IoT Data Management

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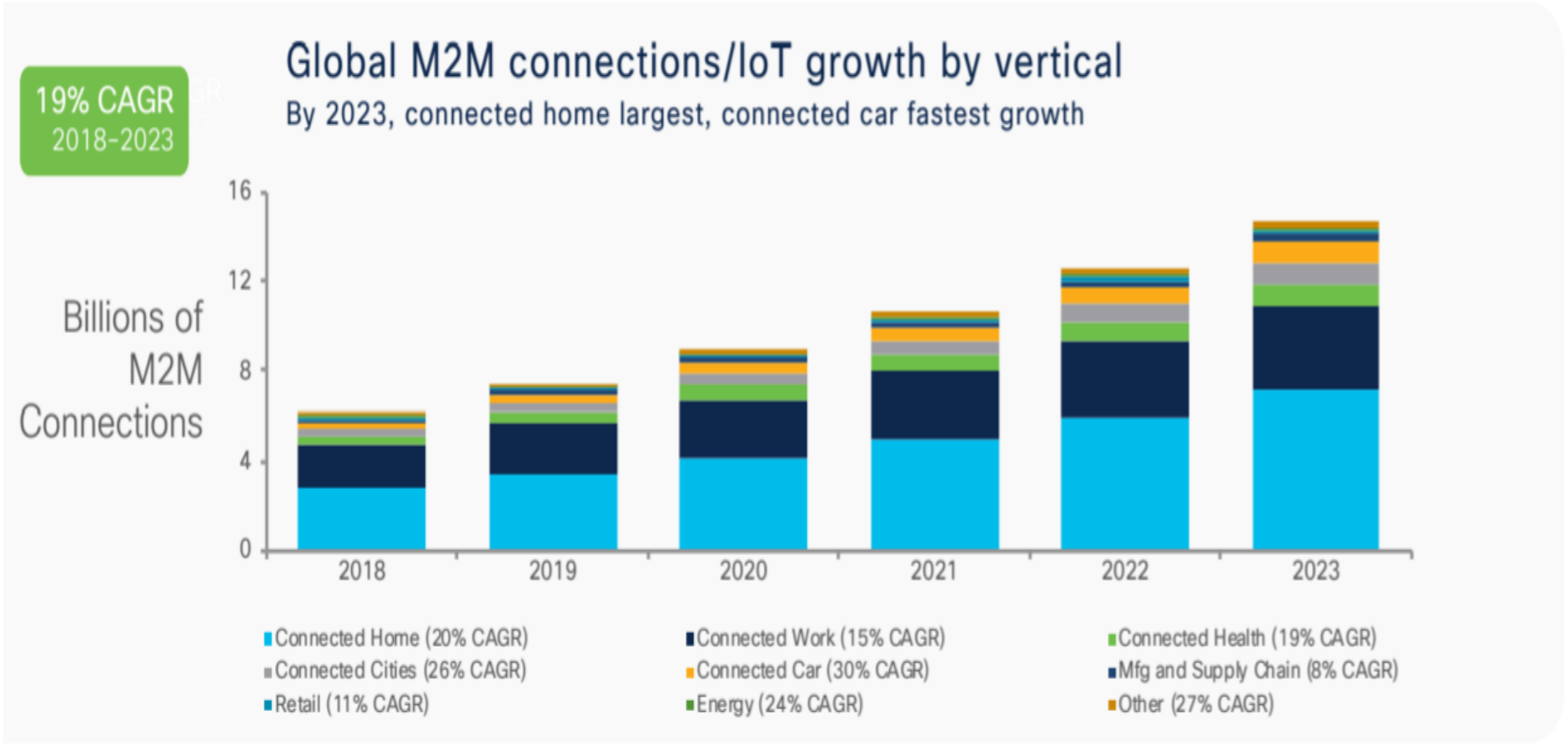
IoT Device

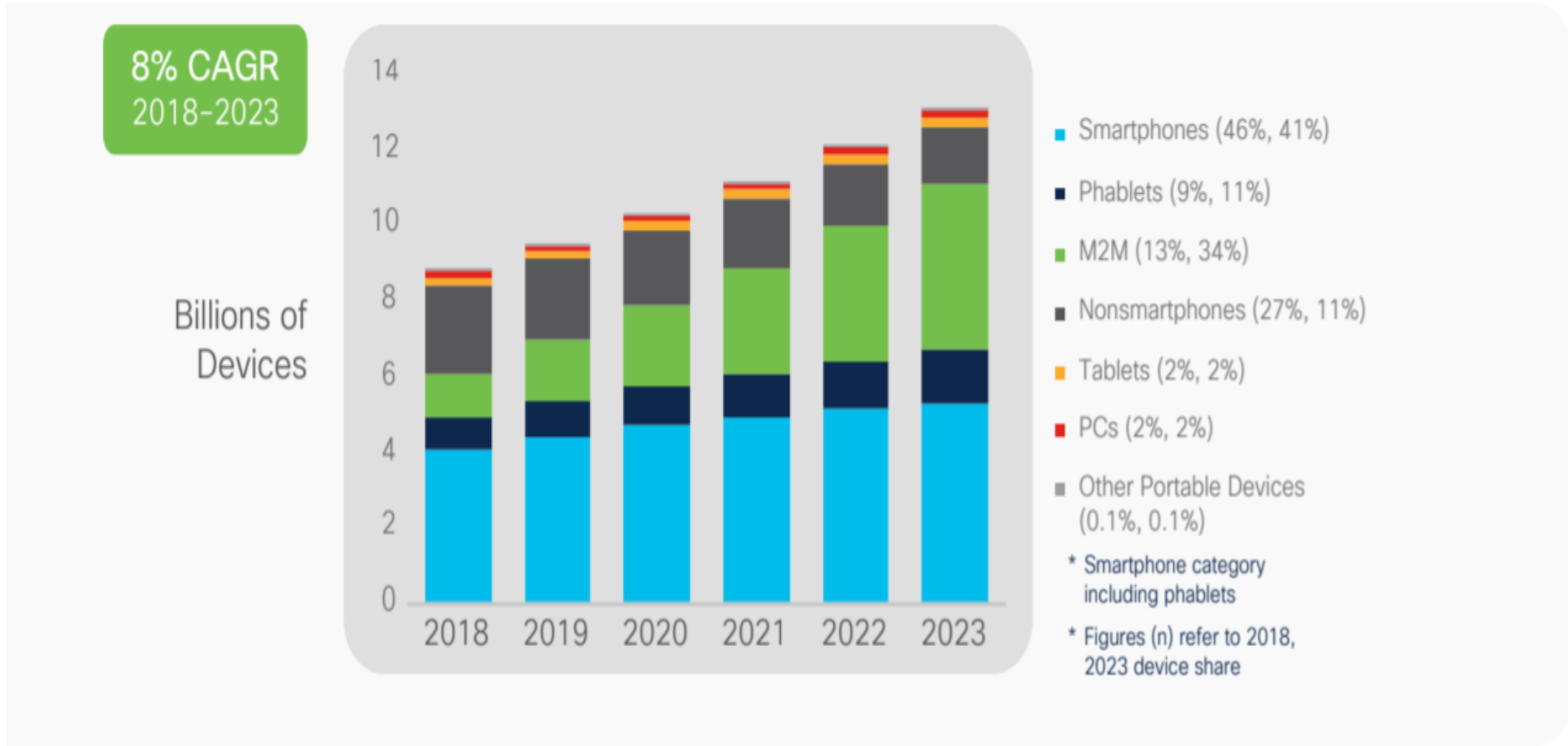
- Wireless IoT devices are becoming more ubiquitous in many business sectors (manufacturing, healthcare, logistics, etc.).
- This wave of IoT applications dramatically changes wireless networking requirements in terms of scale, traffic patterns and volumes, and security.
- By 2023, IoT devices will account for 50 percent of all networked devices
- By 2023, a 5G connection will generate nearly 3X more traffic than a 4G connection.
- By 2023, there will be 628 million global public Wi-Fi hotspots, 4X more than in 2018 (169 million).

