Internet of Things Basic Concepts

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IoT Background

- Since 1991, Mark Weiser predicted what human beings expected from future technology: **ubiquitous computing**.

  - *"Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives"*.

  - *"Welcome to the Calm Technology and The Ubiquitous Computing"*

- The Weiser's *calm technology*:

  - The purpose of a computer is to help you do something else.

  - The best computer is a quiet, invisible servant.

  - The more you can do by intuition the smarter you are; the computer should extend your unconscious.

  - Technology should create calm.

  - The *disappearing computer*:

    - "The most profound technologies are those that <u>disappear</u>. They weave themselves into the fabric of <u>everyday life</u> until they are <u>indistinguishable</u> from it"

- What was Weiser thinking of?
  - Maintenance Examples
    - Industrial plant operation
  - Daily use cases
    - Smart shopping

- What does Weiser's predictions entails?
  - Context awareness
  - Human-Computer-Interface (HCI) or Human-Machine-Interface (HMI)
  - High computational and storage capabilities
    - Computer vision
    - Machine learning
    - Data fusion
  - …

- In 2016, IHS forecast that there would be 30.73 billions of devices connected to Internet in 2020, 35.82 in 2021 and 75.4 in 2025: appliances, wearables, medical devices, cars, smart meters, doors, boxes, …

36 billions things providing and consuming information !!!

Exabytes (10^{18} bytes)

- Providing information about the information:

Metainformation

- Providing meaning to the metainformation.

1. Open Linked Data (OLD)
2. Resource Description Framework (RDF)
3. Ontologies
4. Middleware

It's very important to provide meaning to the information provided by the things in order to reach interoperability among services and applications.

Future Internet

What's going on?
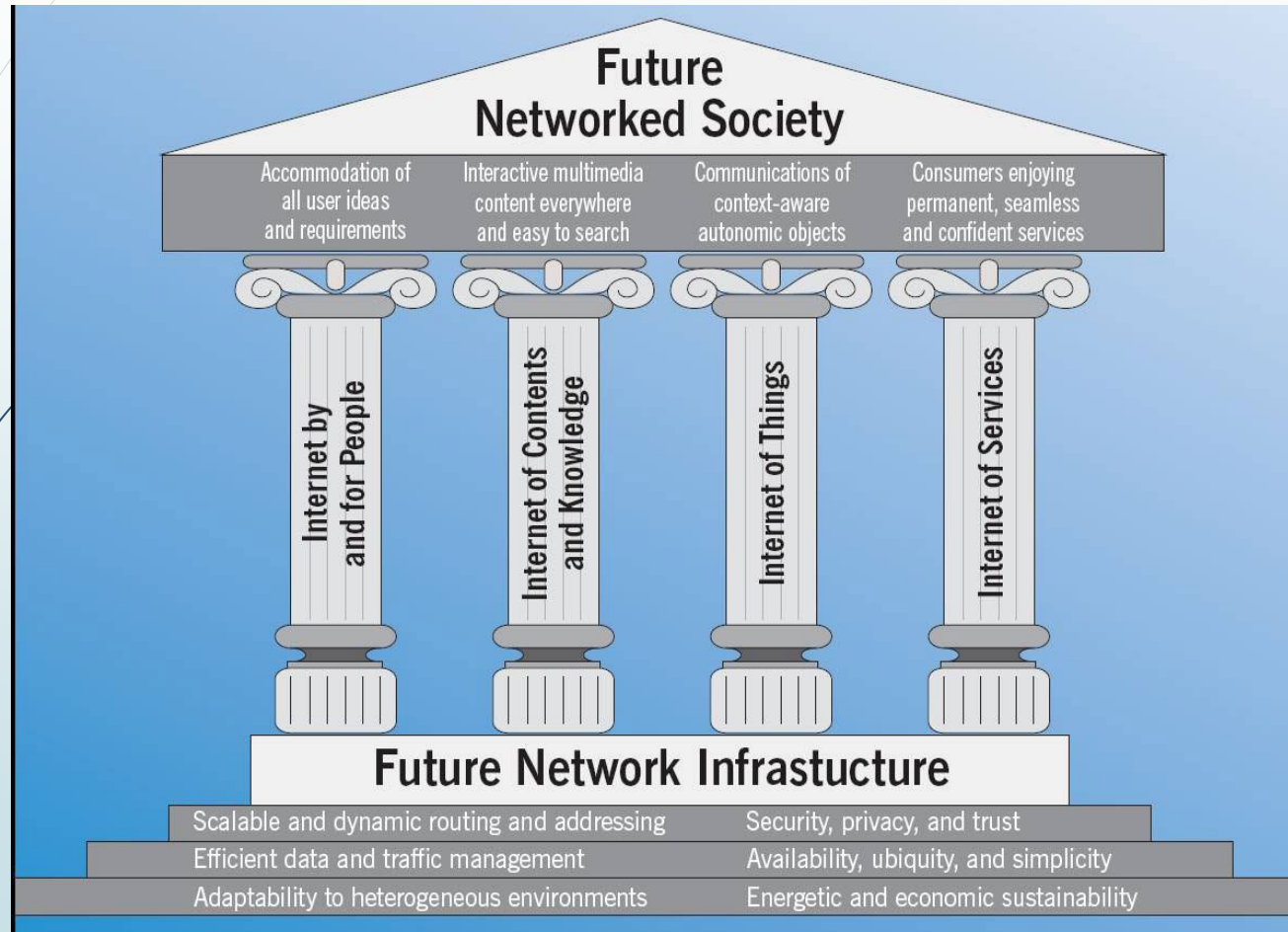
What's the Internet of Things
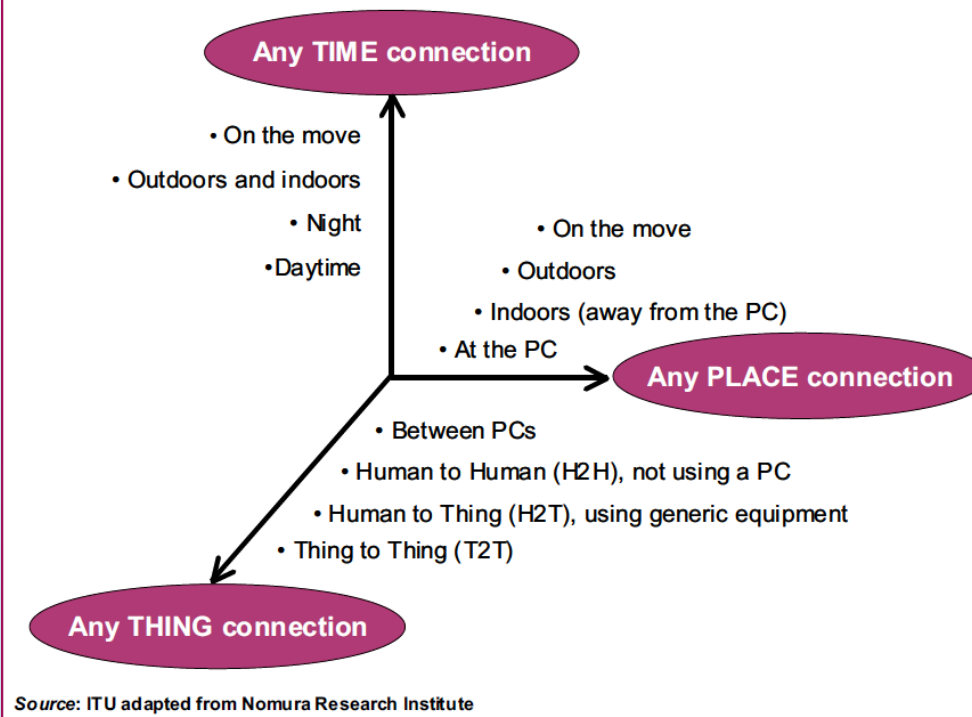
Standardization

Definition

(5) 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.

thing: With regard to the Internet of things, this is an object of the physical world (physical things) or the information world (virtual things), which is capable of being identified and integrated into communication networks.

------Definición (ITU-Y.2060)

From any time, any place connectivity for anyone, we will now have connectivity for anything!

Figure 1 – A new dimension

- Any TIME connection
  - On the move
  - Outdoors and indoors
  - Night
  - Daytime

- Any PLACE connection
  - On the move
  - Outdoors
  - Indoors (away from the PC)
  - At the PC

- Any THING connection
  - Between PCs
  - Human to Human (H2H), not using a PC
  - Human to Thing (H2T), using generic equipment
  - Thing to Thing (T2T)

Source: ITU adapted from Nomura Research Institute

- IoT main enablers:
  - Lower microcontrollers and microprocessors costs:
    - Old microcontrollers and microprocessors costs have decreased, though their computing capabilities are pretty enough for non deeply processing demanding applications in small devices.
  - Wireless communication technologies have improved significantly:
    - Larger ranges.
    - Lower energy consumption.
    - Easily embeddable in tiny devices.
    - …
  - The Cloud Computing effectiveness came to be real.

