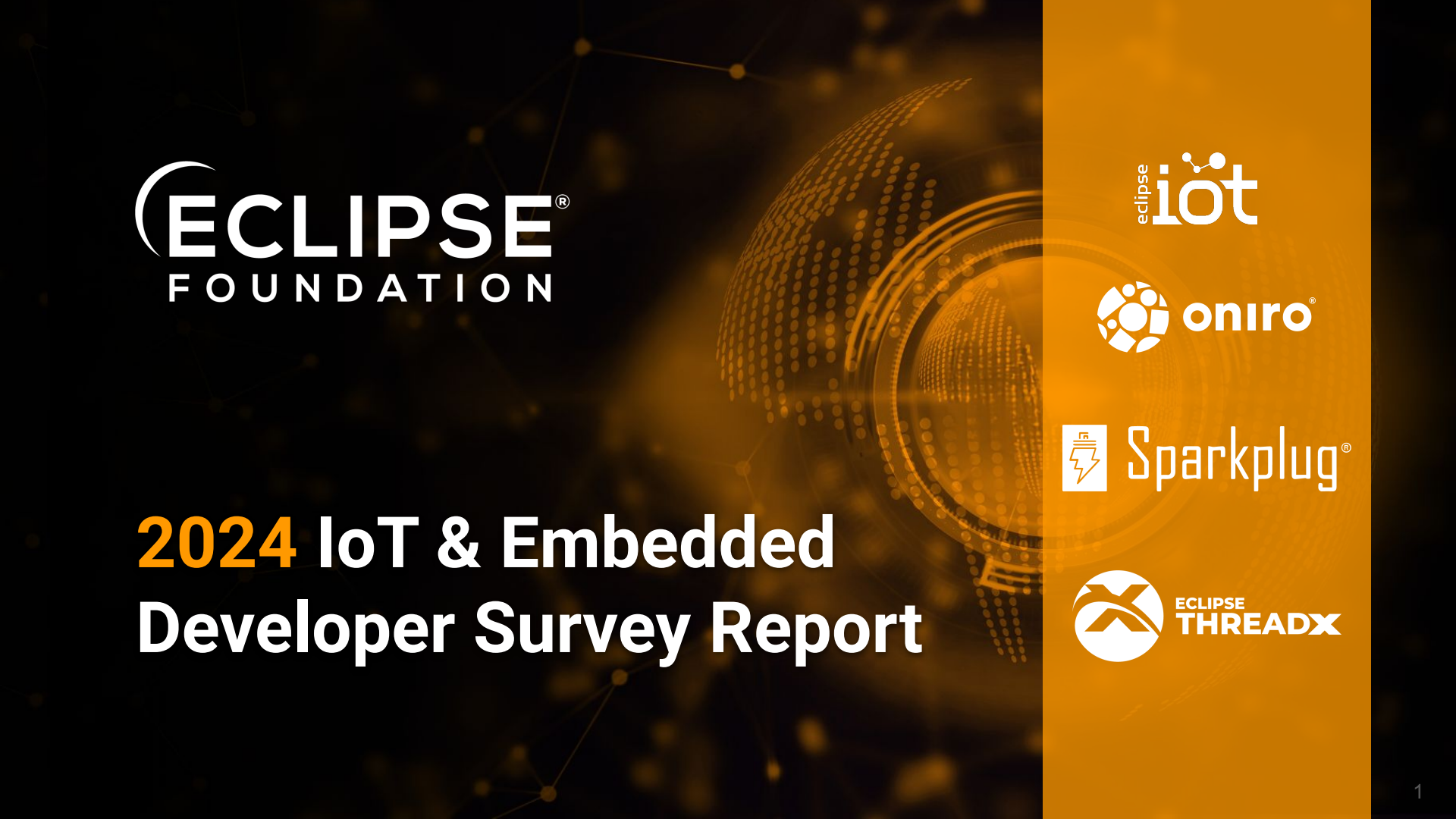
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2024 IoT & Embedded
Developer Survey Report

Introduction

Introduction

Welcome to the 2024 IoT & Embedded Developer Survey Report.

The 2024 survey report expanded the focus to include the embedded systems industry, examining how IoT trends also influence embedded development. Key areas of analysis include:

- **Security and Deployment**: Challenges and priorities as developers address cybersecurity risks.
- **Open Source Engagement**: How open source drives innovation in IoT and embedded applications.
- **Developer Preferences**: Preferred features and frameworks for application development.
- **Safety Certifications**: The role of certifications in software adoption for embedded systems.
- **Hardware and OS Choices**: Leading hardware architectures and dominant RTOS for embedded devices and edge nodes.

We trust this report provides valuable insights into the evolving landscape and welcome your feedback.

Executive Summary

Executive Summary

- **Industrial and Automotive Sectors Lead**: IoT development remains strong in industrial automation (34%) and automotive (29%), maintaining their position as top sectors while reflecting steady growth from previous years.

- **Rising Focus on Sustainability and Lifestyle Solutions**: Increased activity in energy management (29%), environmental applications (23%), healthcare (18%), and home automation (25%) signals a shift toward IoT solutions that prioritise sustainability, efficiency, and improved quality of life.

- **Key Security Priorities in IoT: Communication security** leads at **40%,** followed by **over-the-air updates** rising to **32%**, and **secure boot** increasing to **19%**. This shift suggests a priority on maintaining device integrity and secure communication as primary defenses against evolving threats, while analytics/anomaly detection, now at **16%**, is seen as a secondary layer after establishing core security foundations.

- **Evolving Safety Certifications Highlight Industry Needs**: Nearly **47%** of developers emphasise safety certifications such as **IEC 61508** and **ISO 26262**, particularly in **automotive, medical, and industrial sectors**. This reflects a growing demand for **safety-critical solutions** and the industry's focus on **trusted, certified technologies** for embedded systems.

- **Impact of End User App Design on IoT Solutions**: End user app design plays a crucial role in IoT development, with most respondents acknowledging its influence on solution effectiveness. This emphasis indicates that user experience and functionality are key drivers in shaping IoT applications, aligning design choices closely with performance and usability goals.

Executive Summary

- Embedded **Linux (46%)** and **FreeRTOS (29%)** lead as RTOS choices for constrained devices, yet the growth of **Zephyr (21%)** and **Eclipse ThreadX (13%)** indicates a shift toward solutions balancing performance with integration ease. ThreadX's adoption highlights its appeal for safety-critical IoT applications, positioning it as an emerging competitor in the evolving RTOS landscape.

- While Hardware or Platform Support is the top influencing factor for selecting RTOS for constrained devices , the **licencing model** plays a major role in considering an RTOS as **34%** of respondents, reflecting concerns around costs and legal flexibility.

- **Key Security Priorities in IoT: Connectivity and Threat Defense: Connectivity (48%)** has overtaken **security (35%)** as the leading concern for IoT and edge developers in 2024. Key security measures include **communication security (40%)**, **over-the-air updates (32%)**, and **secure boot (19%)**, which remain primary defenses against threats. **Analytics and anomaly detection (16%)** are emerging as secondary layers for proactive system protection.

- **ESP32** and **RISC-V** are gaining traction in constrained devices, while **x86_64** and **ARM Cortex-M** remain popular for performance needs. The decline in older ARM versions, like **ARMv6**, reflects a shift to newer ARM cores, solidifying ARM's versatility across various applications.

- **Developer Language Preferences: C (55%), C++ (36%), Python (32%), and Java (29%)** are the top programming languages for constrained devices, with Rust showing steady growth in adoption.