Growth of IoT Devices



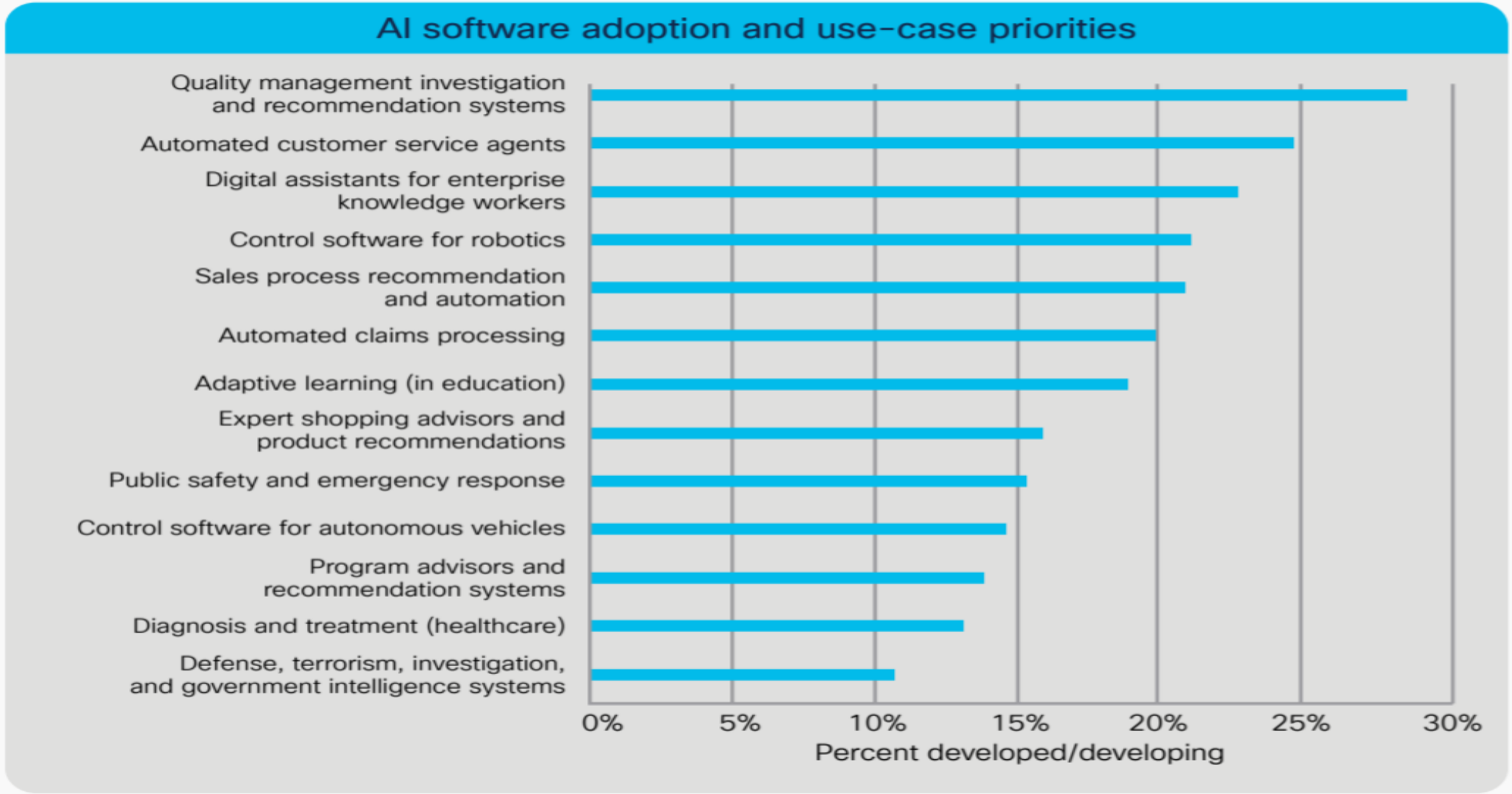
Source: Cisco Annual Internet Report, 2018-2023