But how do we....?

- get things involved in a use case participate in another different use case?

- get things from different providers talk to each other?
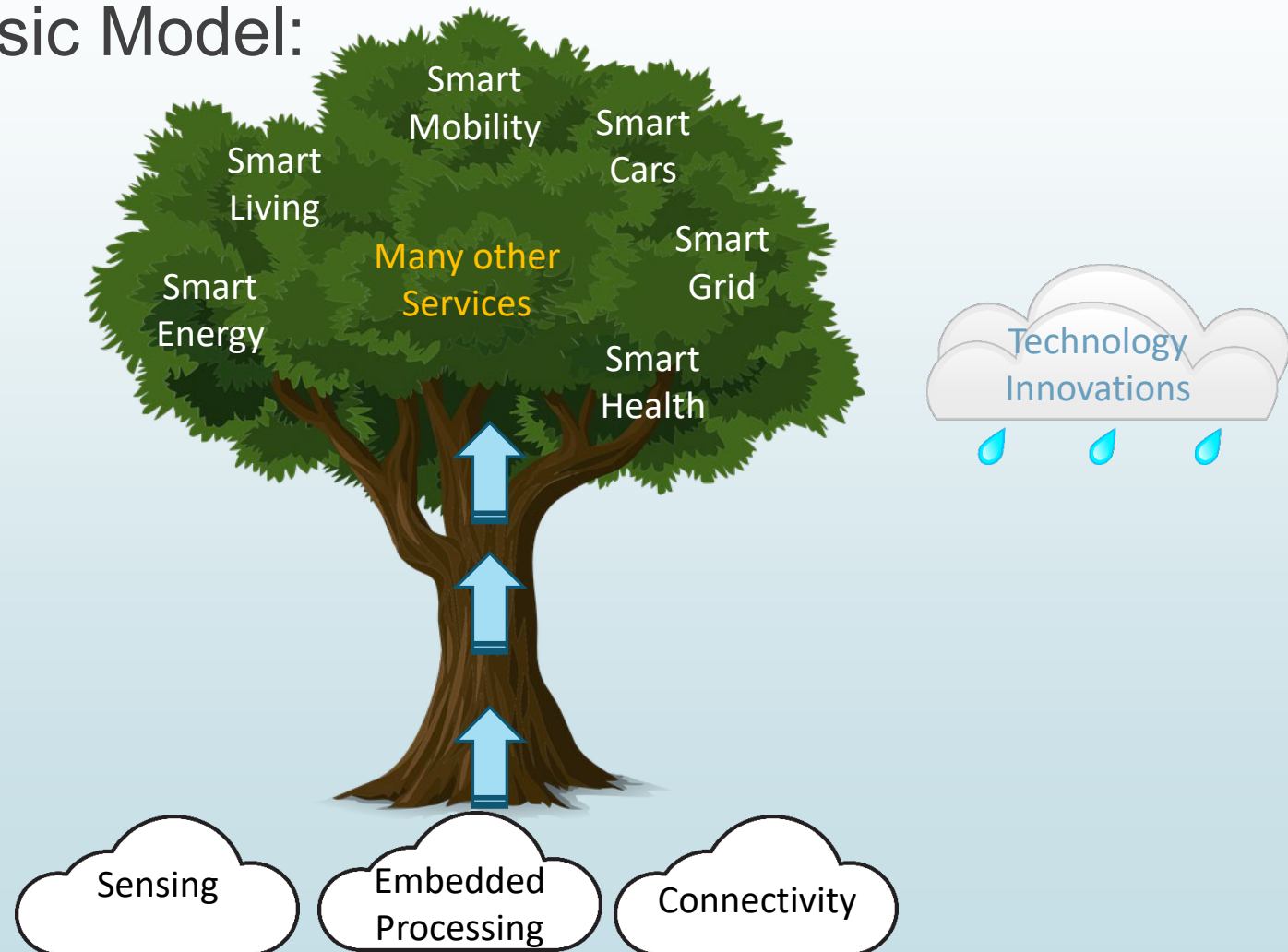
- get things protect privacy and become trustworthy?

- …

STANDARDIZATION & MODELLING

- ## IoT Basic Model:

IoT & Edge Commercial Adoption Survey Report 2023

(follow this link for the full document)

IoT & Edge Survey 2023 Results

IoT technologies are being adopted: 64% of respondents vs 53% in 2022. An additional of 23% plan in 1-2 years

Edge computing stops raising: 33% of respondents have adopted. 30% plan to adopt in 2 years.

Scale-up in Production Deployments: 17% spent between $1-10M in 2023. This indicates a transition from proof-of-concept to ROI-focused deployments

Larger deployments: more than 1K managed assets per deployment. 10% of deployments of 50K or more devices

Open source plays a major role.

Challenges:
- Connectivity: 48%
- Security: 29%
- Data collection & Analytics: 19%

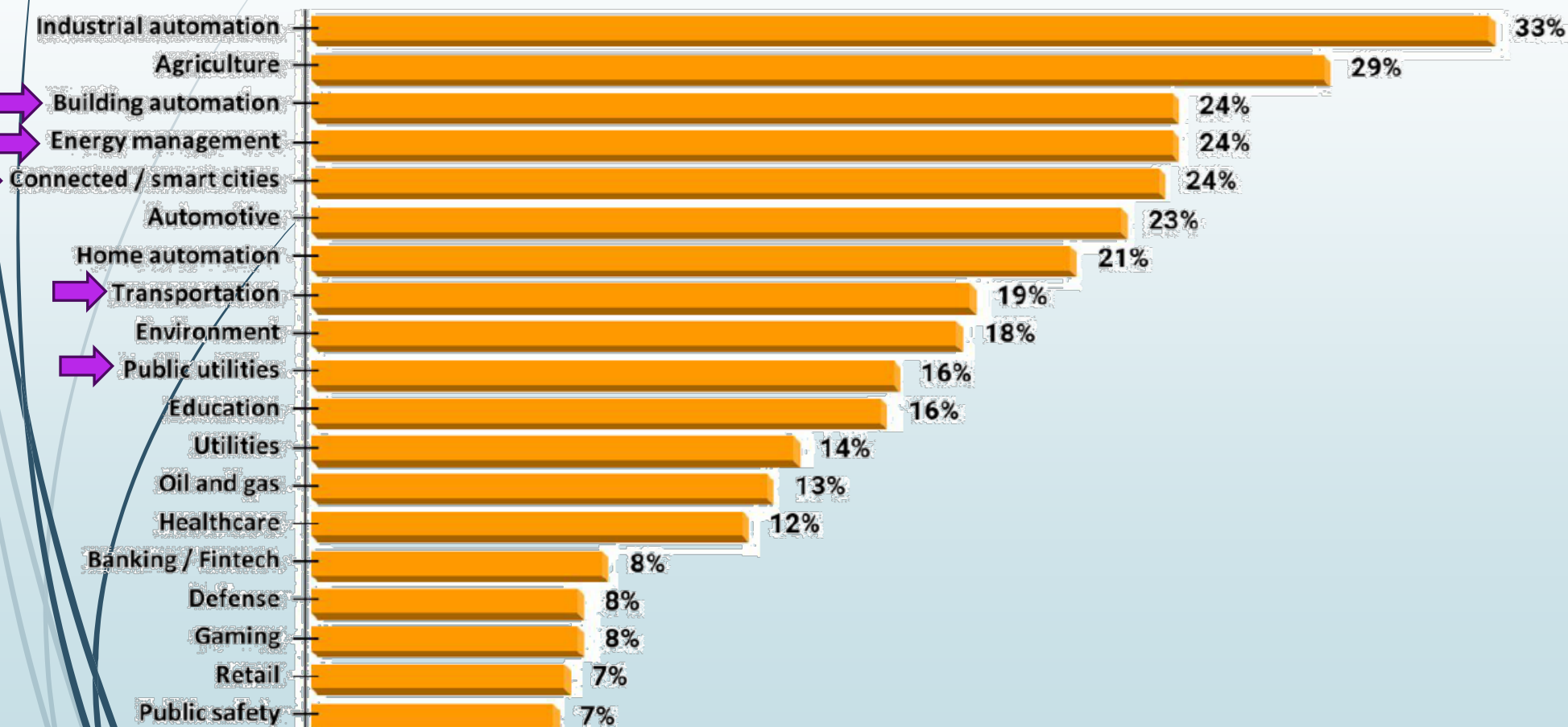Hybrid IoT Cloud strategies lead the way: 39% of organizations.