Executive Summary

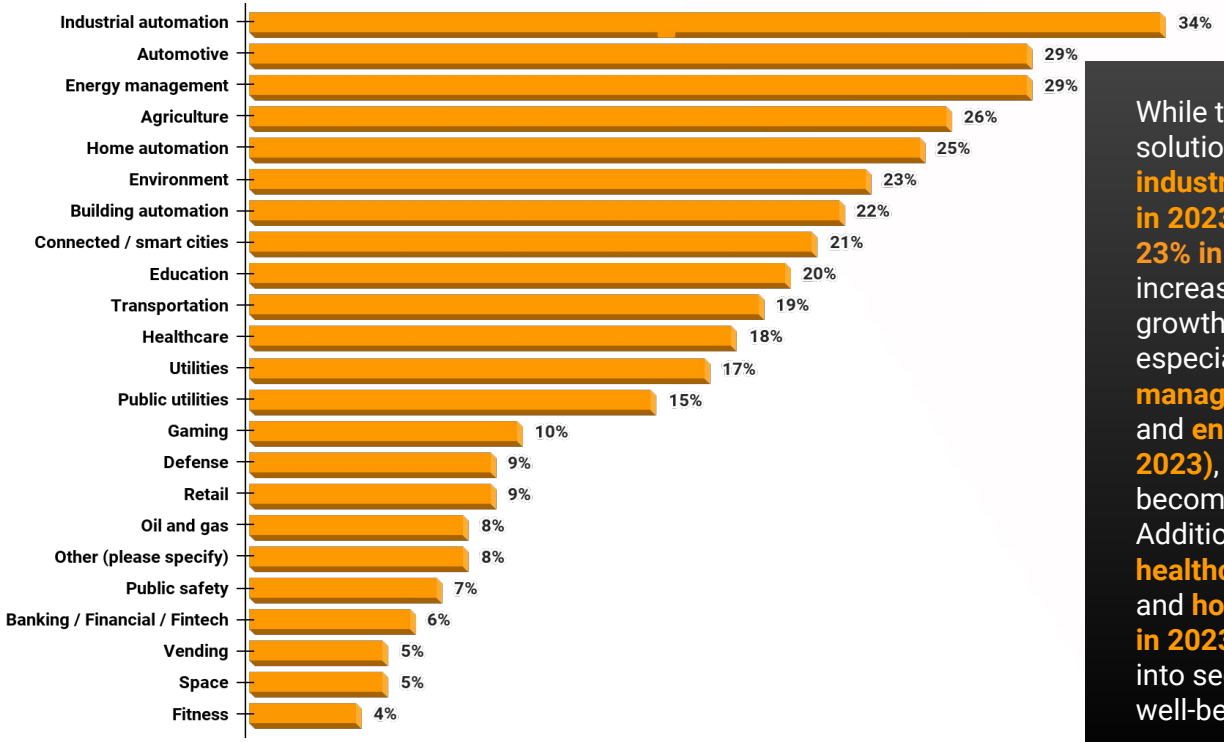
- **IIoT Protocol Trends Show Growth in MQTT and Emerging Technologies: MQTT (56%)** continues as the most widely adopted IIoT communication protocol, up **7% from 2023**, demonstrating its scalability and reliability. **Emerging protocols**, such as **Eclipse Zenoh**, have gained traction, rising to **4.29% (from 1.79%)**, signaling developer interest in **innovative communication technologies**.

- **Open Source Technology Adoption and Engagement Surge**: Open source technology remains integral, with **75% of developers actively using these technologies in 2024**, up from **63% in 2023**. Additionally, **24% of developers now serve as committers**, illustrating a growing commitment to **transparent and collaborative development models**.

- **The regional distribution** in 2024 aligns closely with 2023's data, confirming continued strong engagement from Asia-Pacific and Europe. This consistent geographic representation highlights the ongoing global nature of IoT and embedded development.

- **Evolving Demographics:** A strong presence of experienced developers, with **29%** having over 10 years of experience and **26%** with 5-10 years. New talent is also rising, with **27%** having 0-2 years of experience, while mid-level developers (2-5 years) have declined to **13%**.

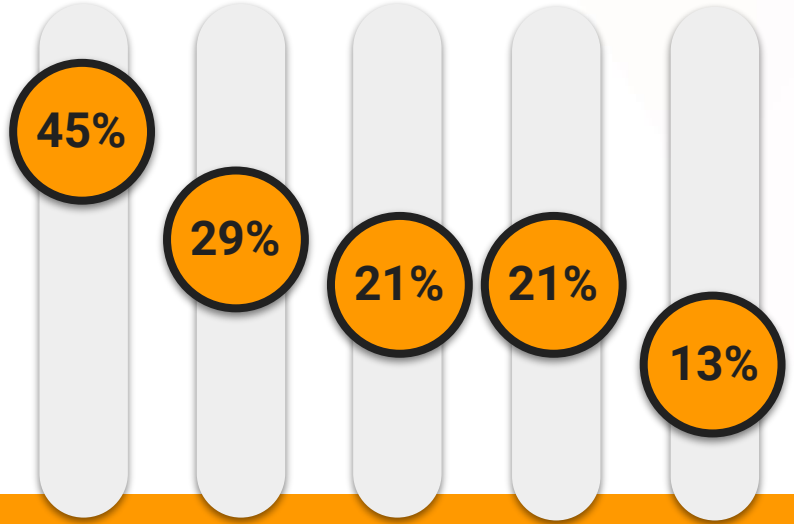
Development Is Increasing Across All Segments



Q: For which industry or industries are you building IoT solutions? (Select all that apply)

While the two top market segments for solution development continue to be **industrial automation (34%, up from 33% in 2023)** and **automotive (29%, up from 23% in 2023)**, developers indicate increased activity in several areas. The growth of IoT and edge solutions is especially noticeable in **energy management (29%, up from 24% in 2023)** and **environment (23%, up from 18% in 2023)**, as sustainability and efficiency become more critical to developers. Additionally, the rising focus on **healthcare (18%, up from 12% in 2023)** and **home automation (25%, up from 21% in 2023)** highlights the expansion of IoT into sectors tied closely to personal well-being and smart living.

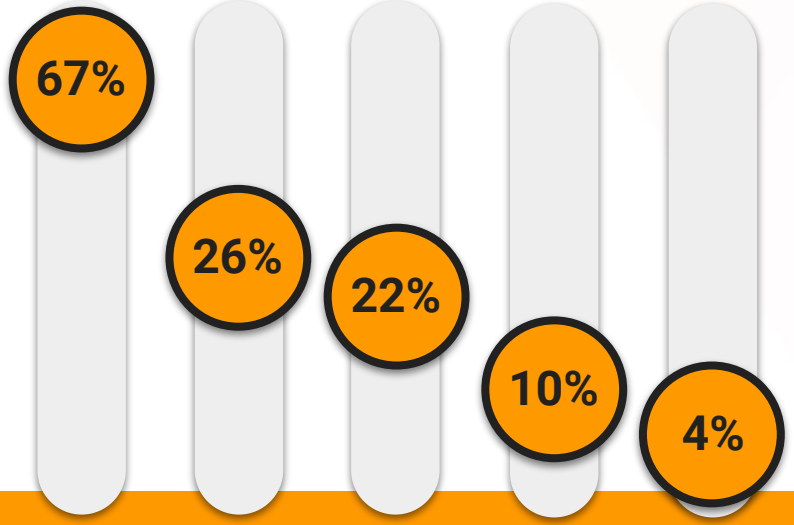
Developer Embedded OS Preferences on Constrained Devices



Linux (45%), and **FreeRTOS (29%)** are the top embedded OS choices for constrained devices. The introduction of **Eclipse ThreadX (Azure RTOS)**, with **13%,** further shows that developers are exploring new RTOS options that offer a balance between performance and ease of integration, particularly for IoT and safety-critical applications.

Q: Which embedded operating system(s) do you use for your constrained devices? (select up to three)

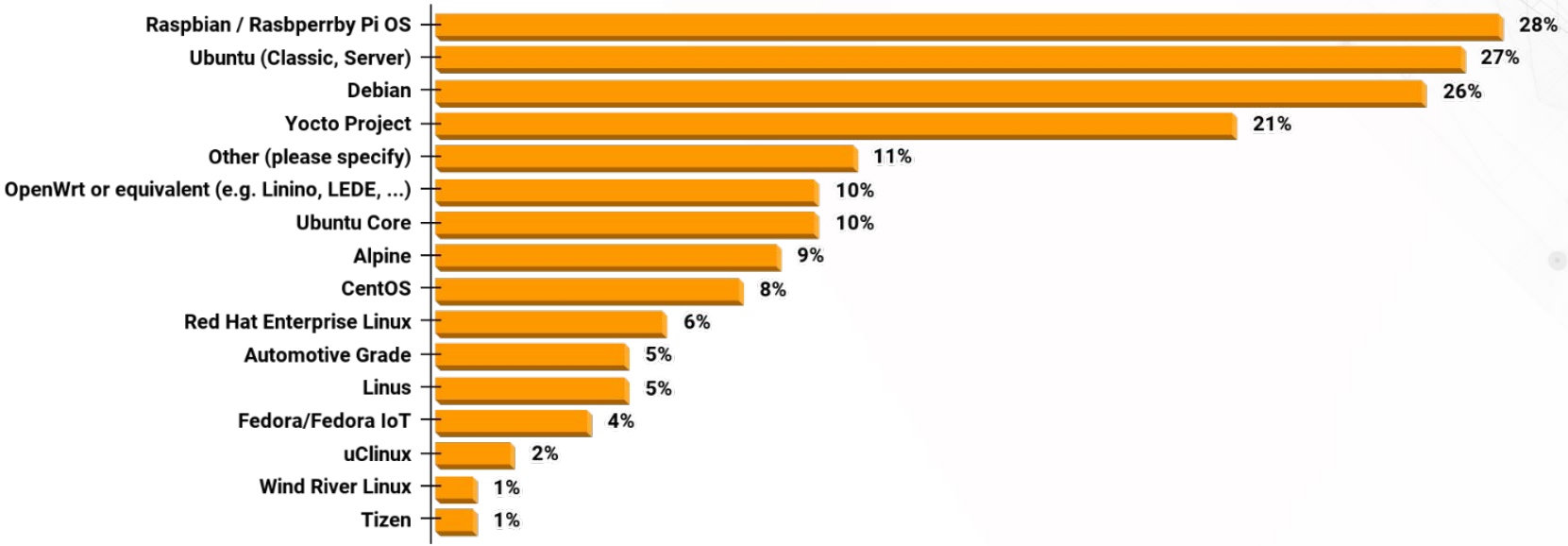
Developer OS Preferences on IoT Gateways & Edge Nodes



Linux (67%, up from 58%), **Windows** (26%, down from 29%), and **Android** (22%, down from 25%) lead as the top OS choices for IoT gateways and edge nodes, with **No OS/Bare-metal** solutions rising to 10% (up from 7%). **Azure Sphere** dropped to 4%, falling out of the top four.

