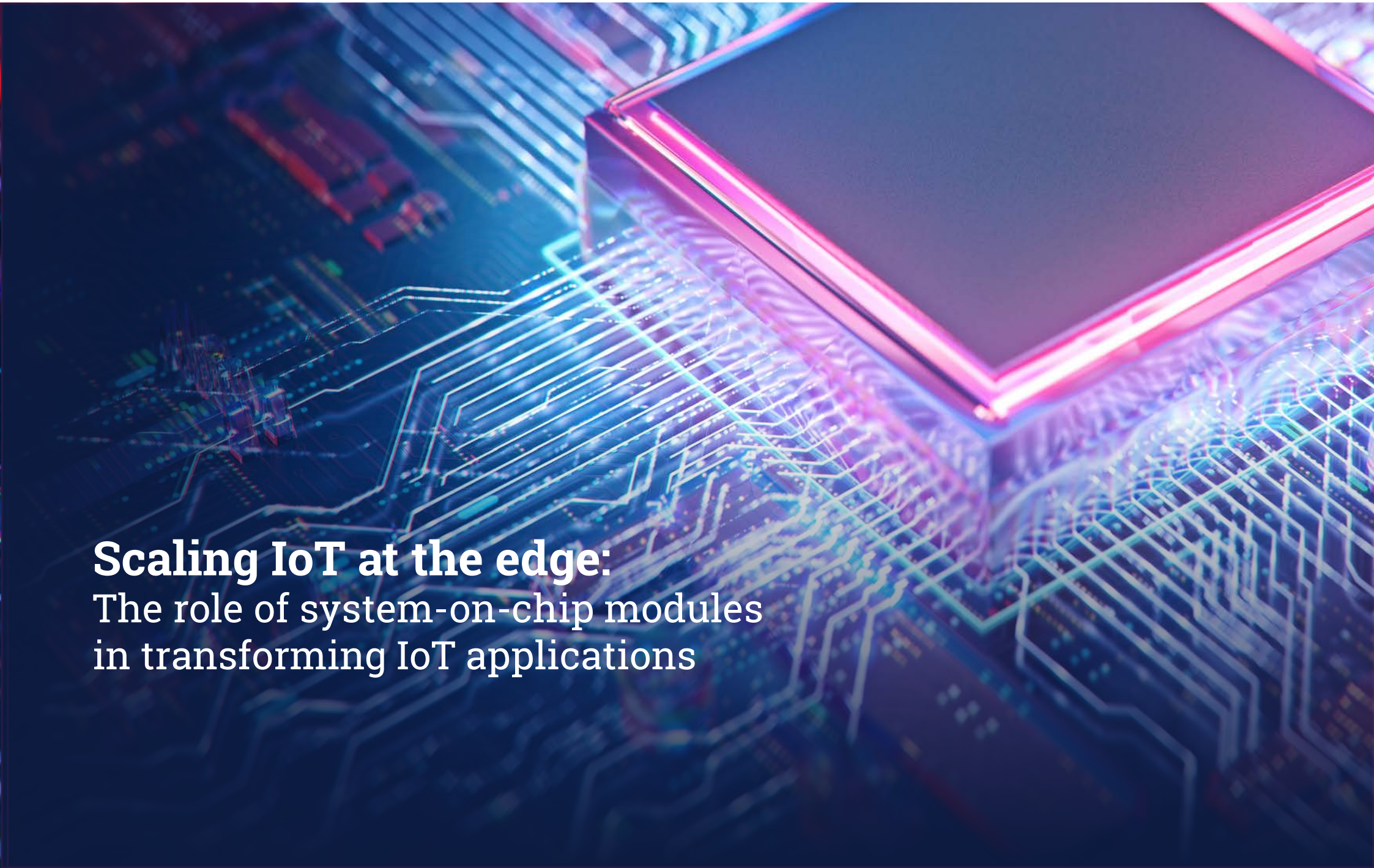
IOT ANALYTICS

SEMTECH



Scaling IoT at the edge:

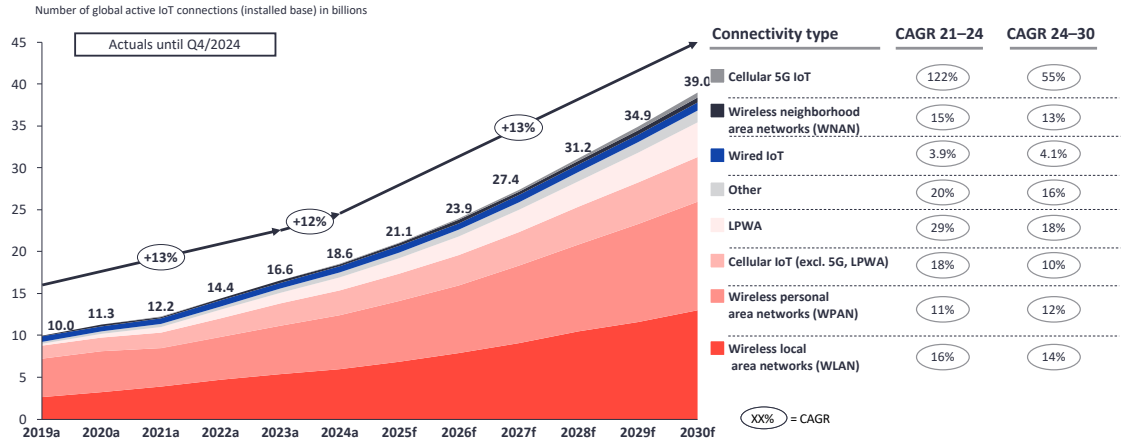
The role of system-on-chip modules in transforming IoT applications

Introduction:
The rise in cellular IoT and SoC modules

Cellular IoT connections are expected to outpace overall IoT connections through to 2030. By the end of 2024, the number of connected IoT devices reached 18.6 billion, a 12% increase YoY. Global cellular IoT connections accounted for 22% of these overall IoT connections, reaching 4.1 billion by the end of 2024, a 16% increase YoY. By the end of 2030, these connected IoT devices are projected to grow at a 13% CAGR, surpassing 39 billion. Cellular IoT connections are projected to grow at a 14% CAGR, reaching 9.1 billion by 2030.

Global IoT market forecast (in B of connected IoT devices)

The number of global active IoT connections grew by 12% to 18.6 billion in 2024.



Note: IoT connections do not include any computers, laptops, fixed phones, cell phones, or consumer tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology (e.g., RFID or NFC) is not considered. Wired includes ethernet and field buses (e.g., connected industrial PLCs or I/O modules); Cellular includes 2G, 3G, 4G, 5G; 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, such as Wi-SUN; Other includes satellite and unclassified proprietary networks with any range.
Source: IoT Analytics Research 2025

Source: Transforma Insights, 2025

Cellular IoT module shipments continued a strong rebound in 1H 2025, growing 20% year-over-year (YoY). Every connected device that utilizes a cellular IoT connection employs either a cellular IoT module or a cellular IoT chipset embedded directly into the device's printed circuit board. In September 2025, IoT Analytics updated its Global Cellular IoT Module and Chipset Market Tracker & Forecast, a quarterly in-depth analysis of the revenues and shipment volumes of companies supplying cellular IoT modules and chipsets. According to the latest data, shipments of cellular IoT modules grew by 23% YoY and are forecast to grow at a 15% CAGR between 2025 and 2030, reaching $14.1B in revenue.

Aiding these growths are two trends: 1) the continued deployments of LTE Cat 1 bis, LPWA, and 5G technologies and 2) system-on-chip (SoC)-based cellular IoT modules enabling edge computing.

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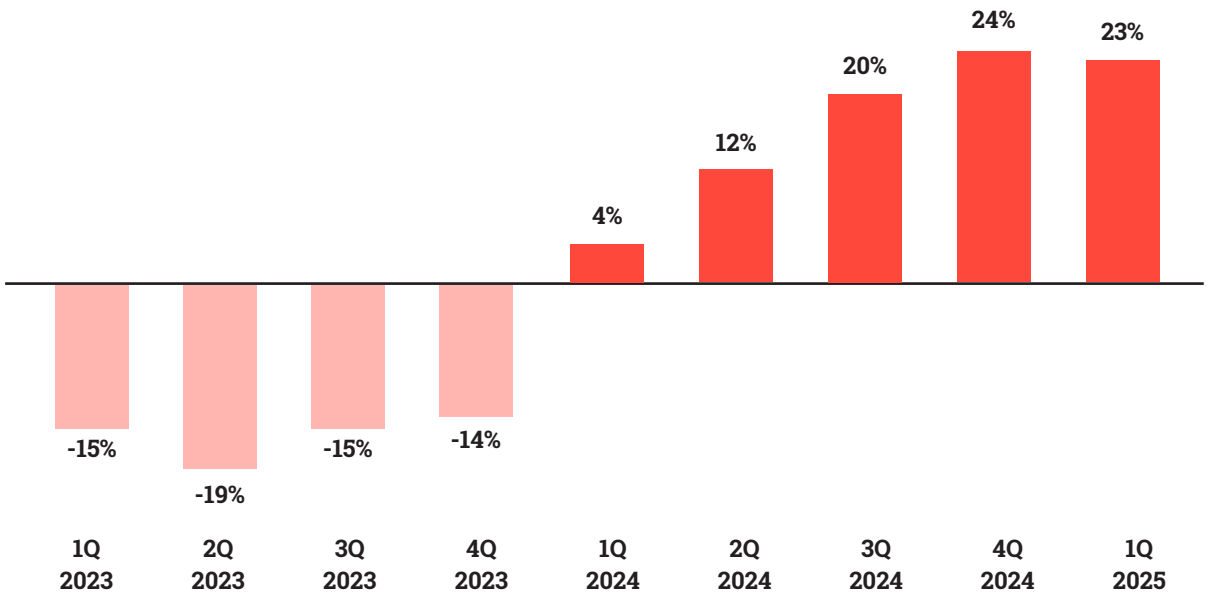
Market growth
Global cellular IoT module shipments growth (YoY) in %