Data management dominates Edge Workloads:
- Facilitates machine learning
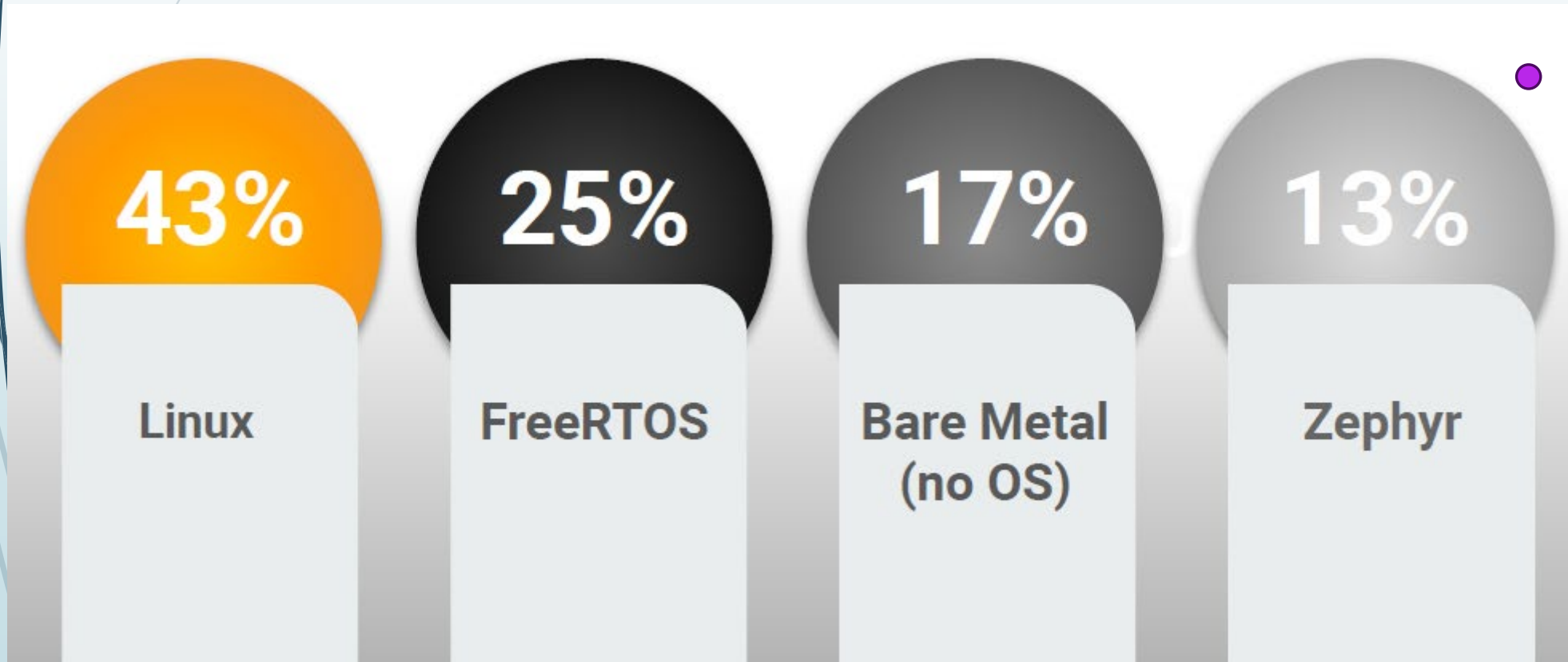- Edge computing is a natural extensión of the hybrid cloud.

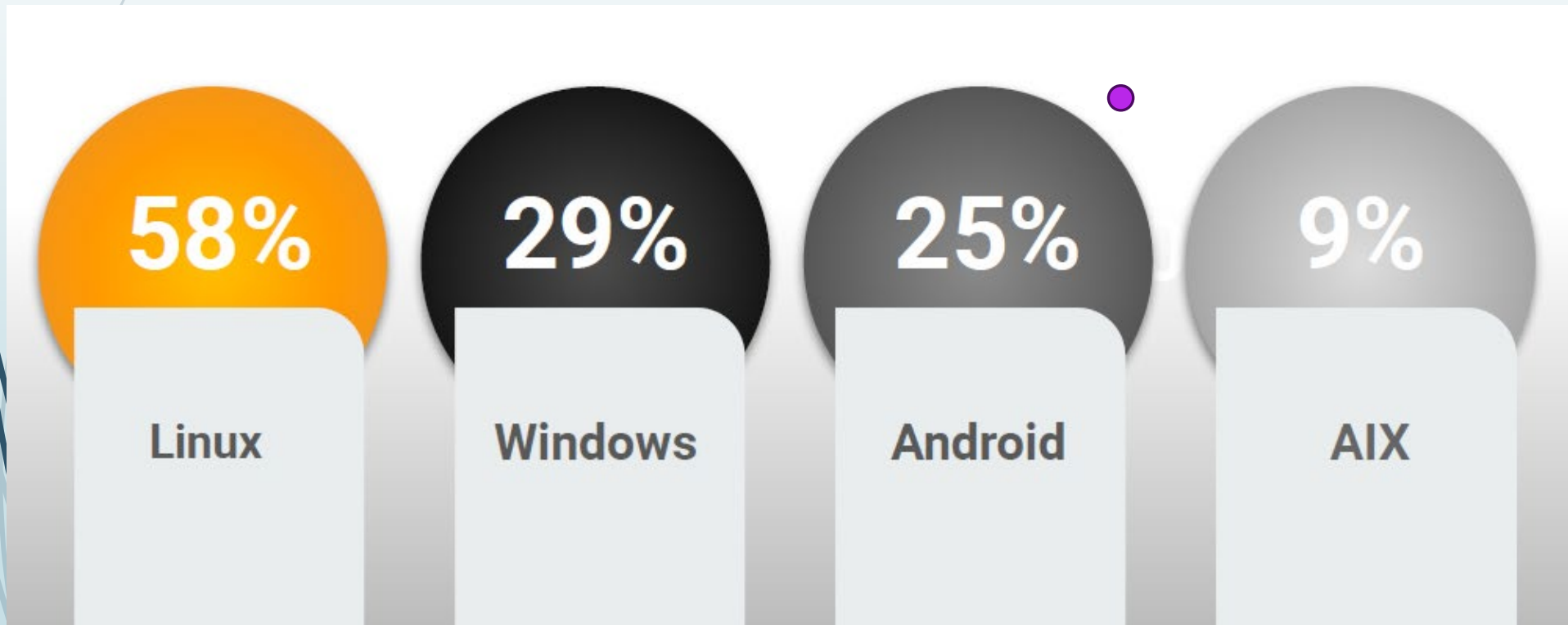# IoT & Edge Developer Survey 2023

(follow this link for the full document)

- **Key Industry Focus Areas**

Industry	Percentage
Industrial automation	33%
Agriculture	29%
Building automation	24%
Energy management	24%
Connected / smart cities	24%
Automotive	23%
Home automation	21%
Transportation	19%
Environment	18%
Public utilities	16%
Education	16%
Utilities	14%
Oil and gas	13%
Healthcare	12%
Banking / Fintech	8%
Defense	8%
Gaming	8%
Retail	7%
Public safety	7%

- Top operating system landscape for constrained devices

43% Linux

25% FreeRTOS

17% Bare Metal (no OS)