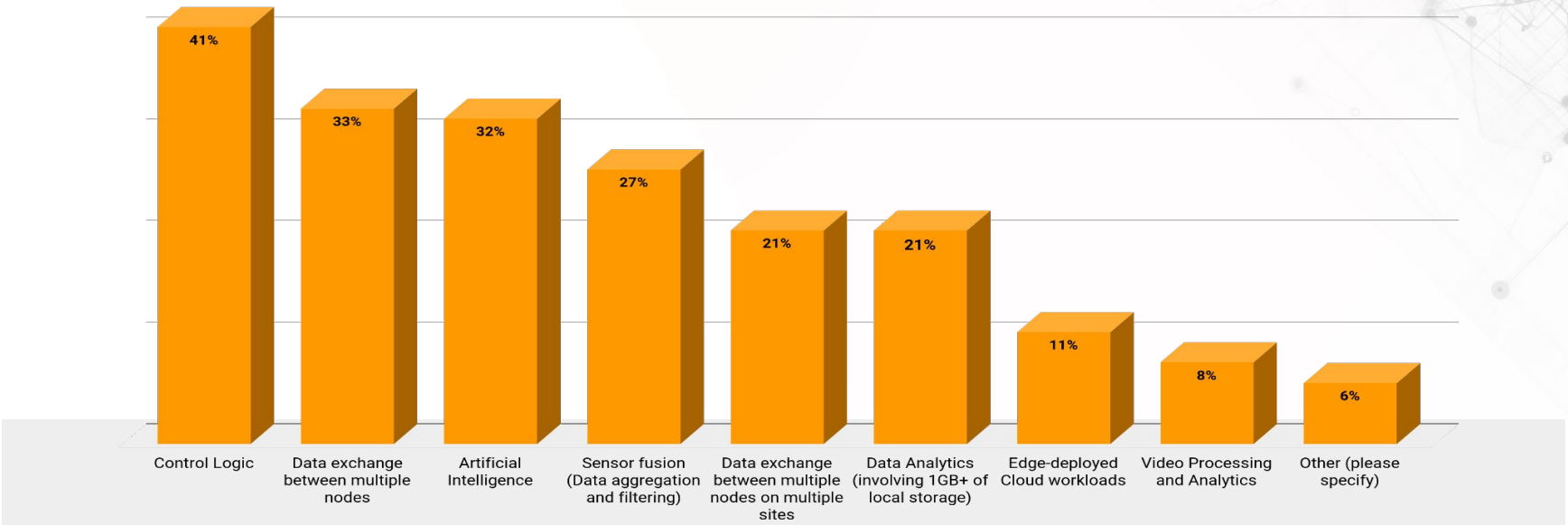
Q: Which operating system(s) do you use for your IoT gateways & edge nodes? (select up to three)

Developers Work With a Broad Range of Linux Distributions



Q: If using Linux for your IoT solutions, what distribution do you typically employ? (Select up to three)

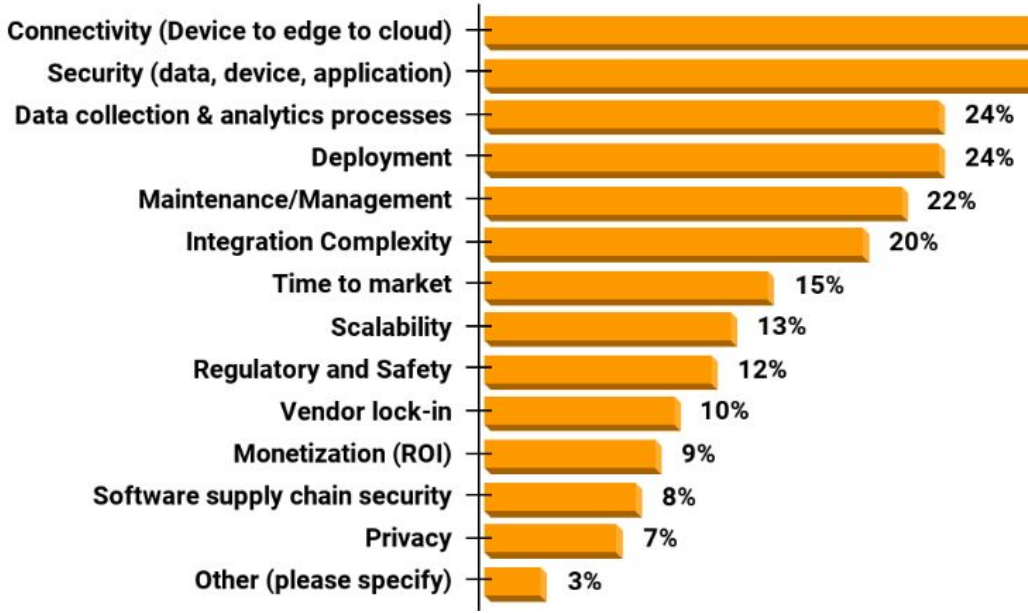
Control Logic Surpasses AI as Most Common Edge Workload



Control Logic remains the top edge computing workload, with **41%** (up from 40% in 2023). **Data exchange between multiple nodes** saw a significant increase to **33%** (up from 25%), while **Artificial Intelligence** slightly decreased to **32%** (from 37%).

Q: If your IoT solution leverages edge gateways and/or edge nodes, what types of edge computing workloads are you running? (Select up to three)

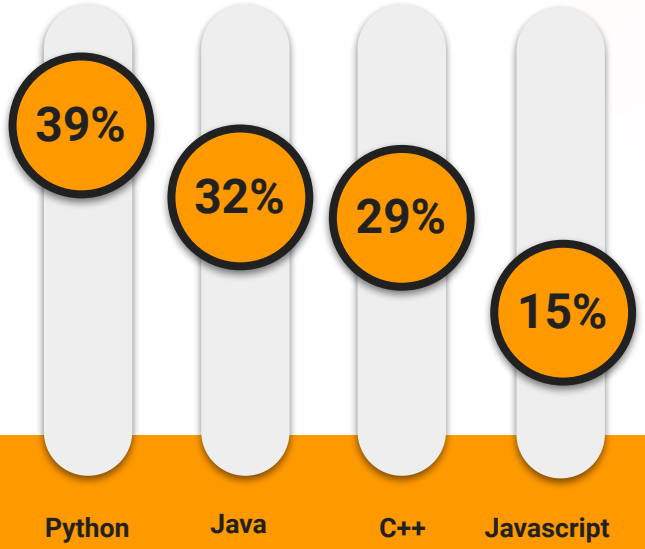
Connectivity Continues To Be the Top Developer Concern



Connectivity (48%, down from 52%) remains the top concern for IoT and edge developers in 2024. **Security (35%, up from 33%)** has further solidified its position as the second-most important issue. **Data collection & analytics processes (24%)** and **deployment (24%)** continue to be key concerns, though connectivity still dominates.

Q: What are your primary IoT development concerns? (Select up to 3)

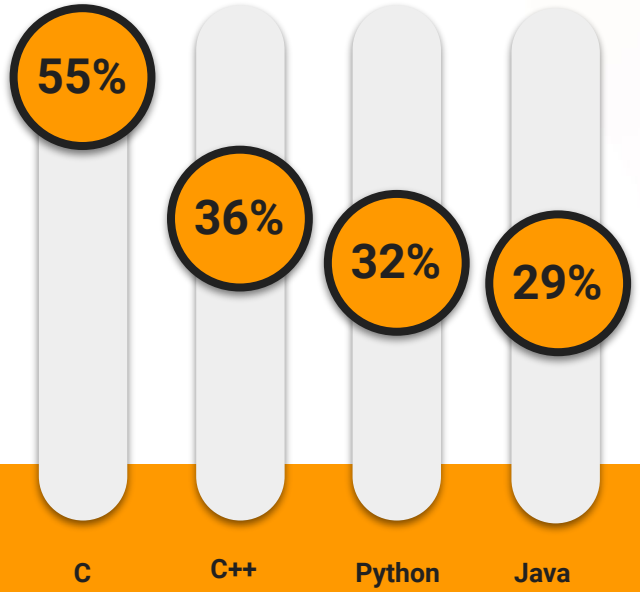
Developer Language Preferences on IoT Gateways & Edge Nodes



Python is the preferred development language for IoT Gateways and Edge Nodes with **39%**. Followed by **Java** at **32%**, **C++** at **29%** and **Javascript** at **15%**.