Global mobile device and connection growth

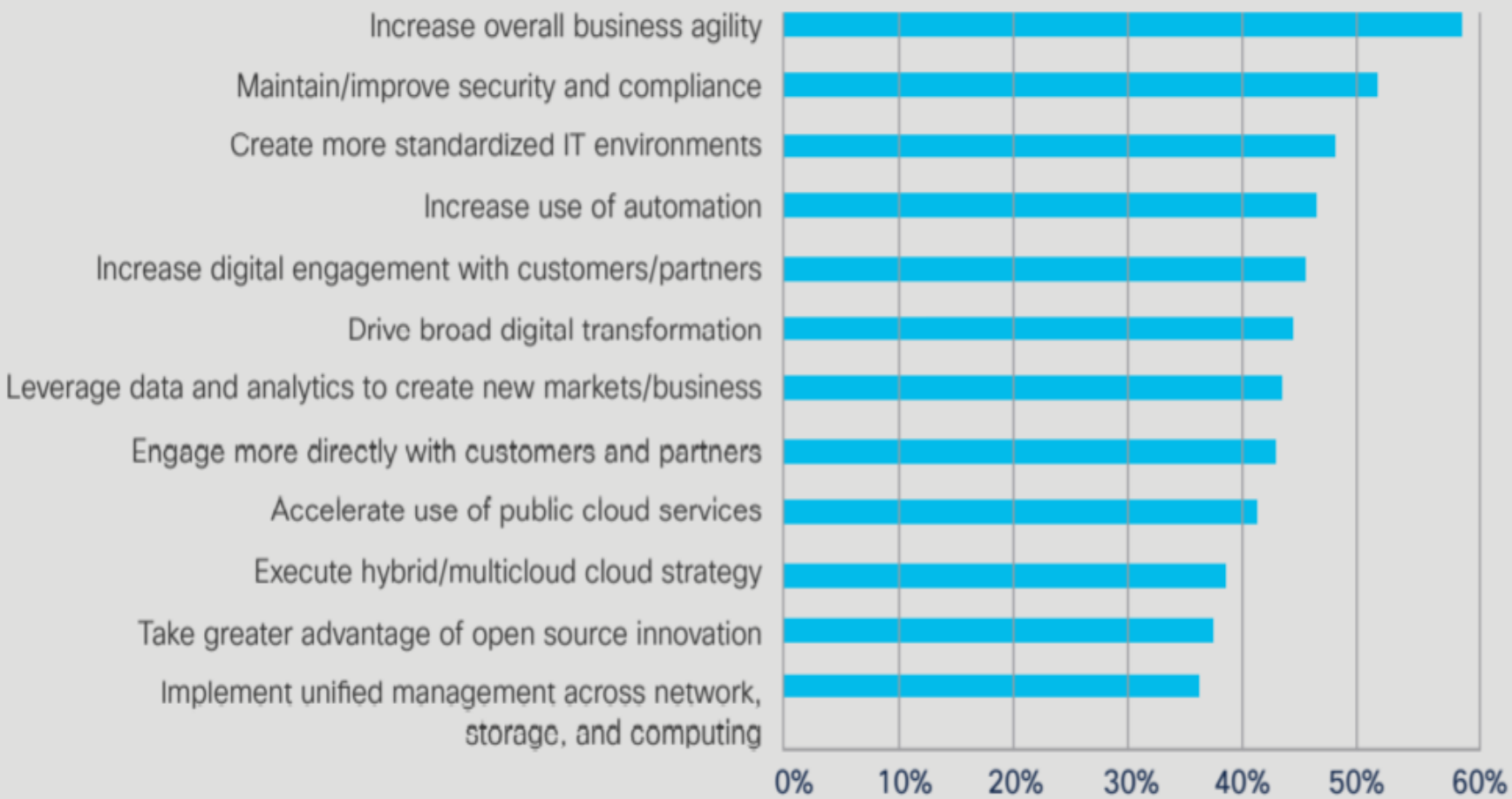


Source: Cisco Annual Internet Report, 2018–2023

AI Adoption and use case priorities



Increasing demands on IT infrastructures



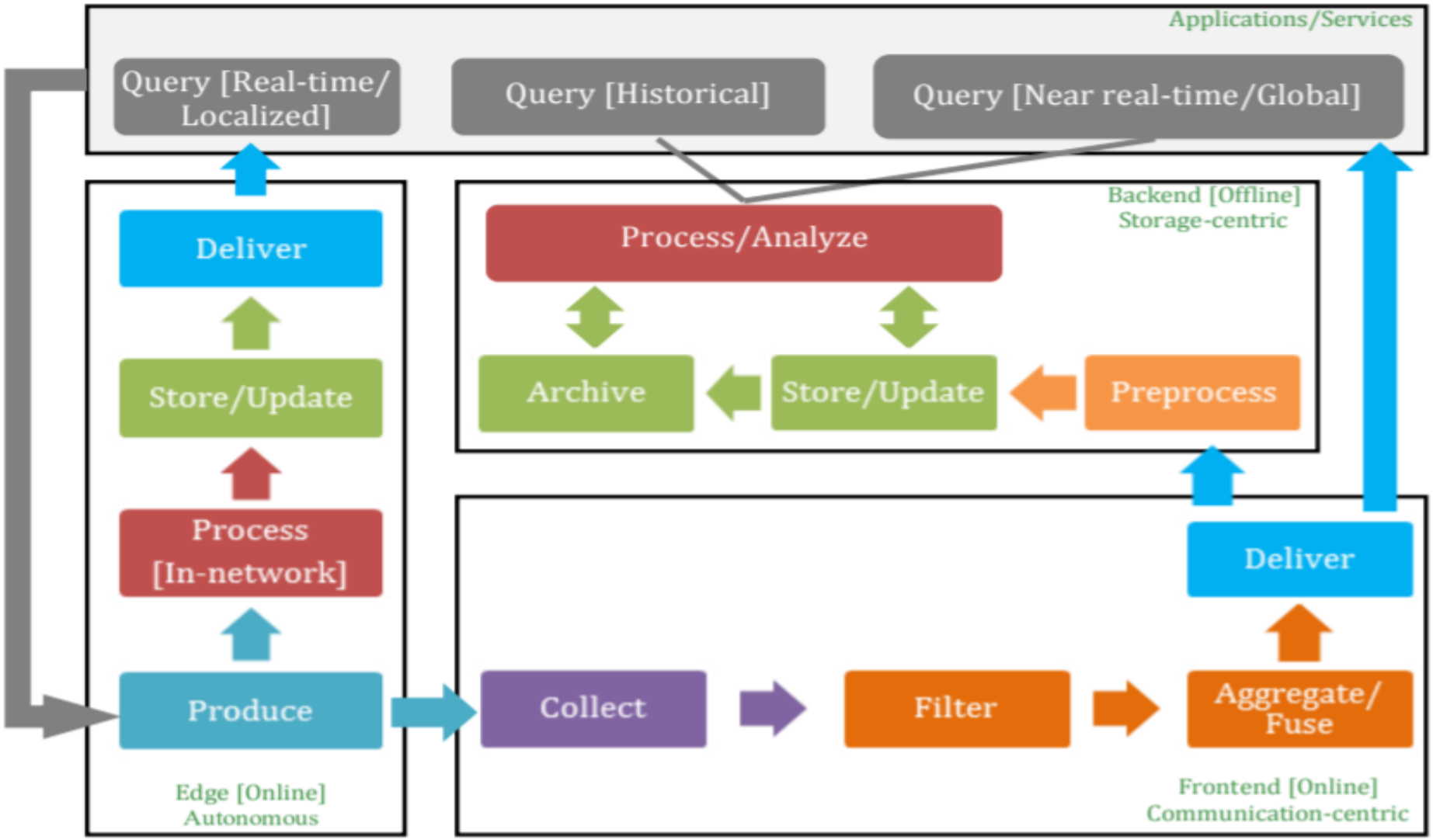
Source: Enterprise Cloud and DevOps Management Survey, IDC, July 2016