13% Zephyr

- Top operating system landscape for IoT Gateways & Edge nodes

58%	29%	25%	9%
Linux	Windows	Android	AIX

- Linux distributions employed in IoT Solutions

Distribution	Percentage
Ubuntu (Classic, Server)	27%
Raspbian	25%
Debian	24%
Yocto Project	16%
Ubuntu Core	14%
Alpine	14%
CentOS	14%
Red Hat Enterprise Linux	11%
Linus	8%
OpenWrt or equivalent...	6%
Automotive Grade	6%
Fedora/Fedora IoT	6%
Wind River Linux	2%
uClinux	2%
Tizen	1%
Other (please specify)	8%
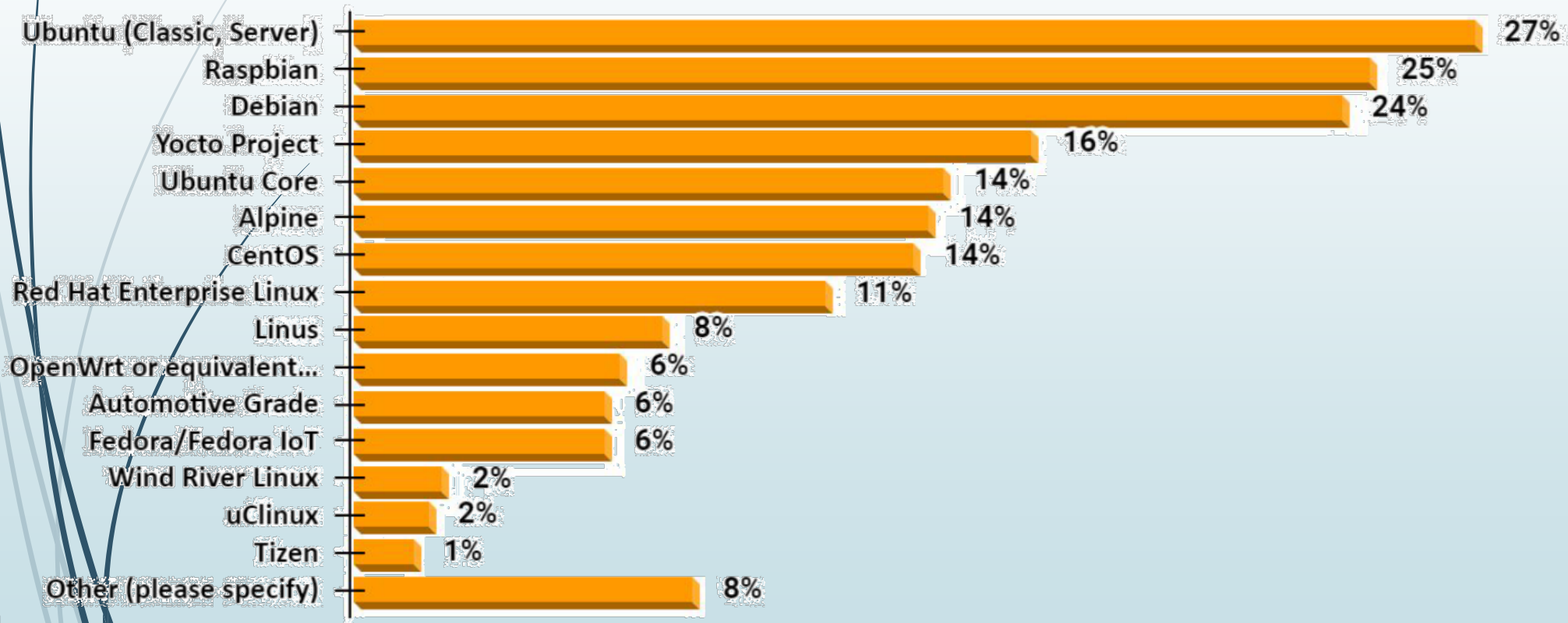
■ Top Edge Computing Workloads
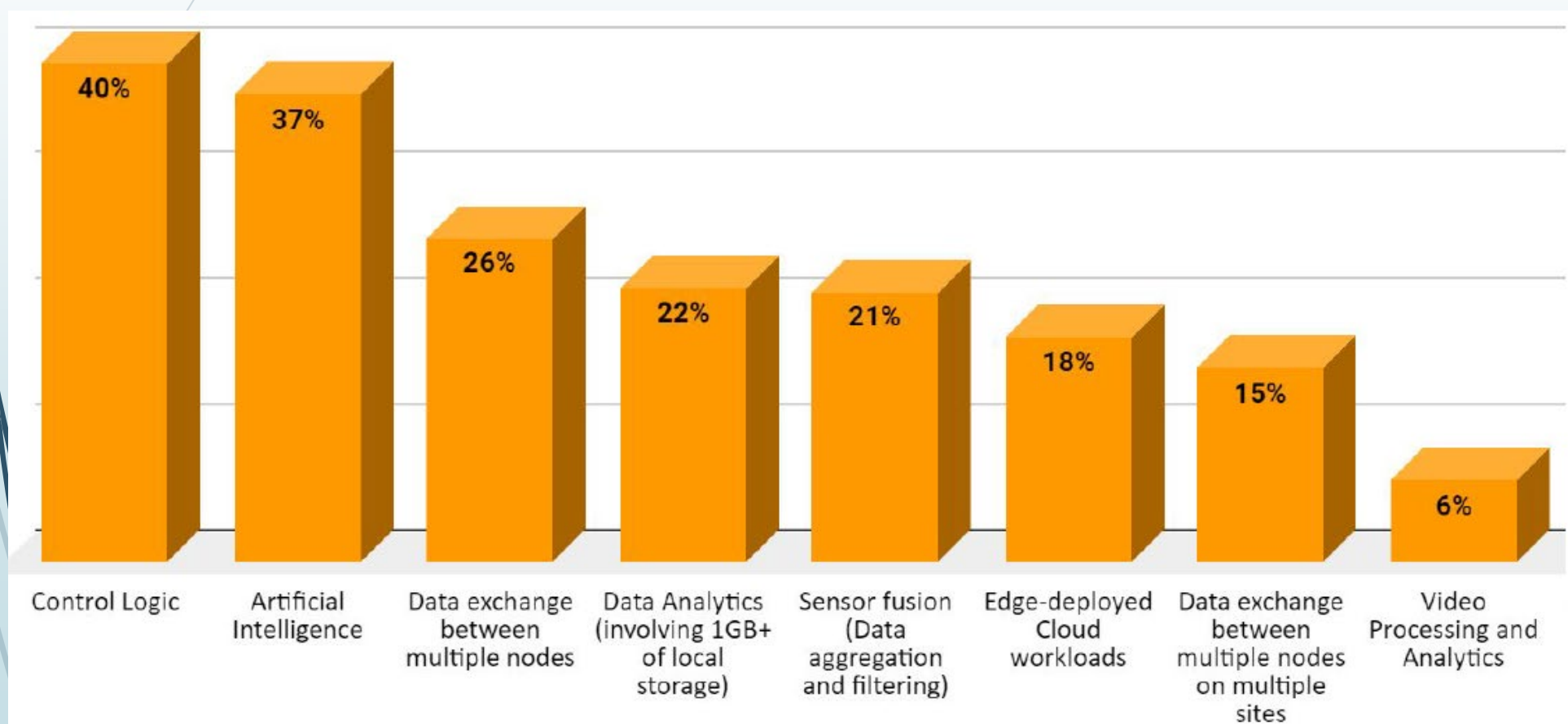
- Top Edge Computing Artifacts Deployed for IoT Solutions

Bar chart — Top Edge Computing Artifacts Deployed for IoT Solutions:
- Container images: 51%
- Native binary: 35%
- Script Files: 28%
- Virtual machines: 21%
- Serverless functions (lambdas, etc): 10%
- OSGi Bundles: 10%