Source: Transforma Insights, 2025

Trend 1:
Cat 1 bis drives volume, 5G drives revenue, and Redcaps unlocks the mid-tier

Cellular market growth is driven by Cat-1 bis for volume and 5G for revenue, with 5G RedCap emerging.

Cat-1 bis sets the baseline

Cat-1 bis gains traction in cost-sensitive IoT. Cat-1 bis has emerged as a cost-effective global alternative to Cat-1 modules. Its single-antenna design simplifies integration and certification, while mature VoLTE capabilities reduce testing and power consumption. Shipments of Cat-1 bis modules grew 75% YoY in 1H 2025, with adoption strongest in tracking, logistics, metering, and POS systems.

5G is the revenue engine

5G modules gain ground in industrial use. 5G module revenue rose 26% YoY in 1H 2025, driven by fixed wireless access (FWA), automotive C-V2X, and industrial routers. Private 5G deployments—especially in China's factories, ports, and mines—are validating reliability and QoS at scale, anchoring new industrial use cases.

RedCap fills the middle

RedCap bridges gap between LTE and full 5G. 5G RedCap targets mid-tier devices, such as cameras, wearables, and industrial telemetry. By simplifying the 5G modem and reducing power consumption, it offers higher uplink speeds than LTE Cat-1 or Cat-4 without the full complexity of 5G. The first Global Certification Forum (GCF)-ready modules and operator trials began in 2024 and 2025, with eRedCap expected to follow.

Trend 2:
SoC modules enable edge computing at the module level

From connectivity to compute

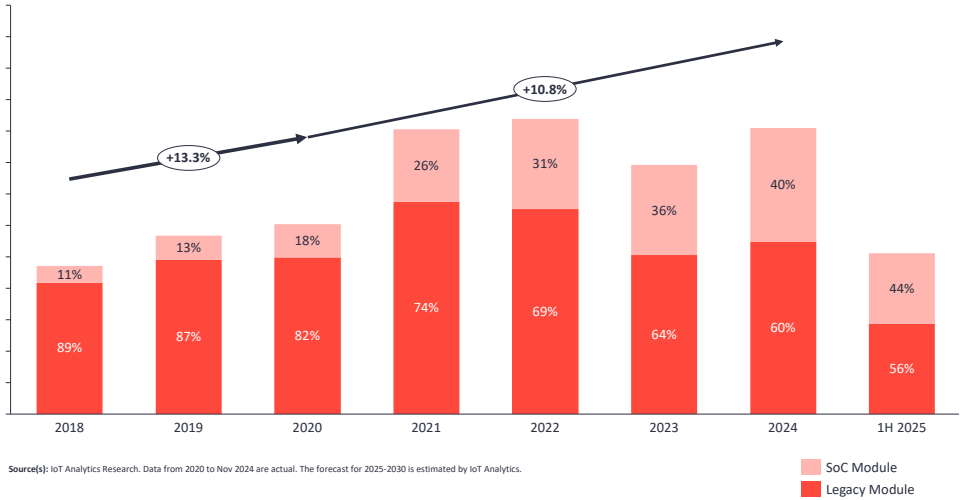
As cellular IoT evolved from 2G and 3G to LTE and 5G, device workloads increased dramatically. Data throughput rose from kilobits to gigabits per second, and applications expanded beyond basic telemetry to include multimedia processing, touch-based HMIs, and edge AI workloads such as computer vision and real-time inference. Traditional modem-only architectures could not keep pace with these demands. They required OEMs to pair the modem with an external application processor, route high-speed interconnects, manage multiple power domains, and maintain separate software stacks. This increased the bill of materials, power consumption, and integration effort, slowing development cycles and raising overall system costs.