Q: Which of the following programming languages do you use to build on IoT Gateways & Edge Nodes? (Select up to three)

Developer Language Preferences on Constrained Devices

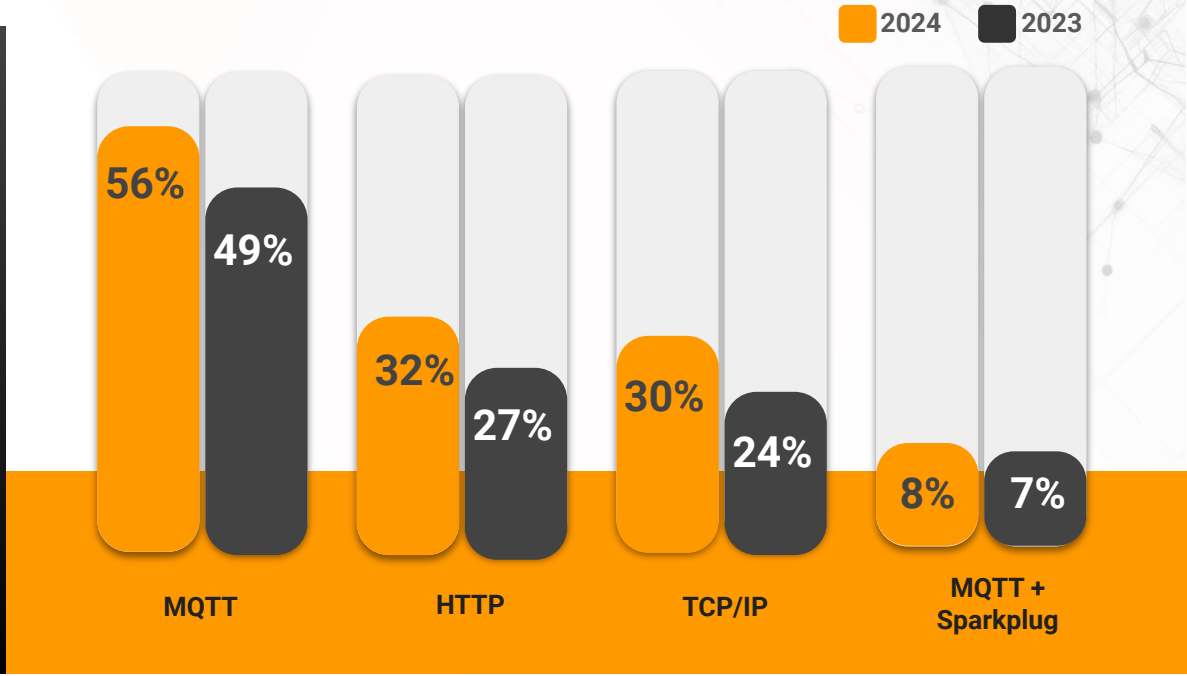


C (55%), **C++ (36%)**, **Python(32%)**, and **Java(29%)** are the programming languages of choice for development on constrained devices. **Rust** continues its gradual rise.

Q: Which of the following programming languages do you use to build on constrained devices? (Select up to three)

MQTT's Continued Leadership in IIoT Communication Protocols

- More than half (56%) indicate that **MQTT** is their preferred IIoT communication protocol. A **7%** growth from 2023
- **HTTP/HTTPS and TCP/IP** usage increased by **(+5%)** and **(+6%)** compared to 2023
- **MQTT + Sparkplug** checked in at **8%.**
- Newer protocols like **Eclipse Zenoh** gained ground, rising to **4.29%** (up from **1.79%**), indicating growing interest in emerging technologies.



Q: What communication protocol(s) do you use? (Select up to three)

5G Propels Cellular to the Top Connectivity Option

Cellular (LTE, 4G, 5G, etc)
59%

WiFi
46%

Ethernet
45%

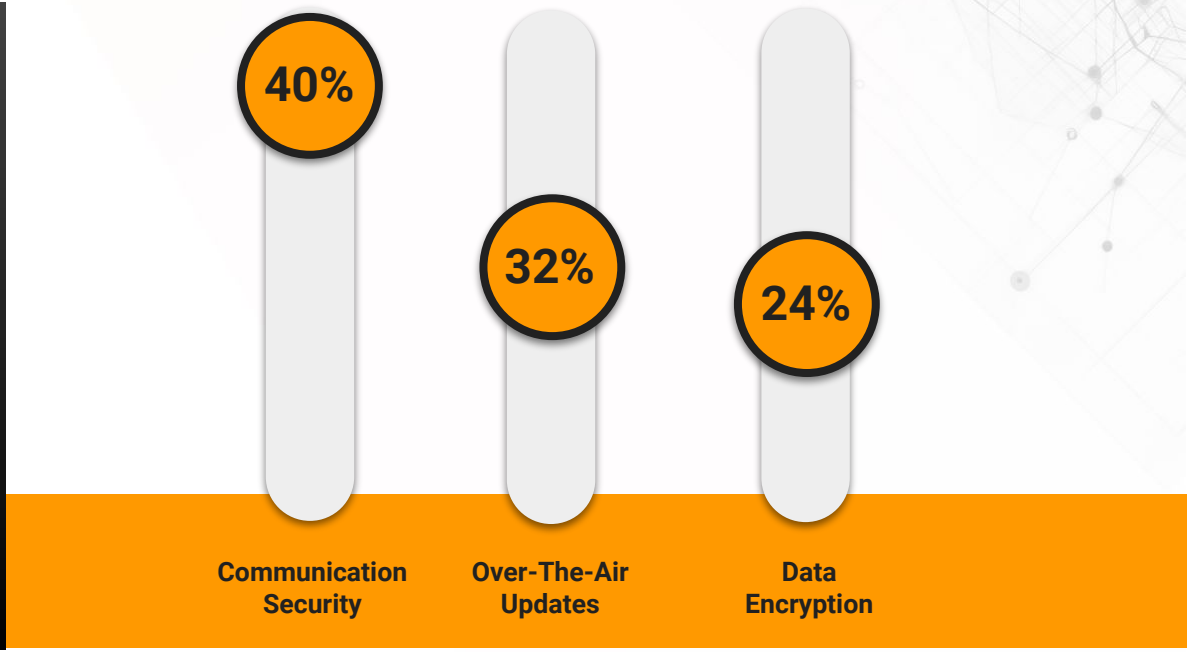
Bluetooth/Bluetooth Smart
31%

Top connectivity technologies being used are **cellular** at 59% (44% in 2023), **WiFi** at 46% (38% in 2023), **Ethernet** at 45% (38% in 2023) and **Bluetooth/Bluetooth Smart** at 31% (23% in 2023).

Q: What connectivity protocol(s) do you use? (Select up to three)

Most Favored Security Technologies for IoT/Edge Solutions

Communication security (40%) remains the top security technology, seeing a slight increase from 39% in 2023. **Over-the-air updates** surged to **32%**, up from 24%, making it the second most popular choice. **Data encryption** remains stable at **24%** (up slightly from 23%).

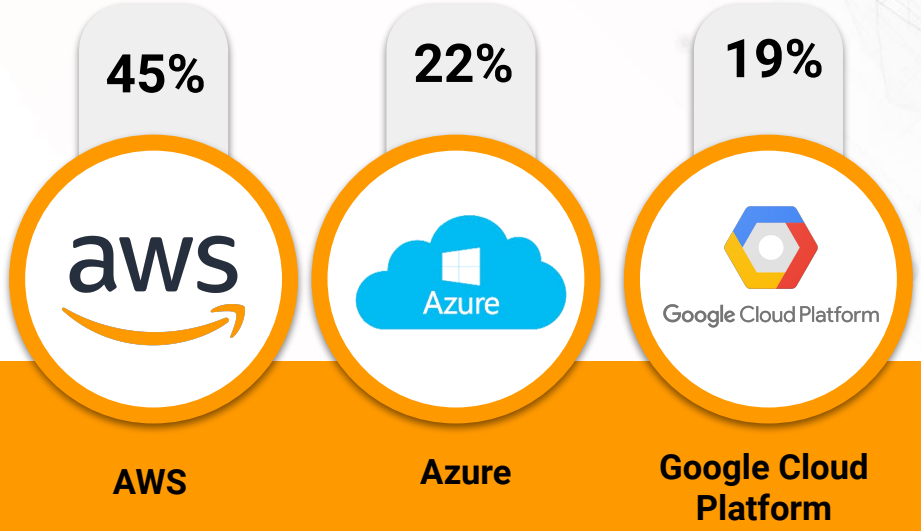


Q: Which security-related technologies do you use on your IoT/edge solutions: (Select up to three)