- Top Edge Computing Container Orchestration in IoT Solutions

Bar chart: Top Edge Computing Container Orchestration in IoT Solutions

Technology	Percentage
Docker	48%
None	16%
Eclipse ioFog	11%
MicroK8s	11%
Other Kubernetes	9%
Eclipse Kura	9%
Eclipse Kanto	9%
KubeEdge	8%
k3s	8%
Red Hat OpenShift (including OKD)	6%
Podman	5%
Red Hat Device Edge	4%
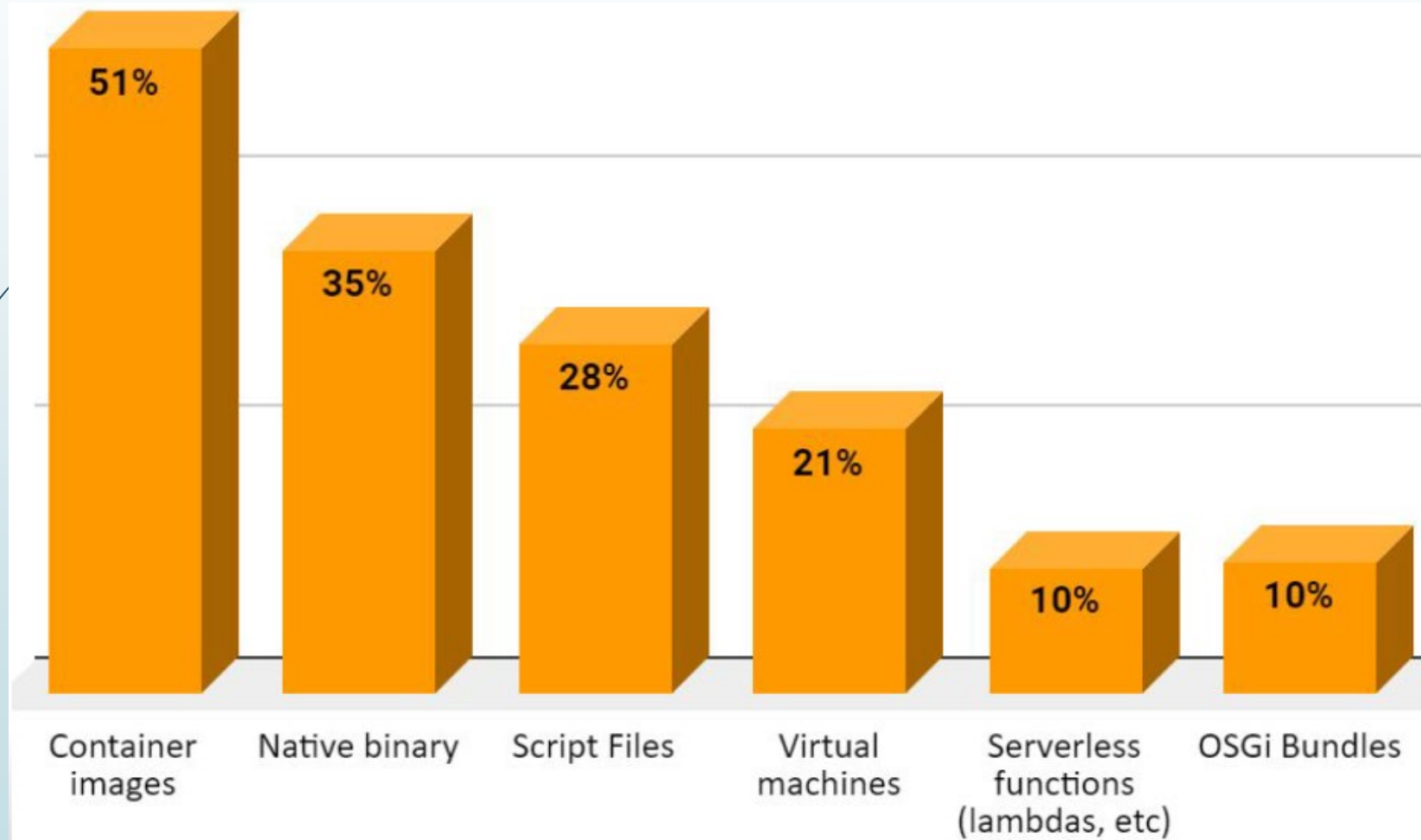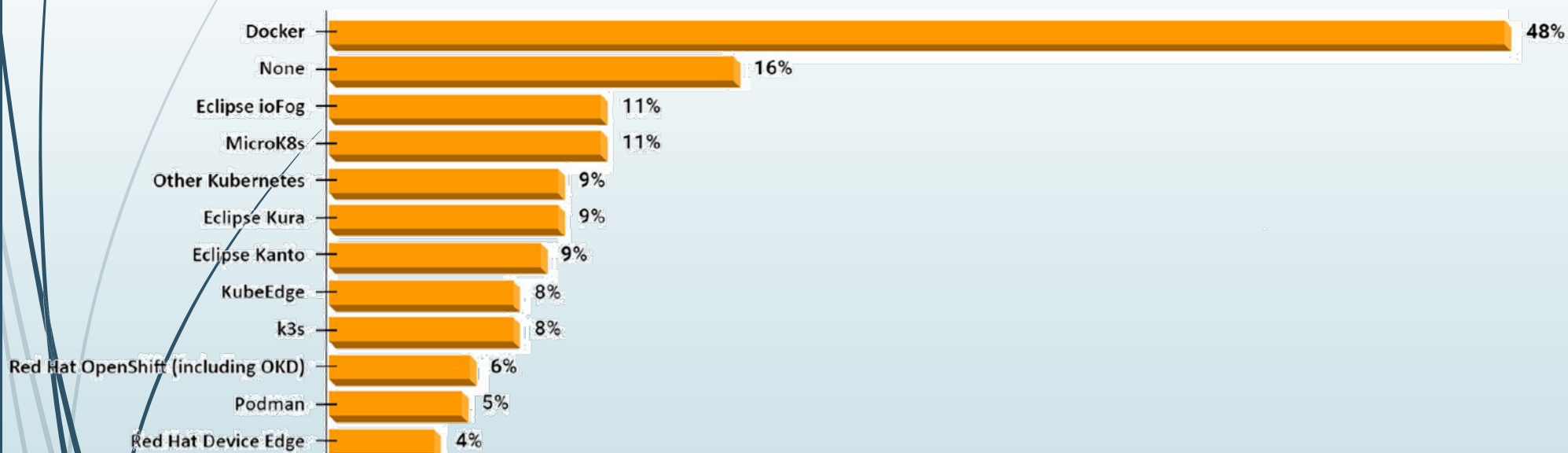
- Top programming languages

Contrained Devices

43%	36%	35%	29%
C	C++	Java	Python

IoT GW and Edge Nodes

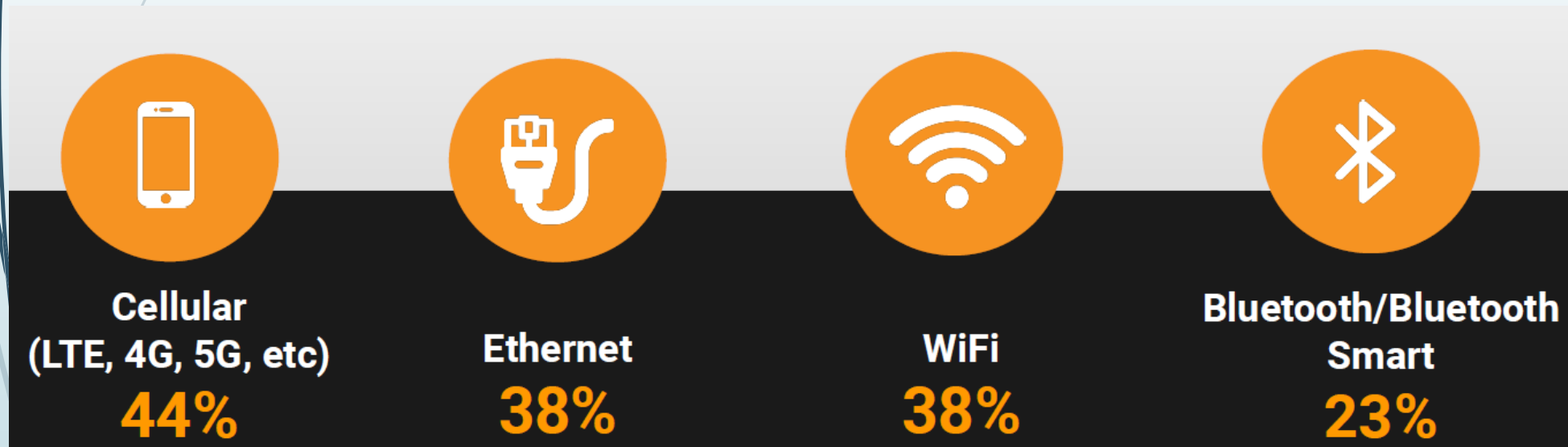| 36%	31%	28%	26%
Java	Python	Javascript	C++
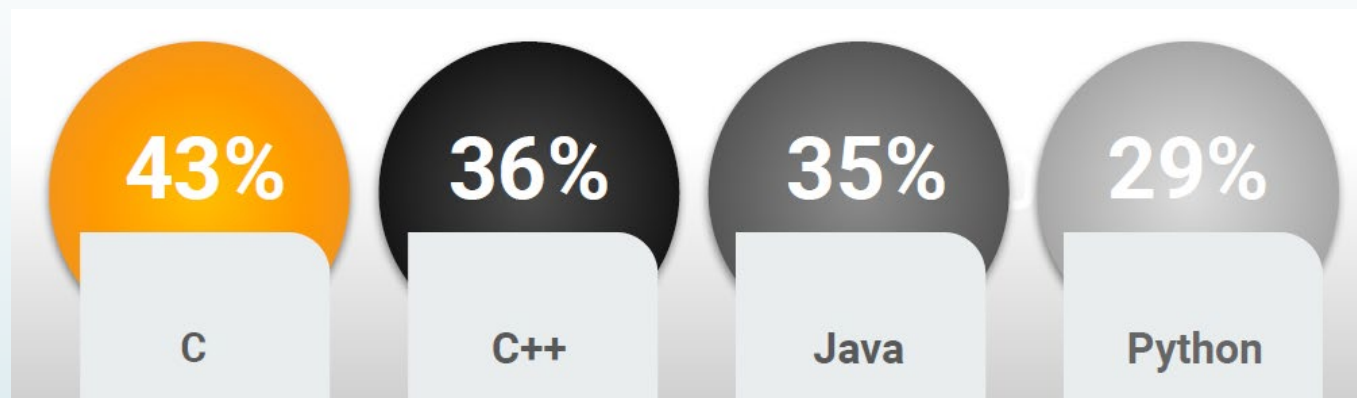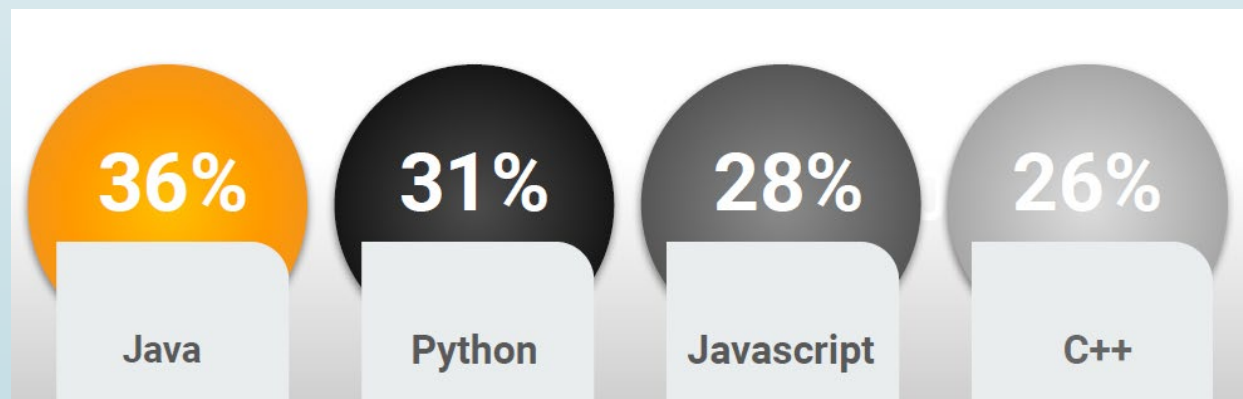
- Preferred IoT Communication Protocols
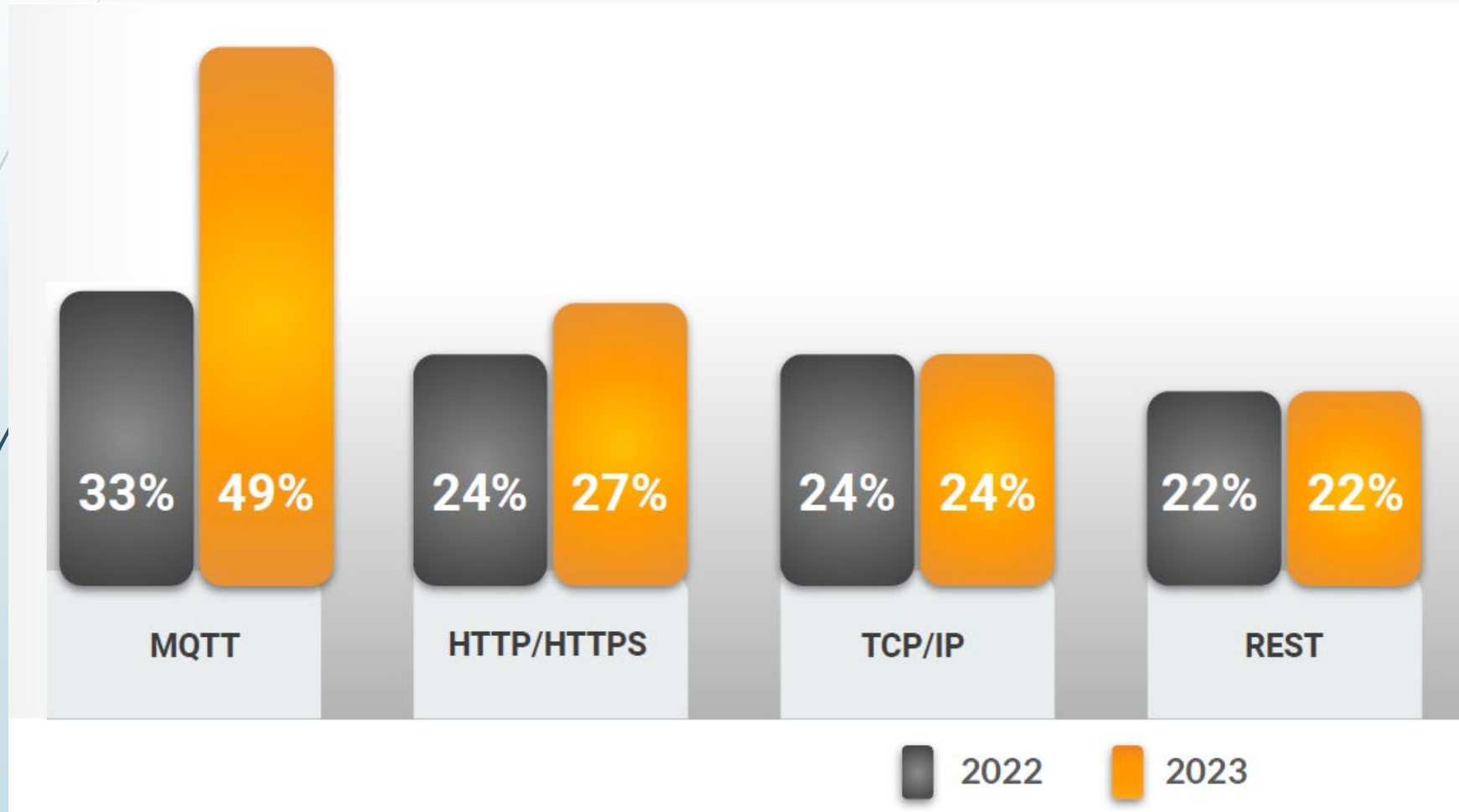
- Most used connectivity technologies

