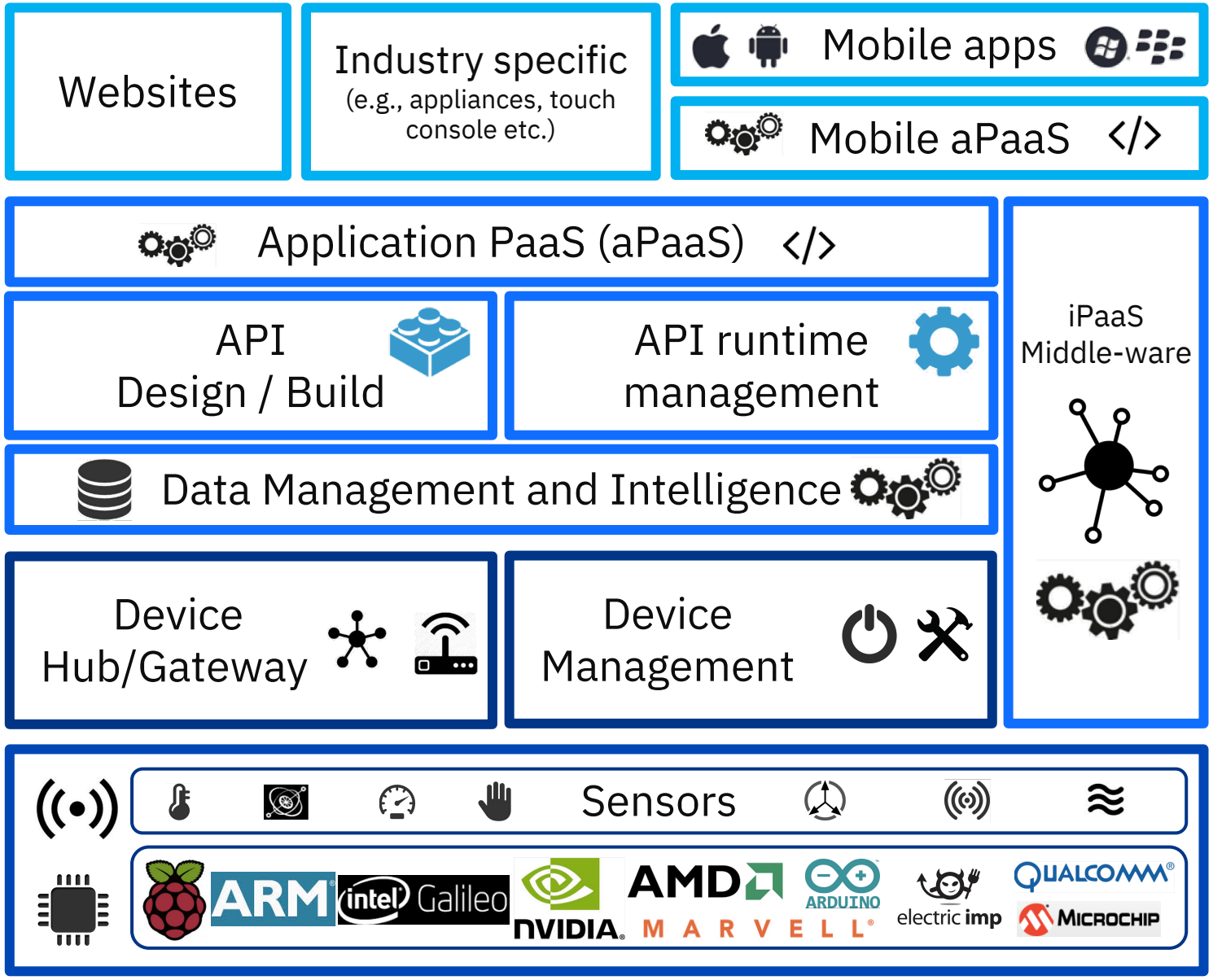
Device Management

iPaaS
Middle-
ware

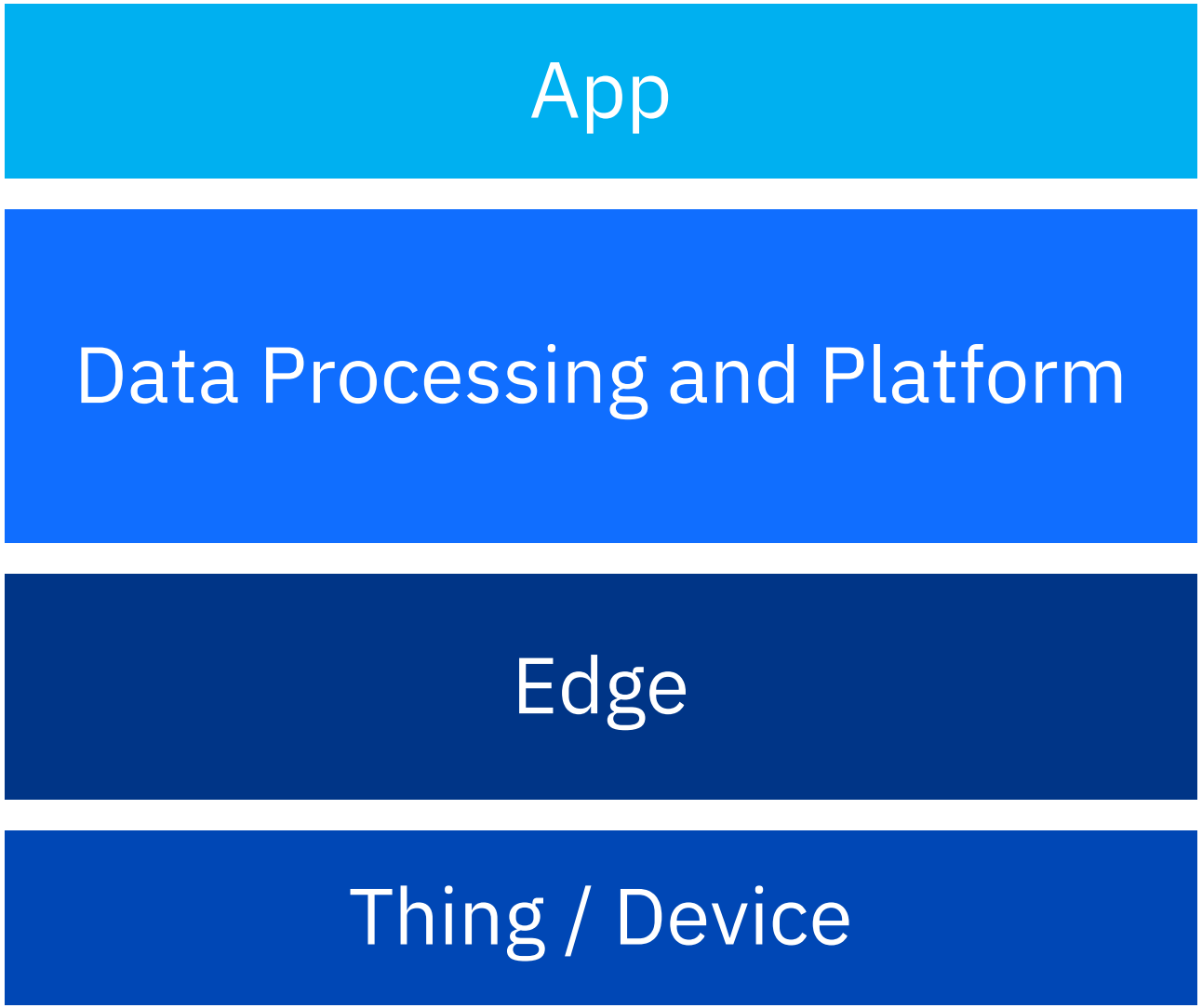
Sensors