Percentage of respondents: N = 200 IT and DevOps decision makers]

IoT Data Life Cycle

- **Querying:** Query can be issued either to request real-time data to be collected for temporal monitoring purposes or to retrieve a certain view of the data stored within the system.
- **Production:** Data production involves sensing and transfer of data by the —Things
- **Collection**: The sensors and smart objects within the IoT may store the data for a certain time interval or report it to governing components. Data may be collected at concentration points or gateways within the network where it is further filtered and processed, and communicated by using Zigbee, Wi-Fi and cellular are used by objects to send data to collection points.
- **Aggregation/Fusion:** Transmitting all the raw data out of the network in real-time is often prohibitively expensive given the increasing data streaming rates and the limited bandwidth. Aggregation and fusion techniques deploy summarization and merging operations in real-time to compress the volume of data to be stored and transmitted.
- **Delivery:** As data is filtered, aggregated, and possibly processed either at the concentration points or at the autonomous virtual units within the IoT, sent further up the system, either as final responses, or for storage and in-depth analysis.
- **Preprocessing:** IoT data will come from different sources with varying formats and structures. Data may need to be preprocessed to handle missing data, remove redundancies and integrate data from different sources into a unified schema before being committed to storage.
- **Storage/Update—Archiving:** This phase handles the efficient storage and organization of data as well as the continuous update of data with new information as it becomes available. Archiving refers to the offline long-term storage of data that is not immediately needed for the system's ongoing operations.
- **Processing/Analysis:** This phase involves the ongoing retrieval and analysis operations performed and stored and archived data in order to gain insights into historical data and predict future trends, or to detect abnormalities in the data that may trigger further investigation or action.

Figure 1. IoT data lifecycle and data management.



STRATEGIES TO IMPLEMENT IOT DATA MANAGEMENT

Identify use cases

- Before adopting IoT solutions, business leaders must identify potential IoT use cases for various business procedures. For instance, a retailer may use IoT data to understand customer behavior, while a manufacturing firm may use it for predictive maintenance.
- With this approach, business leaders can make informed decisions while choosing IoT solutions and understand their data storage and management requirements.

Hire skilled professionals

- To implement IoT solutions and IoT data management successfully, hire skilled professionals. These professionals can help in developing and executing effective IoT adoption strategies.

Allocate sufficient budget

- Need to carefully understand several necessities such as infrastructure and resources for successful IoT data management. By analyzing these requirements, businesses can allocate sufficient budget for their project.

Understand data requirements

- Before beginning the data collection process, organizations have to understand which type of data they will require and how much data storage they own. Business leaders need to analyze how different data sets can correlate to one another to utilize available data efficiently and minimize storage requirements.
- Additionally, developers and business leaders need to collaborate to figure out how collected data can be optimized and integrated with enterprise systems.

Implement security protocols

- Businesses need to implement a multifaceted approach for data security. For starters, organizations can encrypt their data to ensure data integrity. Organizations should also restrict access to sensitive data by providing data access only to concerned parties.
- Additionally, organizations must educate their employees about data security.

Educate and train employees

- Businesses must educate their employees about IoT solutions, their benefits, and IoT data management.
- For this purpose, organizations can also incentivize educating other employees about IoT.

Figure 4. IoT data management framework.