Status Quo for IoT Cloud Platforms

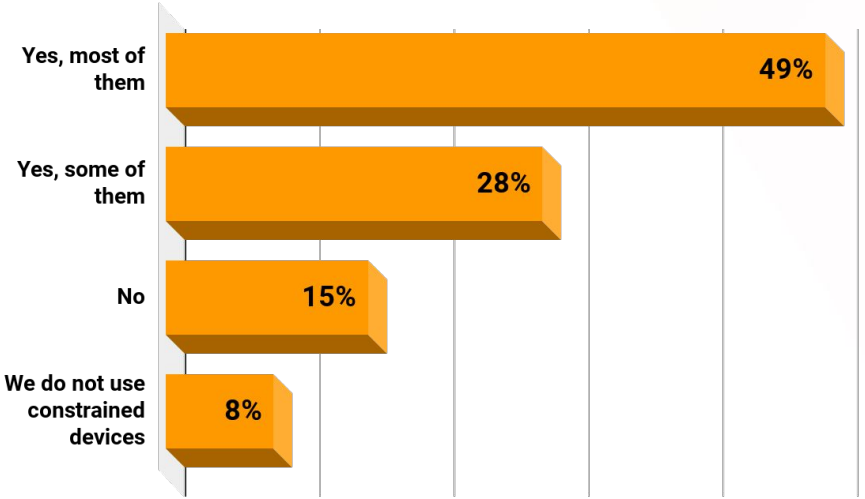
Amazon AWS continues to lead, increasing to **45.00%** (up from **41%** in 2023). **Google Cloud Platform** saw a slight decline to **19%** (from **20%**), while **Microsoft Azure** dropped to **22%** (from **27%**).

Other Private / On-premises cloud saw a sharp increase to **16%** (up from **7%**), indicating growing interest in private cloud solutions. **Red Hat OpenShift** usage also grew to **6%** (from **4%**).



Q: Do you use any of the following platforms as part of your IoT solution? (Select up to three)

Adoption of Real-Time Operating Systems in Constrained Devices

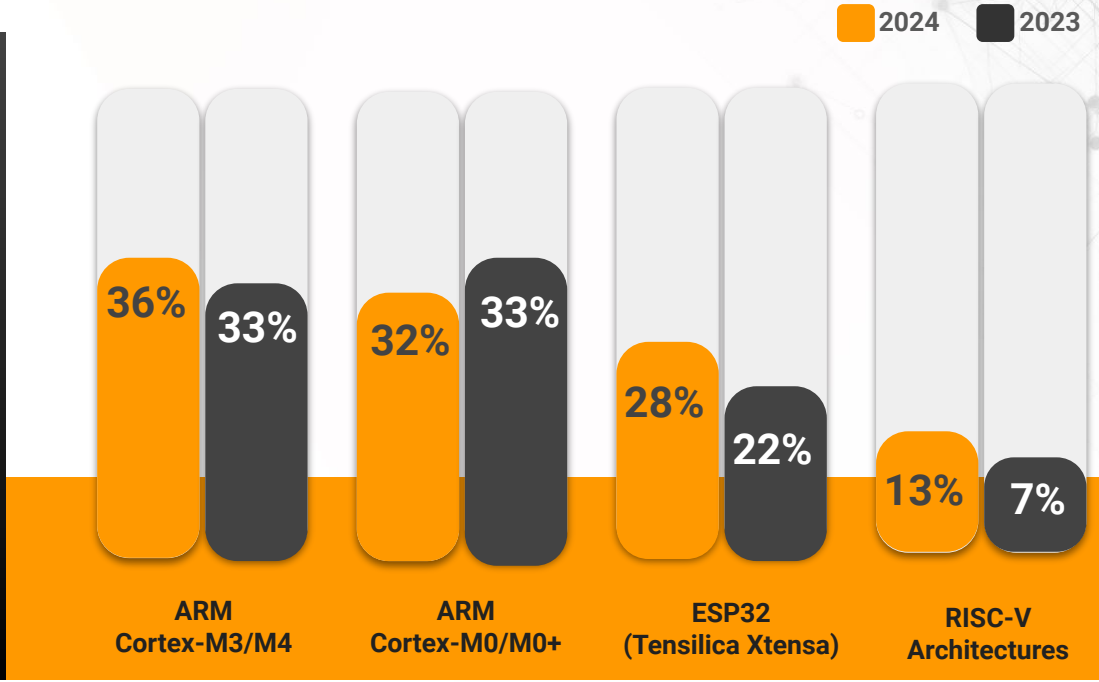


Nearly half **(49%)** of respondents indicating most of their devices rely on RTOS for real-time capabilities, essential in many IoT applications. Additionally, **28%** report partial RTOS adoption, using it only where specific devices need real-time performance. This suggests a strong demand for immediate, predictable responses in IoT operations.

Q: If your solution leverages constrained devices, do those devices use a real-time operating system or not?

Hardware Architecture Usage for Constrained Devices

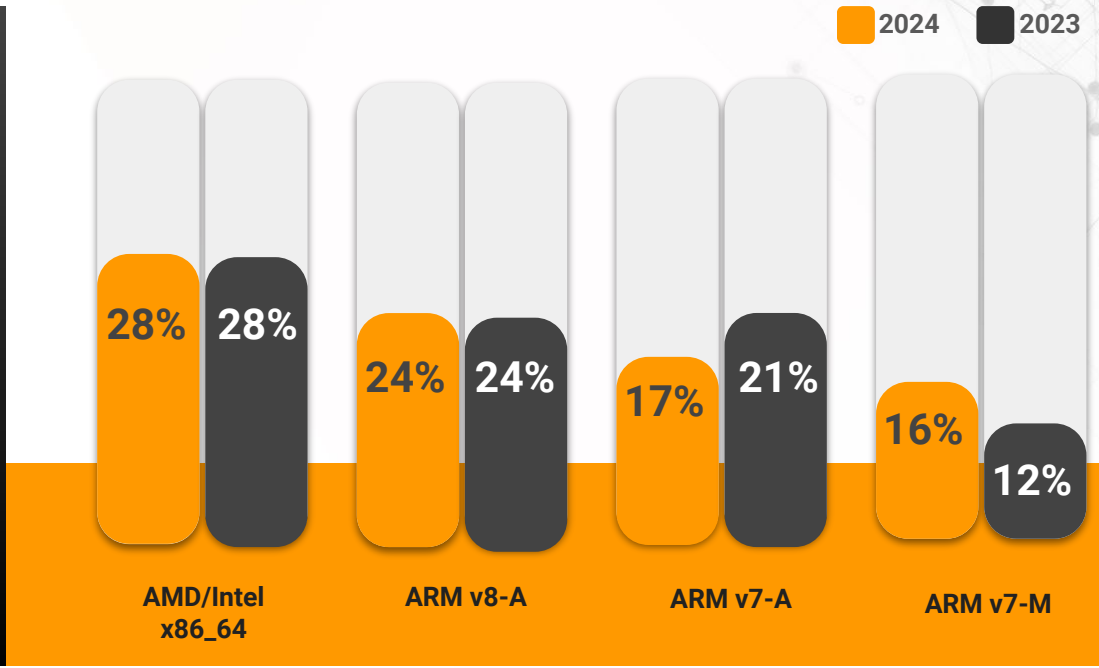
In 2024, **ARM Cortex-M3/M4** leads MCU usage at **36%** (up from 33%), with **ARM Cortex-M0/M0+** close behind at **32%. ESP32 (Tensilica Xtensa)** rose to **28%** (from 22%), while **RISC-V architectures** saw significant growth to **13%** (from 7%). **ARM Cortex-M7** usage dropped to **18%,** and **ARM Cortex-R** appeared with **12%**, highlighting real-time applications. MIPS and ARM Cortex-M85 declined slightly.