Hardware / Firmware

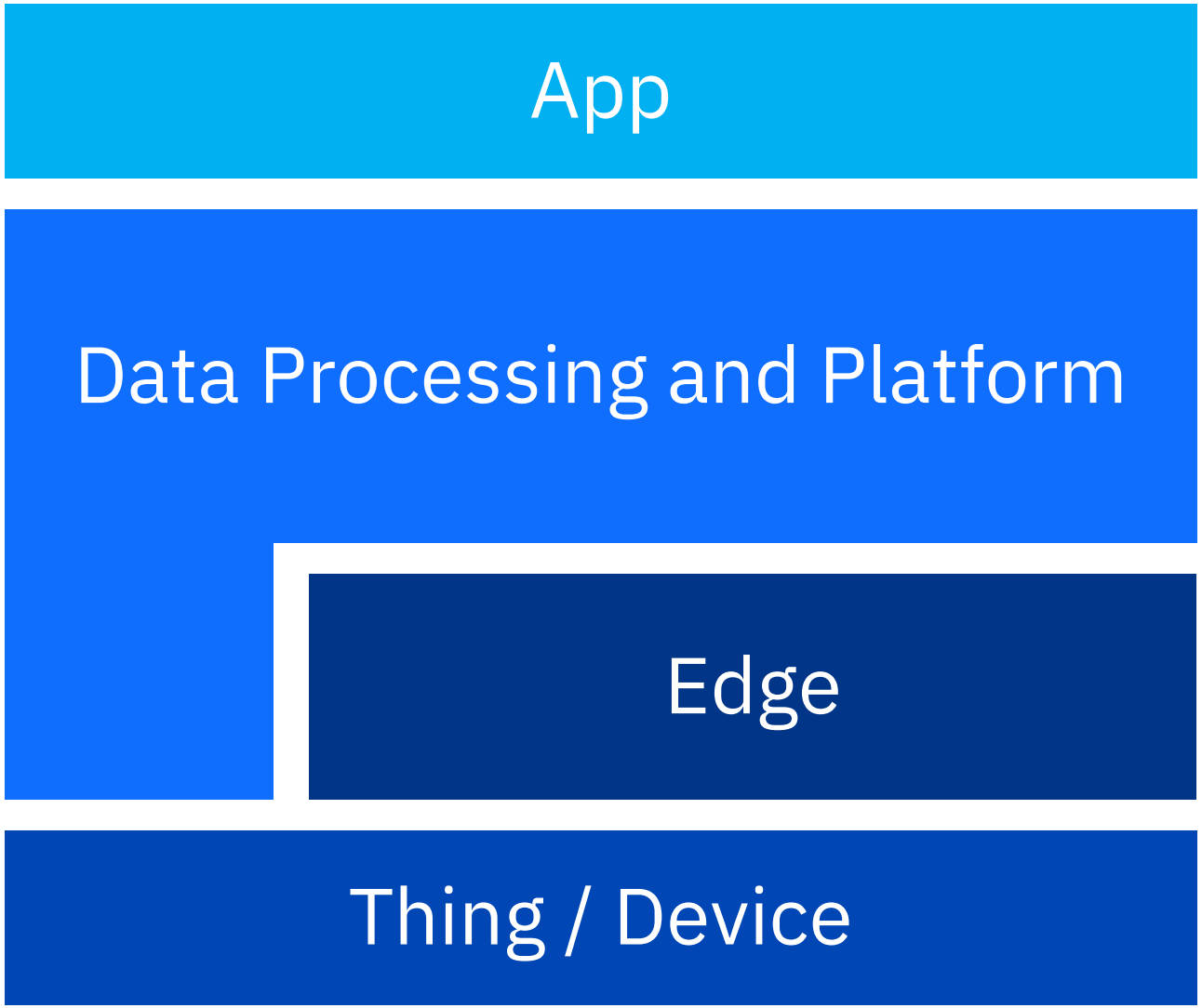
IoT Stack



The stack as it exists today is also converging...



Scenarios where the middleware and edge have converged



Scenarios where the app layer is directly connected to the Thing/Device layer