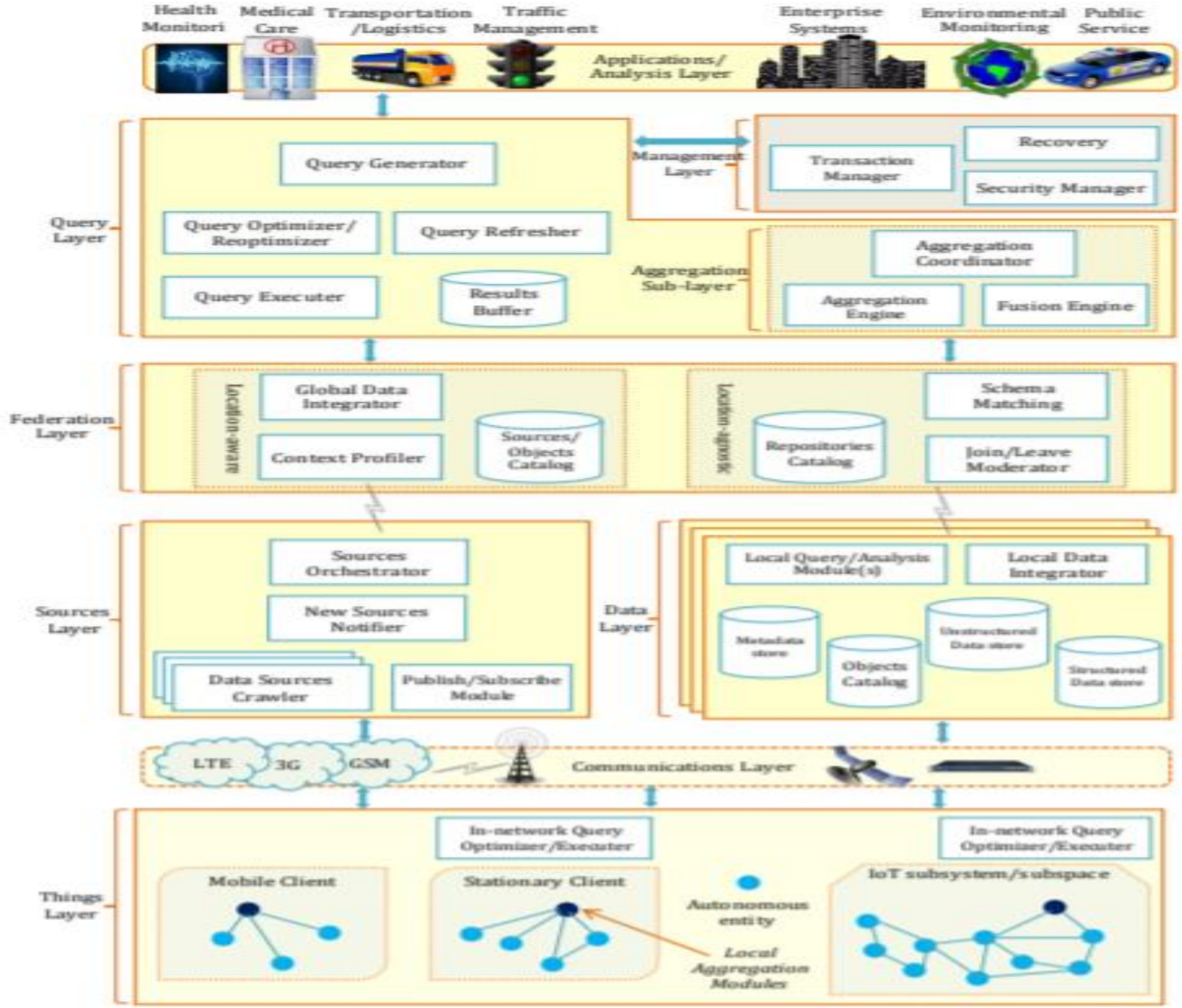
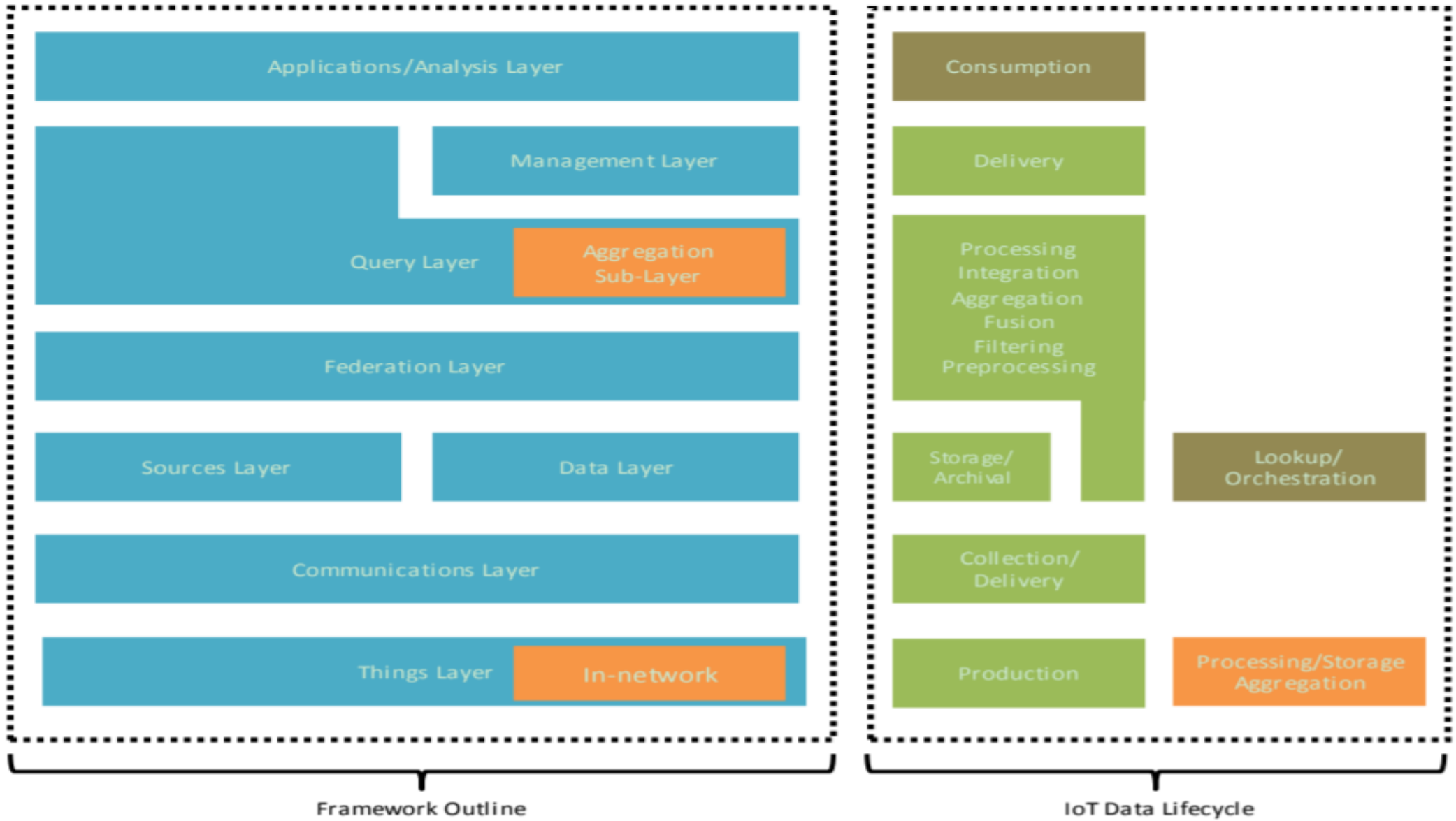


Figure 2. Design primitives for an IoT data management solution.

Figure 3. Outline of the proposed IoT data management framework and mapping of its layers to the IoT data lifecycle.



CHALLENGES FOR IOT DATA MANAGEMENT

Scalability

- Data collected using IoT sensors are expected to grow in volume exponentially. IoT devices would generate more than 500 zettabytes of data per year by the end of 2019.

  We need to address the following questions:
  - Can the existing infrastructure handle large volumes of data?
  - Which platform can be used to manage the obtained data?
  - Who can access the collected data?
  - What will be the expected rate of data growth over the next five years?
- As the volume of IoT data grows, various applications and functions will start finding value in the data. However, the rising number of applications will increase data volume even more.