Q: What hardware architecture(s) do you use for Constrained Devices? (Select up to three)

Hardware Architecture Usage for IoT Gateways and Edge Nodes

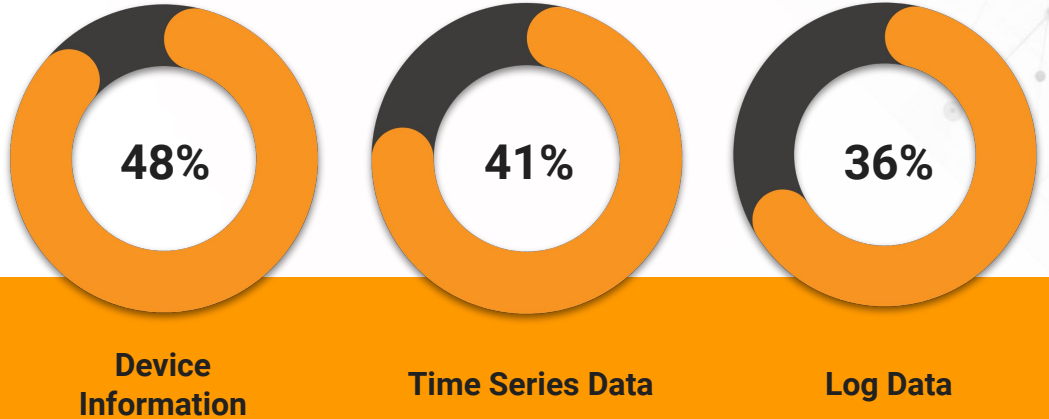
AMD/Intel x86_64 remains the leader at **28%**, with **ARM v8-A** maintaining a second palace at **24%**. **ARM v7-A** declined to **17%**, and **ARM v6** dropped significantly to **10%(From 19% in 2023)**. **ARM v7-M** grew to **16%**, showing increased interest in **Cortex-M solutions**. **RISC-V** adoption also rose to **8%.**



Q: What hardware architecture(s) do you use for IoT Gateways & Edge Nodes? (Select up to three)

Types of Data Being Stored from IoT/Edge Solutions

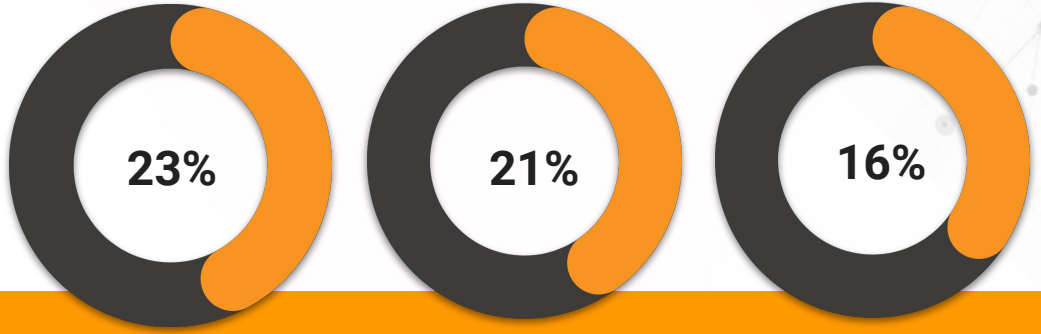
The most common types of IoT data being gathered and stored are **Device information (48%)** (up from **44%** in 2023), followed by **Time series data**, which saw an increase to **41.07%** (up from **36%**). **Log data** also rose to **36%** (up from **29%**).



Q: What type of IoT data/information do you store either in a database or data store? (Select up to three)

The Role of Security Certifications in IoT Adoption

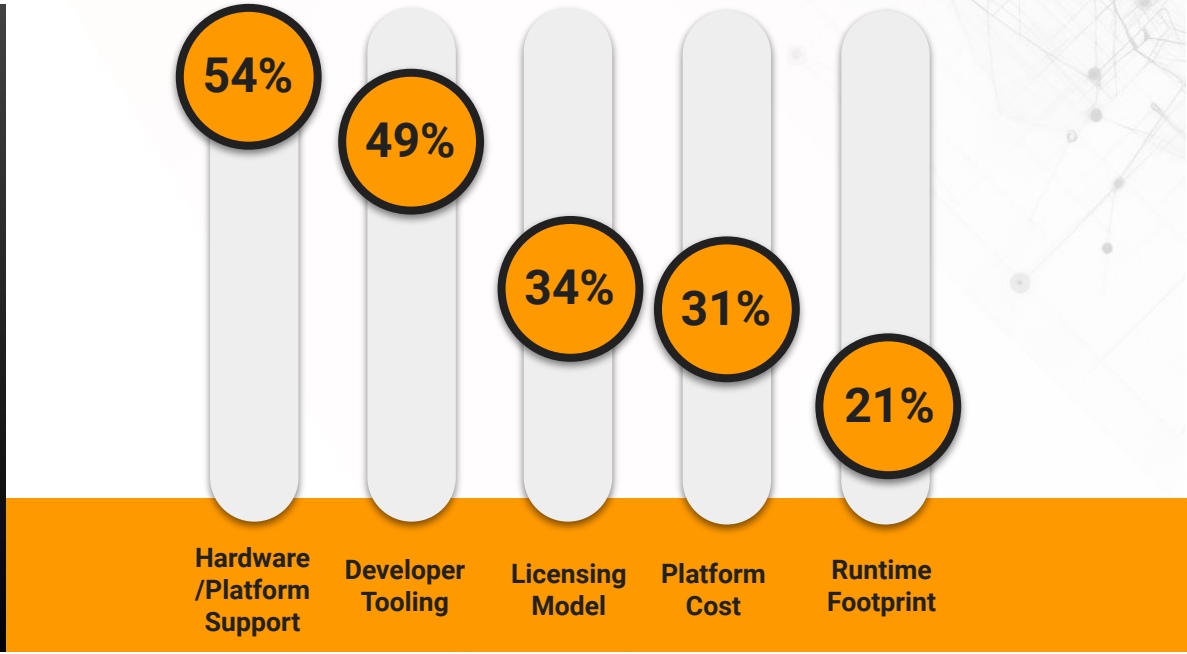
69% percent of respondents reported that security certifications positively impact their IoT product adoption and purchase decisions. Among valued certifications, **Common Criteria (EAL)** was the most influential at **23%**, followed by **PSA (any level) at 21%** and **FIPS 140-2 at 16%. SESIP (9%)** had the least impact. This indicates that certifications are a critical factor for most users in their decision-making process.



Q: Some IoT products and solutions possess security certifications. Which of the following security certifications would positively influence your adoption or purchasing decisions? (Select up to three)

Key Criteria for Selecting Real-Time Operating Systems in Constrained Devices

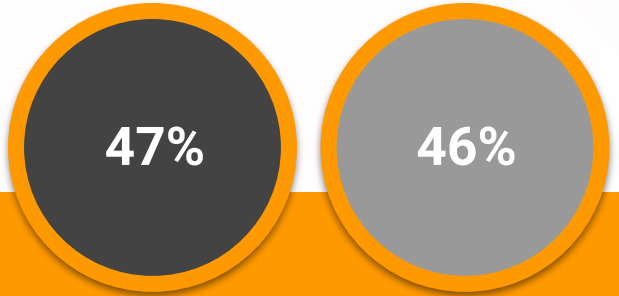
The top factors in choosing an RTOS for constrained devices are **hardware/platform support (54%)** and **developer tooling (49%)**, emphasising compatibility and ease of development. **Licensing model (34%)** and platform cost **(31%)** are also key, with **runtime footprint (21%)** highlighting the need for lightweight solutions.



Q: If some or most of your constrained devices run a real-time operating system, which of the following criteria influenced your decision? (Select up to three)

Importance of Certification for Safety

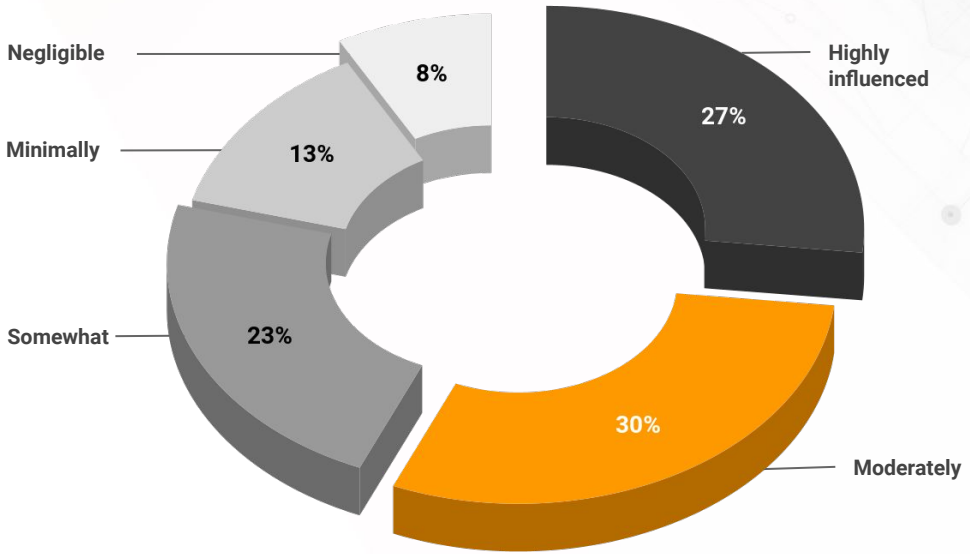
With **47%** of respondents prioritising safety certifications, **IEC 61508 (24%)** and **ISO 26262 (ASIL) (21%)** are the most relevant, reflecting their broad industry impact. **IEC 62304** (16%) and **EN 50128 (SIL) (14%)** are also notable, underscoring the importance of safety in medical and rail applications. **UL 603xx / 607xx (8%)** remains more niche, focused on appliance safety. This highlights a growing commitment to certified safety standards in IoT and embedded sectors.