Cellular (LTE, 4G, 5G, etc) 44%

Ethernet 38%

WiFi 38%

Bluetooth/Bluetooth Smart 23%

- **Most Favoured Security-Related Technologies**

39%	24%	23%	23%	19%
Communication Security (e.g. TLS, DTLS)	Over-the-Air Updates	Analytics / Anomaly Detection	Data Encryption	JSON Web Token or Similar Token Formats
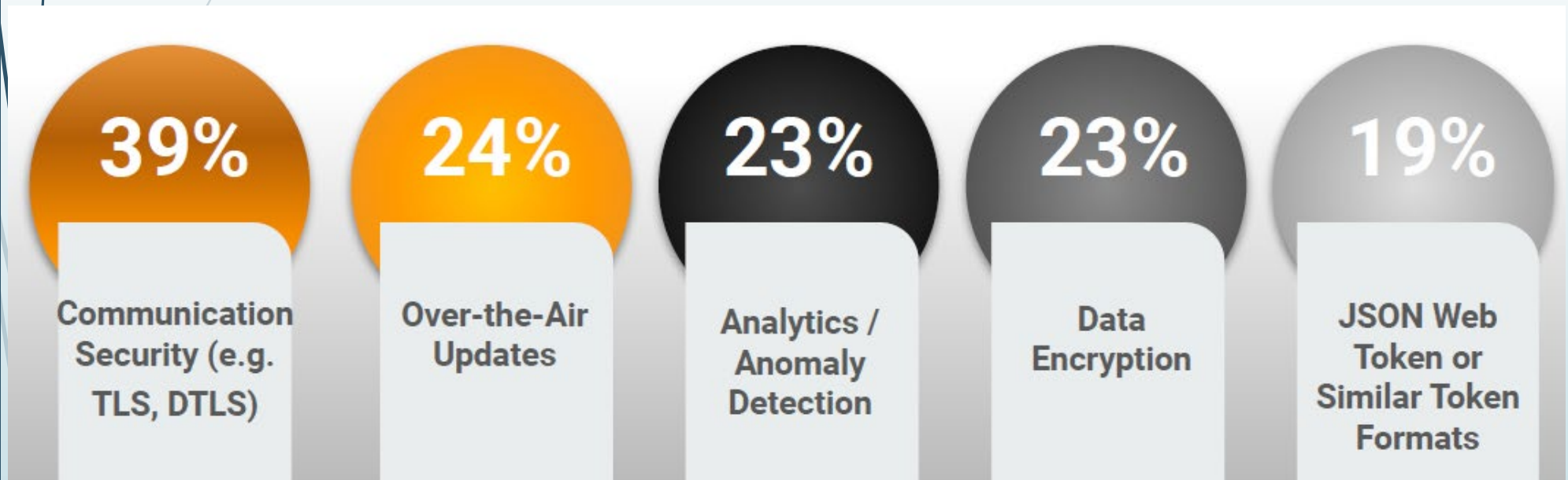
- **HW architecture usage for constrained devices**
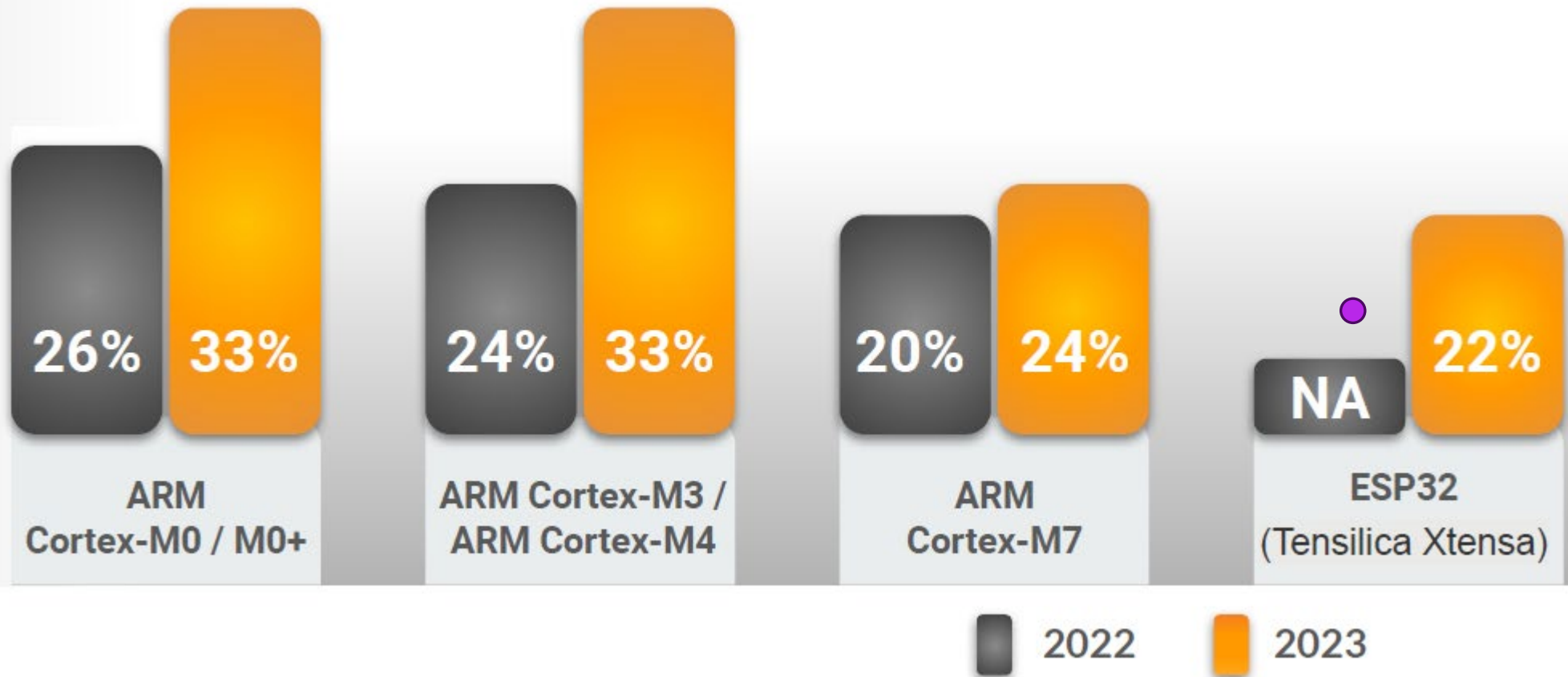
- HW architecture usage for IoT GW & Edge