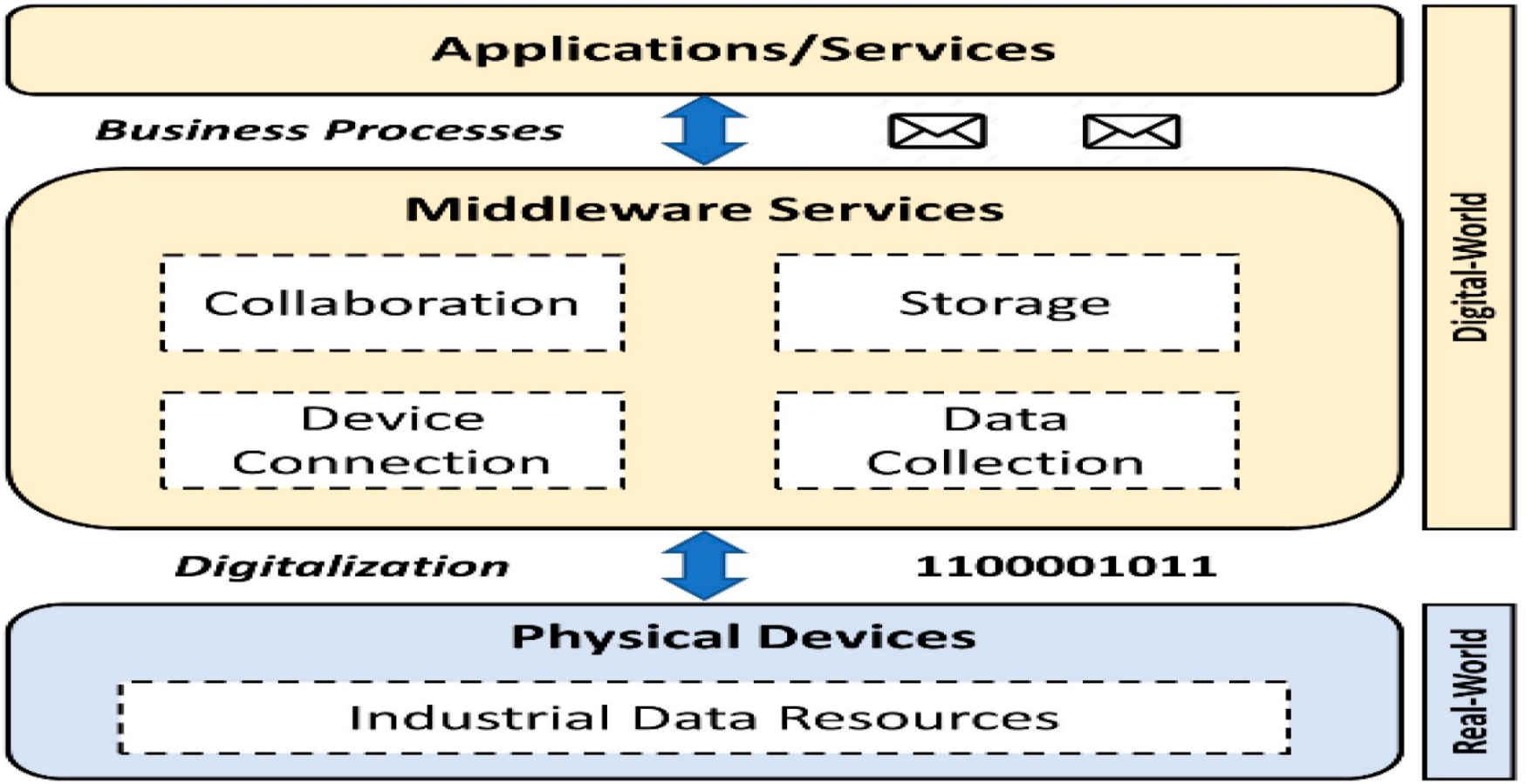
Security

- The generation of large data volumes can attract cybercriminals, who wish to gain illegal access to crucial data.
- Several big players such as Google, Facebook, Marriott, and British Airways have been victims of sophisticated cyber attacks. Sensitive data of hundreds of millions of users was compromised in these cyber attacks. Hackers can also target operational data, which could disable critical processes in an organization.
- Various network vulnerabilities and newly-created malware strains can exploit loopholes in an organization's security protocol to illegally access data. Hackers can also launch automated cyber attacks to hack into an organization's network

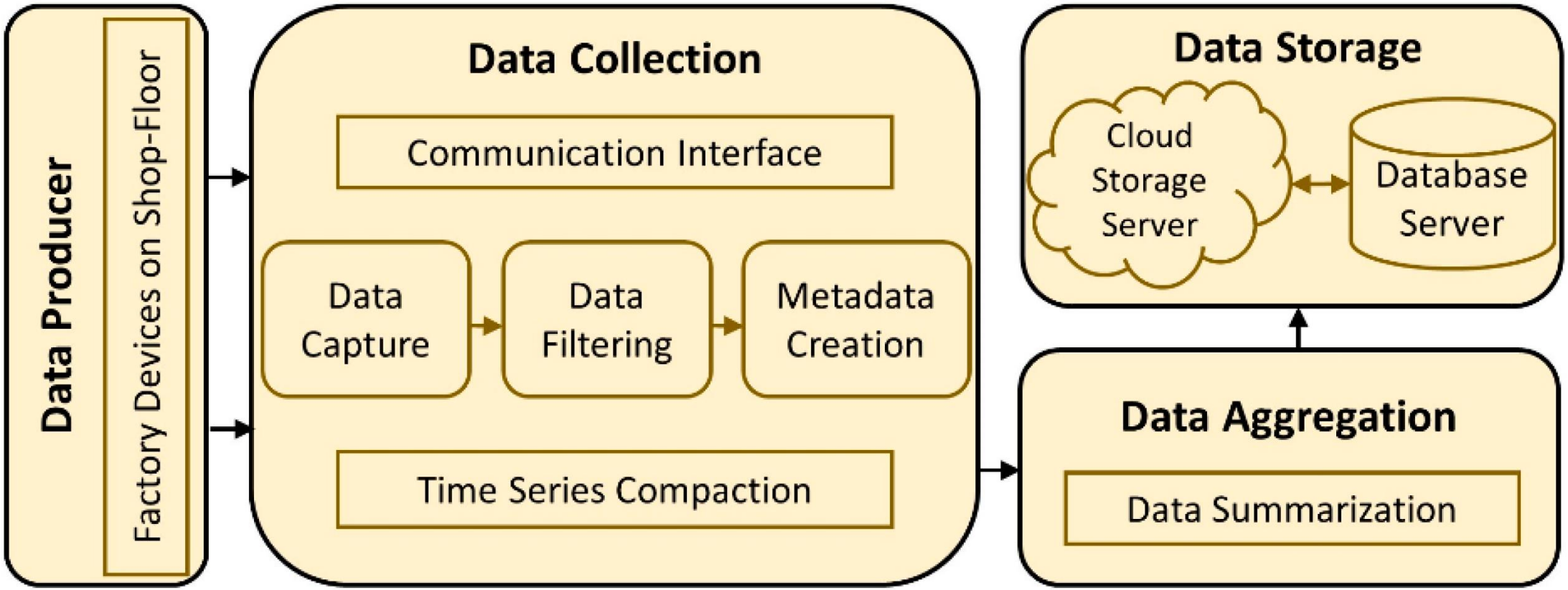
Big Data and Data Analytics[5]