Q: Certification for safety critical use cases is increasingly important in the embedded and IoT markets. Which of the following international standards is relevant to your organisation from a safety certification perspective? (Select up to three)

Impact of End-User App Design on IoT Solutions

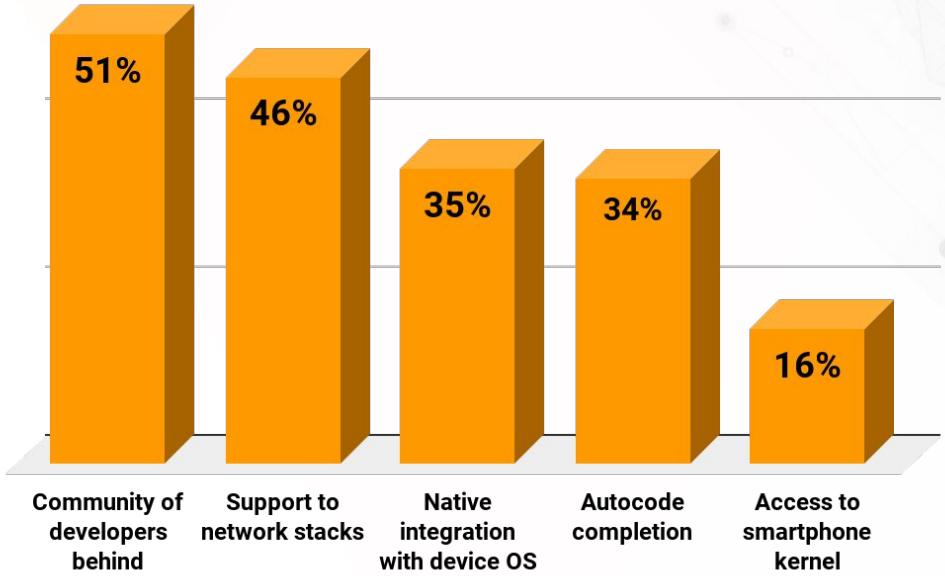
App design significantly impacts **IoT solutions**, with **27%** of respondents citing a strong influence, **30%** noting moderate influence, and **23%** reporting a slight influence, highlighting the importance of app design in shaping IoT solutions.



Q: How much influence does the design of the end user app have on your IoT solution?

Top Criteria for Choosing Development Framework

When choosing an app development framework, **developers prioritise a strong community (51%)** and **network stack support (46%)**, reflecting the importance of collaboration and reliable connectivity. **Native OS integration** is also important for **35%**, while **Autocode completion (34%)** and **smartphone kernel access (16%)** are less critical but valued by some.



Q: Which are the two most important elements in the selection of an app development framework for building your end user app?

Recommendations

- **Expand Security Focus**: With communication security and over-the-air updates being top concerns, prioritise these areas to enhance device protection and enable secure remote management.
- **Promote RTOS Innovation and Adoption**: The rising adoption of Zephyr and ThreadX reflects increasing interest in performance-driven and safety-critical solutions. Companies should evaluate and promote these RTOS options to align with specific use cases, balancing performance, safety, and cost considerations..
- **Lead With Sustainability Solutions**: Focusing on energy-efficient designs and partnerships in energy, healthcare, and environmental sectors to address the growing demand for sustainability-focused IoT applications that enhance quality of life.
- **Leverage Emerging Hardware Architectures**: With increased interest in ESP32 and RISC-V, invest in compatible development and testing frameworks to optimise for these architectures.
- **Build Strong Development Communities**: As a top framework selection factor, support robust developer communities to enhance collaboration and leverage collective expertise across projects.
- **Focus on Lightweight Protocols**: MQTT remains the dominant IIoT communication protocol, so companies should standardise and explore advanced options like Sparkplug for seamless IIoT communications.

Methodology and Demographics

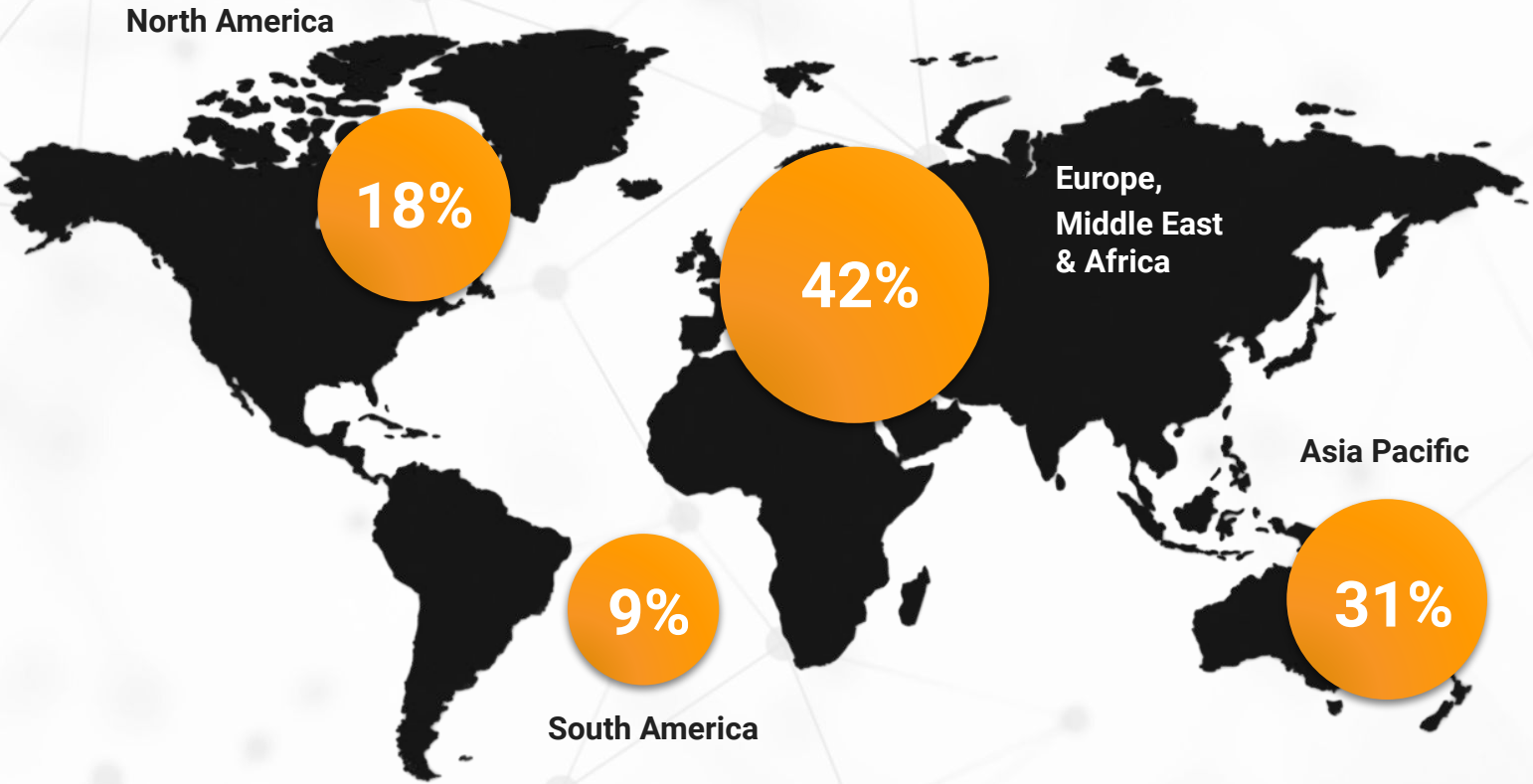
Methodology

Sponsored by the Eclipse IoT, Eclipse Sparkplug, Oniro Working Group, and Eclipse ThreadX, the 2024 IoT & Embedded Developer Survey was conducted from May 15 to July 31 2024. The survey garnered participation through social media channels, the Eclipse Foundation websites, and the enthusiastic support of our valued members and partners.

A total of 747 respondents, comprising developers, committers, architects, and decision makers, participated in the survey. These participants work in diverse industries worldwide.

Among the respondents, 75% identified as open source users, with 24% actively contributing to open source projects (23% in 2003).

In Which Region Are You Located?



Which Best Describes Your Role?