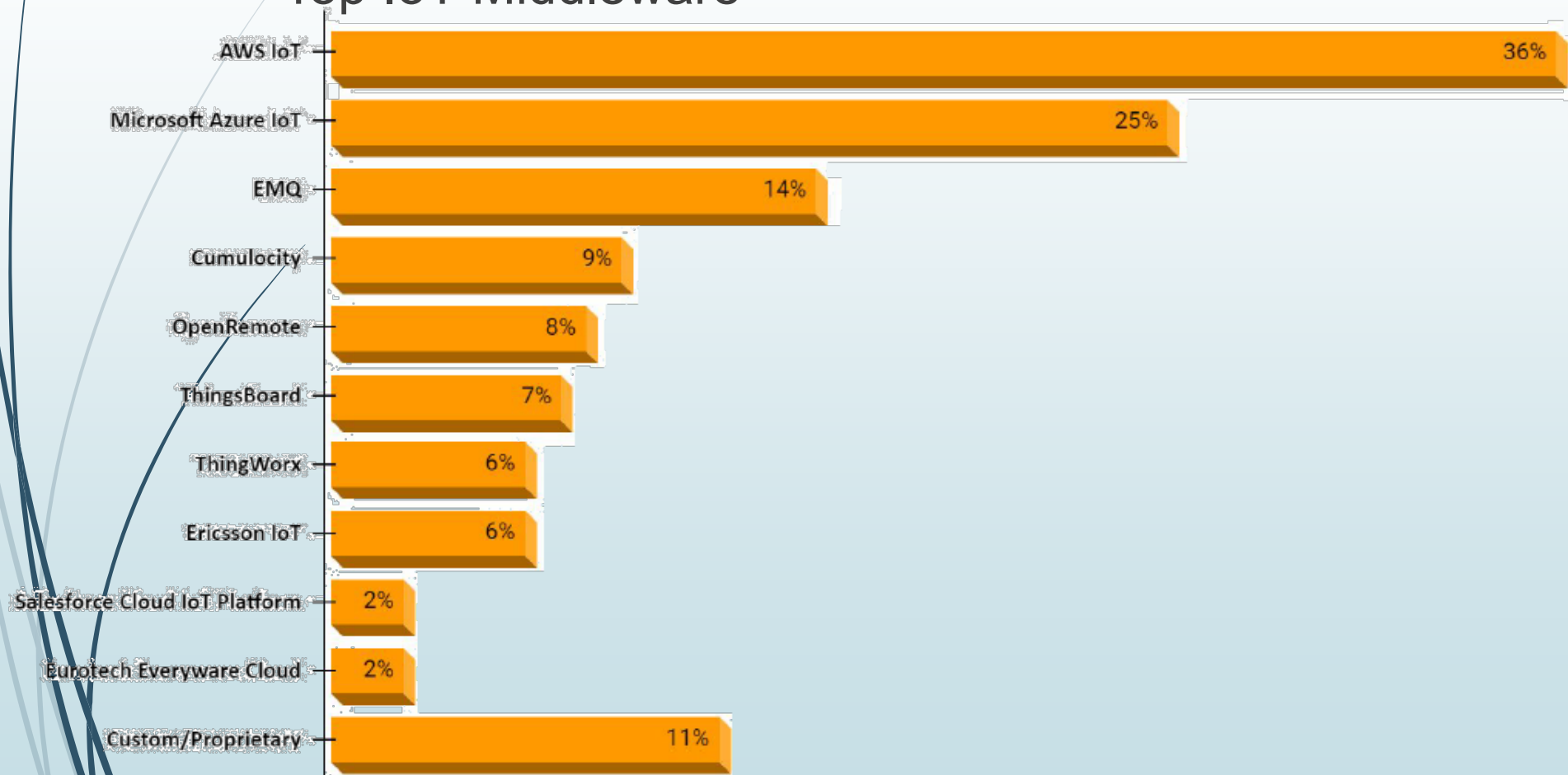|	AMD/Intel x86_64	ARM v8-A (Cortex-A 64 bits)	ARM v7-A (Cortex-A 32 bits)	ARM v6
2022	26%	22%	15%	17%
2023	28%	24%	21%	19%
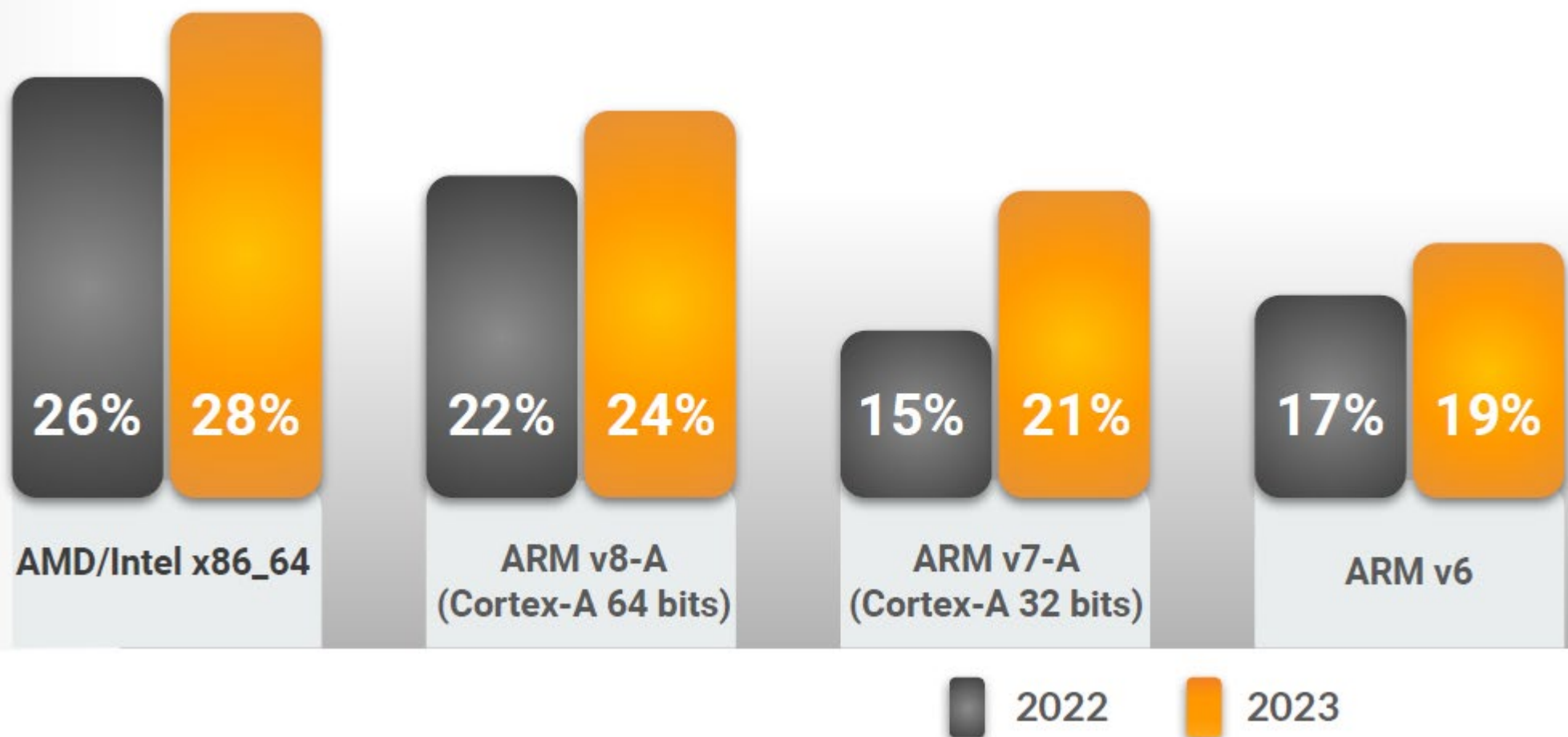
- Types of IoT Data Stored in Database/Data Store
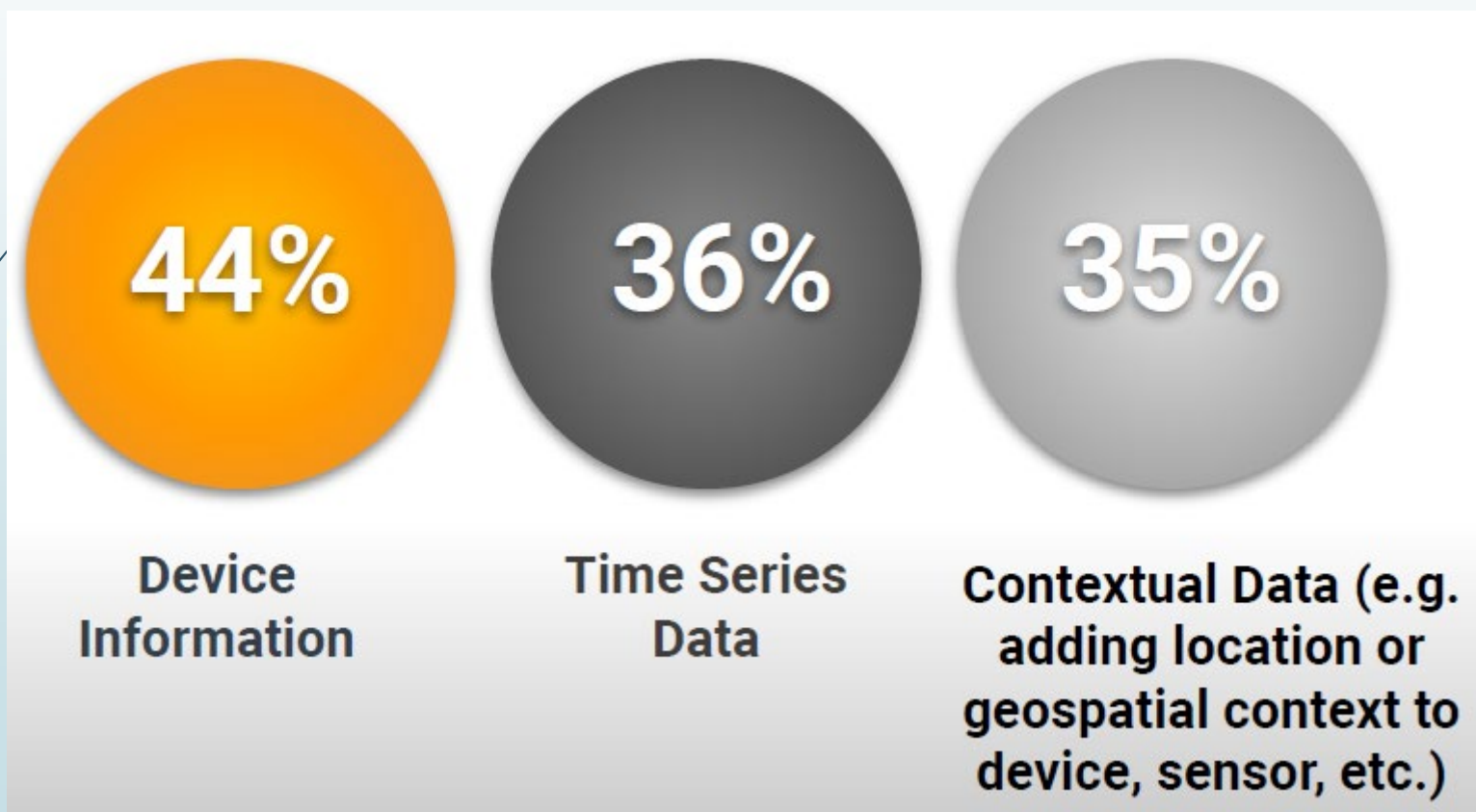
- Top IoT cloud platforms