- Big data technologies can offer data storage and processing services in an IoT environment.
- Data analytics allow business people to make better decisions
- IoT is the Source of data generation

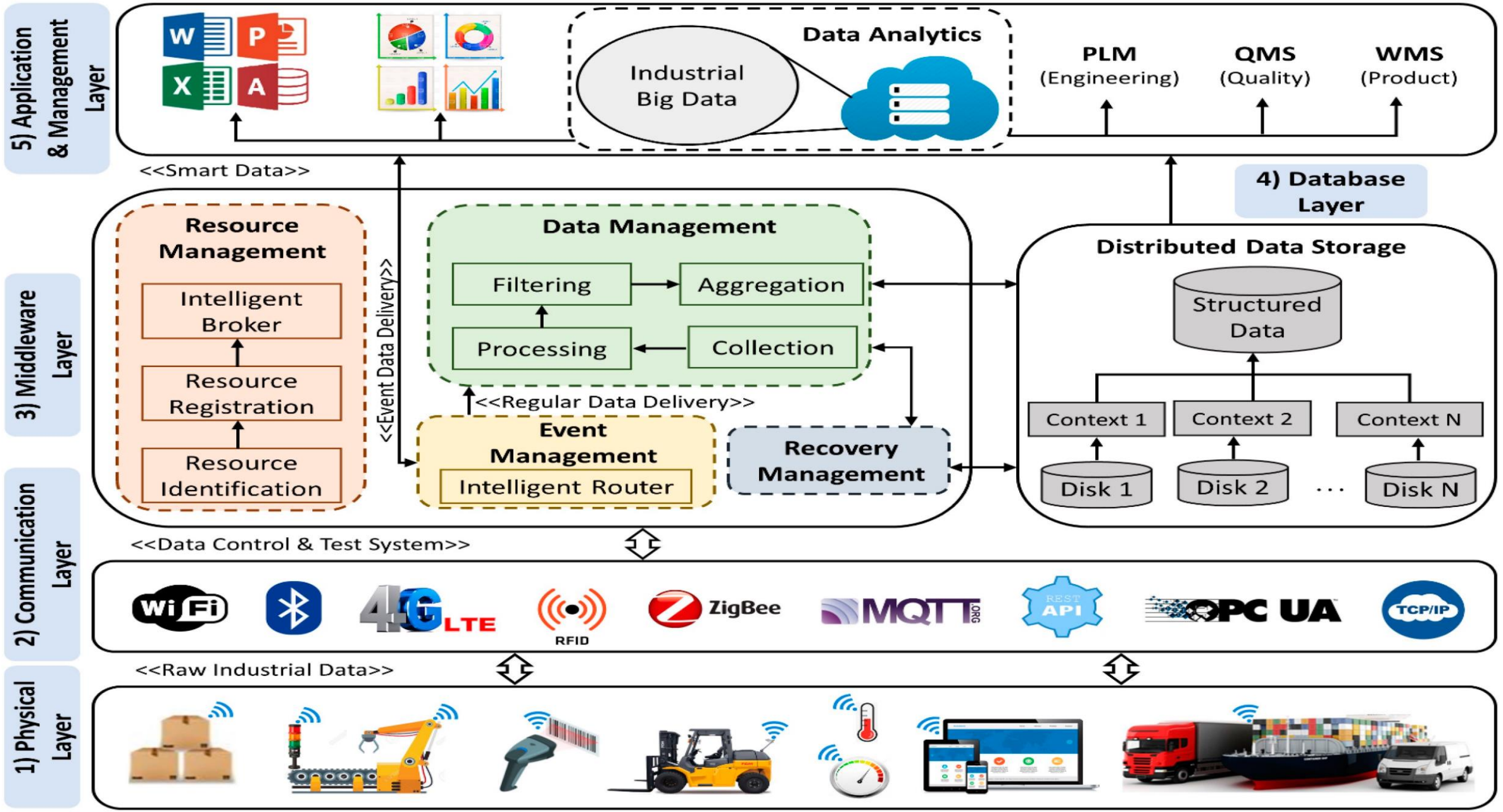
Industrial Data Life Cycle[6]



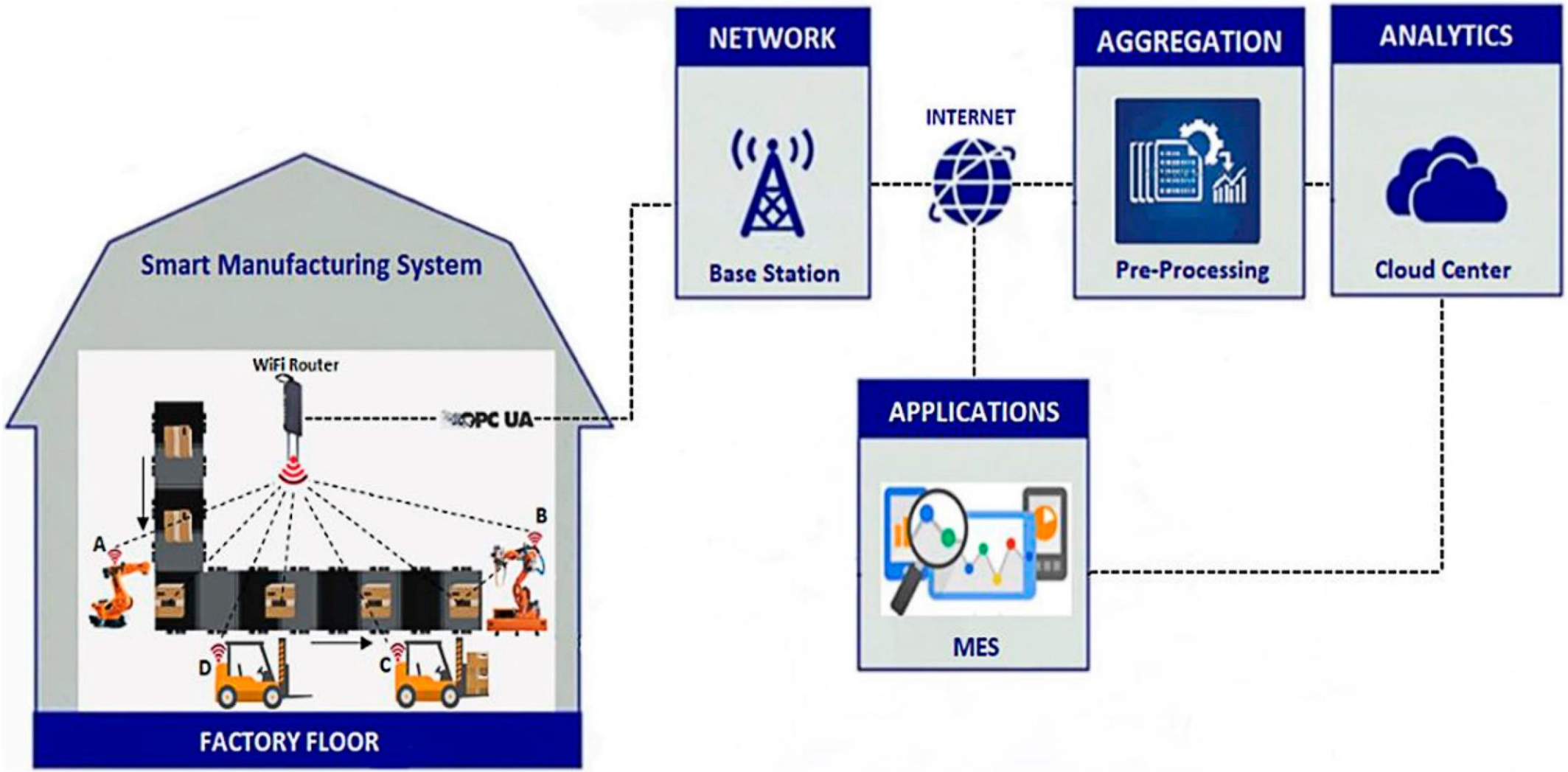
Data Flow at Data Management [6]