38%
Developer

11%
CTO or VP of engineering

12%
Engineering/R&D Management

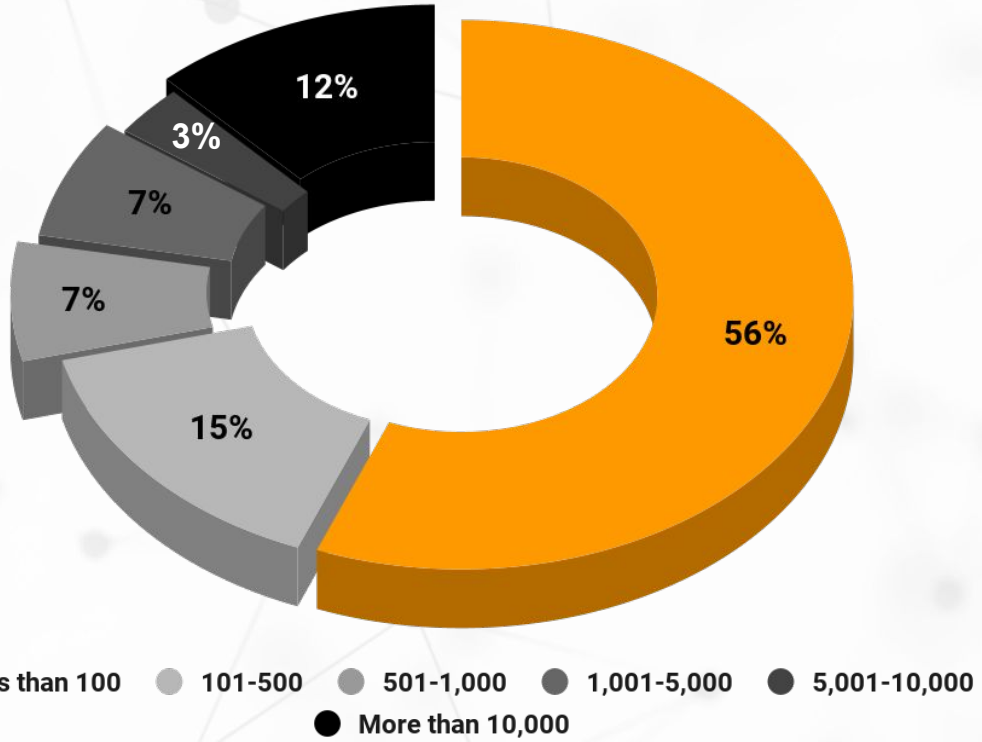
14%
Other

8%
IT Management

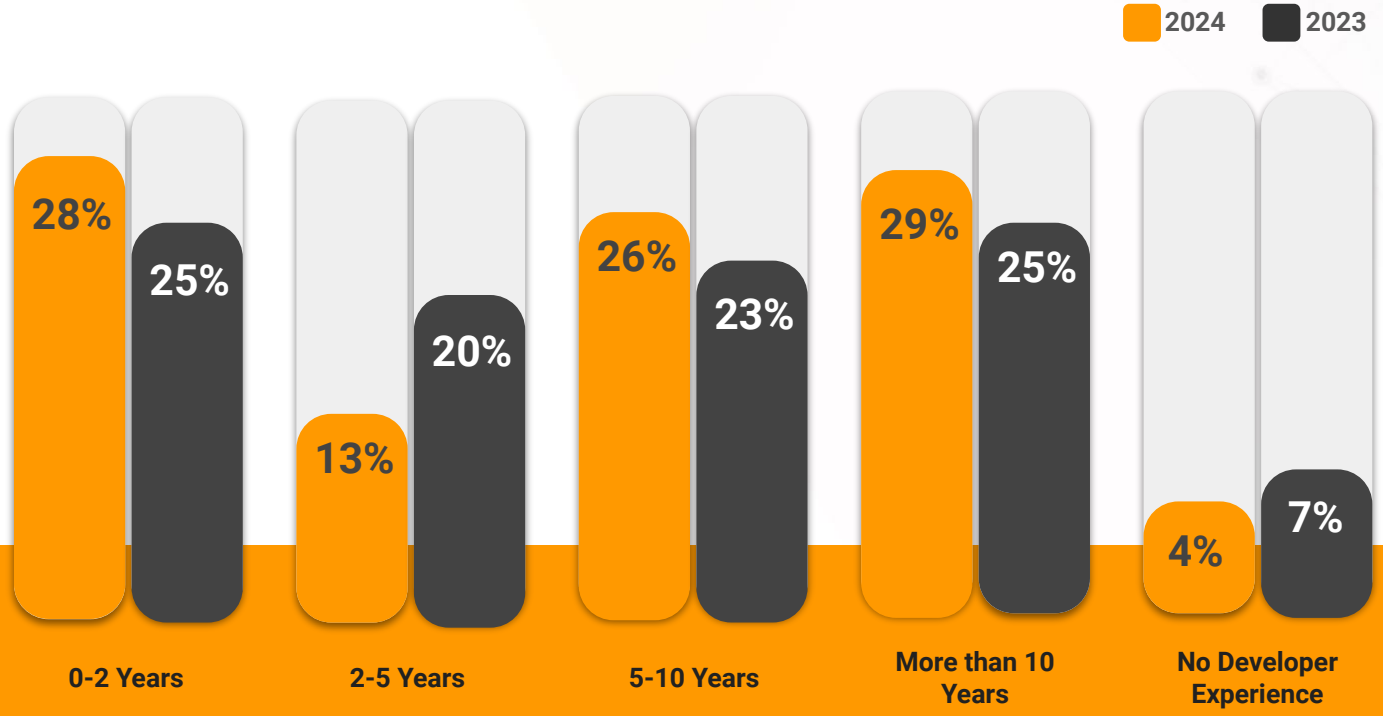
9%
Engineer/R&D (Hardware)

7%
Product Manager

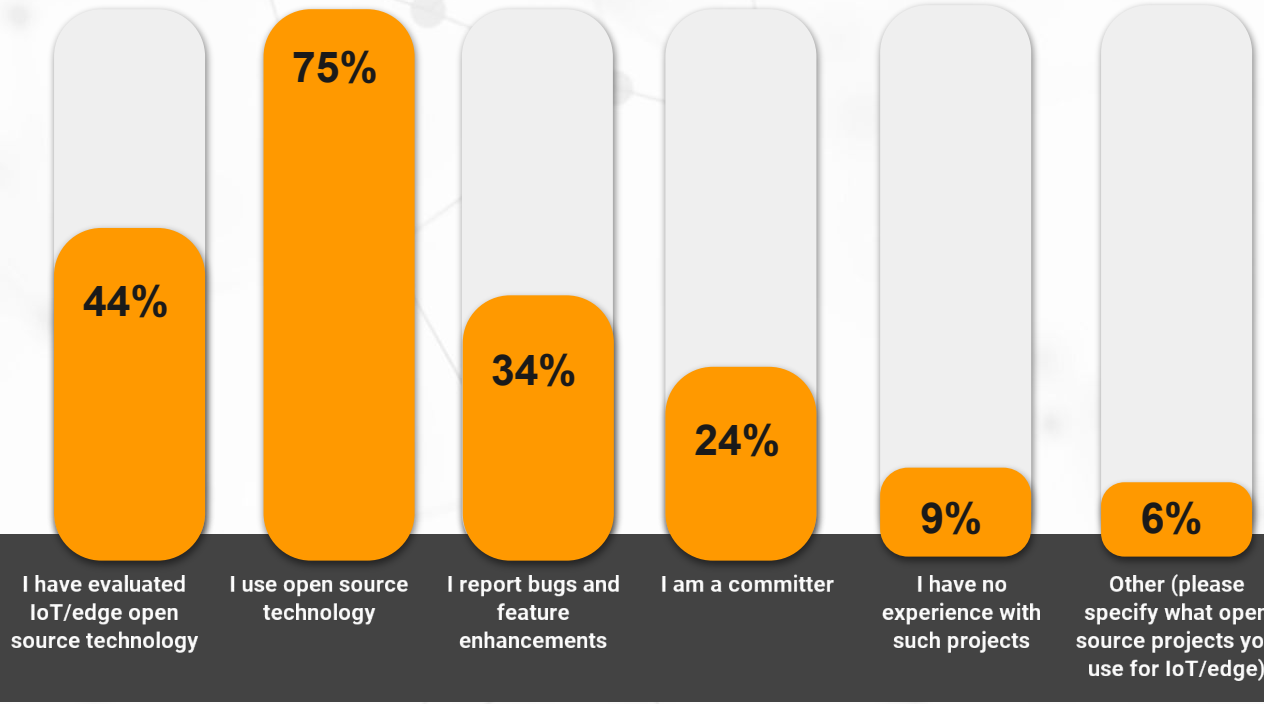
How Large is the Organisation You Work For?



How Much Experience Do You Have Developing IoT/Edge Solutions?



Open Source IoT/Edge Project Participation



Q: Which statement(s) best describes your IoT/edge open source project participation? (Select up to three)

Thank You!

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