- ## Top IoT Middleware

Middleware	Percentage
AWS IoT	36%
Microsoft Azure IoT	25%
EMQ	14%
Cumulocity	9%
OpenRemote	8%
ThingsBoard	7%
ThingWorx	6%
Ericsson IoT	6%
Salesforce Cloud IoT Platform	2%
Eurotech Everyware Cloud	2%
Custom/Proprietary	11%
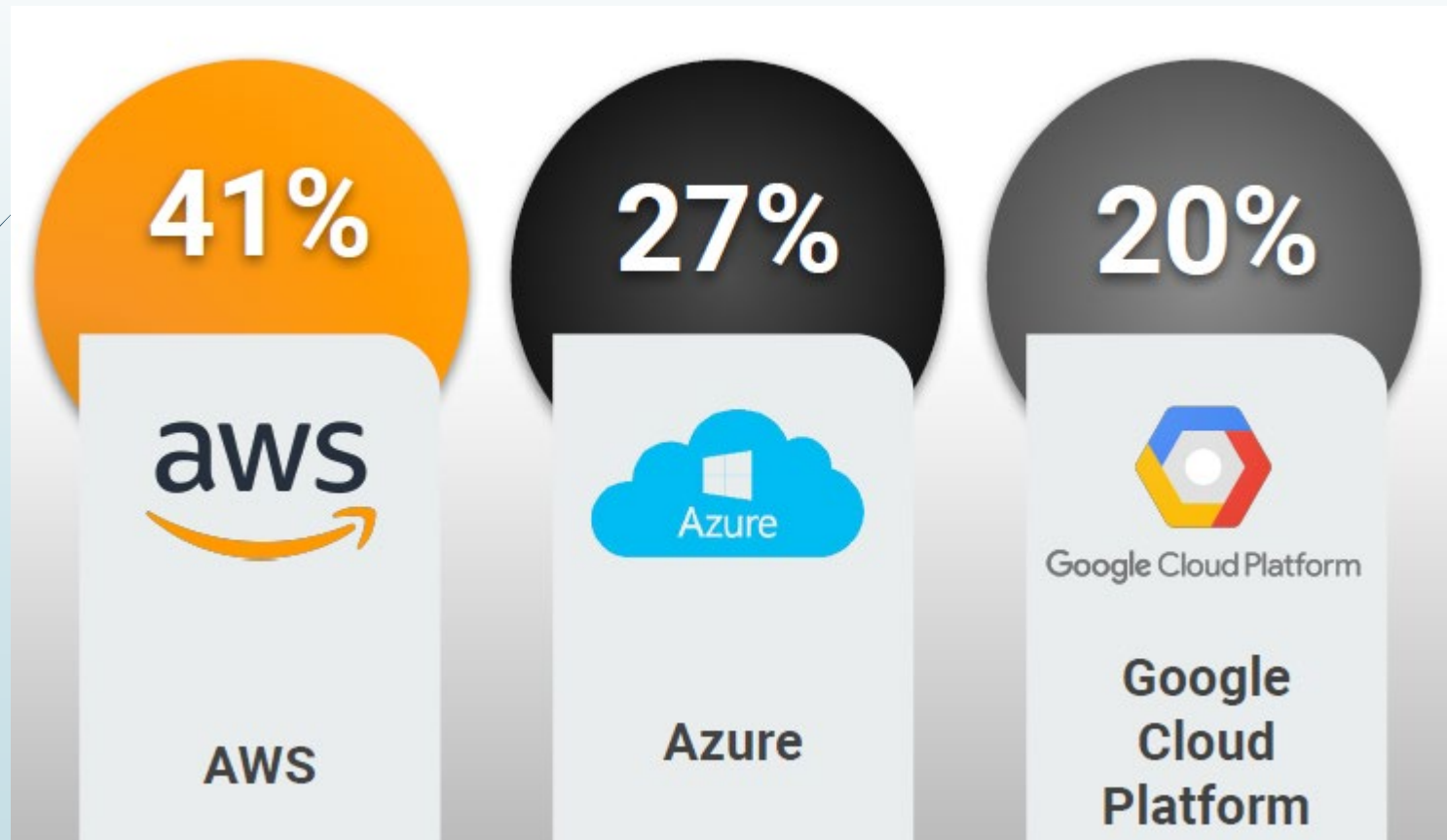
- Top IoT developer concerns

QUESTIONS?