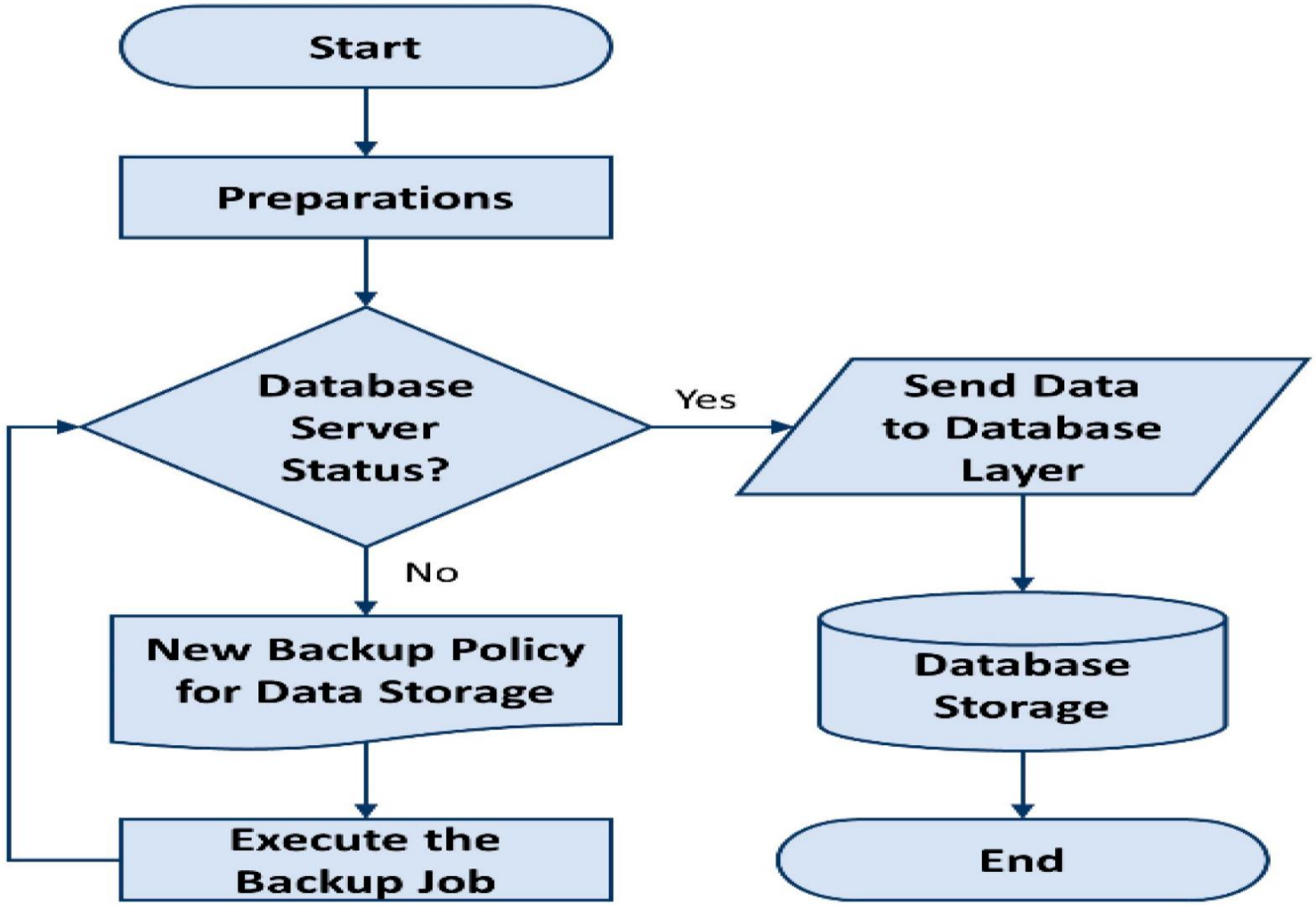
IoT based Industrial Data Management System[6]



Online Factory Flore Monitoring System



Data Base Recovery



Benefits of data analytics for IoT applications[5]

. **Smart transportation**

(a) Reduce the number of accidents by looking into the history of the mishaps

(b) Minimize traffic congestion

(c) Optimize shipment movements

(d) Ensure road safety

Smart healthcare

(a) Predict epidemics, cures, and disease

(b) Help insurance companies make better policies

(c) Pick up the warning signs of any serious illnesses during their early stages

Smart grid

(a) Help design an optimal pricing plan according to the current power consumption

(b) Predict future supply needs

(c) Ensure an appropriate level of electricity supply

Smart inventory system

(a) Detect fraudulent cases

(b) Strategically place an advertisement

(c) Understand customer needs

(d) Identify potential risk

Abbreviations

- Product Lifecycle Management (PLM)
- Enterprise Resource Planning (ERP)
- Supply Chain Management (SCM)
- Manufacturing Execution System (MES)
- Quality Management System (QMS)
- Warehouse Management System (WMS)
- Machine learning (ML)
- Deep learning (DL)
- Industrial Data Management System (IDMS)

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