Chipset vendors such as Qualcomm, MediaTek, and UNISOC addressed these limitations by creating SoC modules. A SoC module (also referred to as a SoC-based module) combines a cellular modem and an application-class processor in one package, running a general-purpose (often Linux-based) OS, such as Ubuntu, Android, or OpenWRT, and eliminating the need for an external processor. This integration reduces board size, simplifies certification, and accelerates time-to-market for use cases like POS terminals, kiosks, and smart cameras.

With connectivity now a given, the next evolution centers on intelligence at the edge. As SoC-based modules combine communication and computation on a single platform, this enables devices to analyze data and perform AI inference locally, reducing latency, minimizing network load, and paving the way for smarter, more autonomous IoT systems.

Global SoC-based cellular IoT module Shipment Penetration in %

Global cellular IoT module shipment: SoC-based module vs Legacy module



Source(s): IoT Analytics Research. Data from 2020 to Nov 2024 are actual. The forecast for 2025-2030 is estimated by IoT Analytics.

Source: Transforma Insights, 2025

SoC-based cellular IoT modules grew 35% YoY in 1H 2025, reaching 45% market penetration (up from 11% in 2018). Their built-in compute capabilities—CPUs, GPUs, and AI accelerators in some variants—enable data pre-processing, UI rendering, and real-time analytics directly on the device, reducing latency and cloud dependence.

Technology foundations and adoption drivers of SoC-based smart modules

Smart module architecture and key features

Integration of connectivity and compute
SoC modules combine the modem and application processor on a single silicon die, eliminating the need for an external host CPU. This consolidation reduces component count, lowers latency, simplifies thermal design, and minimizes certification effort.

Example:

Embedded OS support (Linux/Android/ OpenWRT)
SoC modules run full OSs such as Linux, Android, or OpenWRT directly on the module, allowing developers to deploy applications without writing low-level firmware. This approach simplifies software development and shortens time-to-market.

Example:

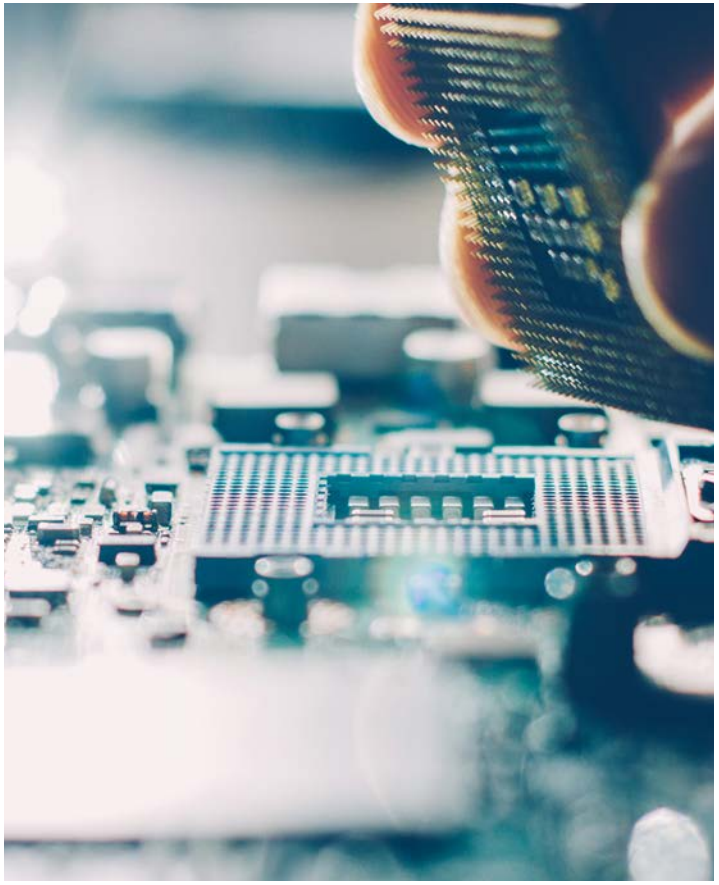
A cellular mobile broadband module (based on Qualcomm SDX8x) runs OpenWRT on a quad-core A55 applications processor. The WWAN SDK that integrators previously had to include and code to in their own separate applications processor is pre-integrated and tested within the OpenWRT environment on the module's application processor.

Unified memory and power domain
By sharing RAM, flash, and power rails within the module, SoC designs reduce interconnect complexity and improve efficiency.

Simplified architecture
A single SoC module replaces multiple chips, such as CPU, modem, Wi-Fi, GPS, or NFC. This reduces the number of board layers, eliminates interconnects, and simplifies both integration and certification processes.

Ready-to-deploy software environment
SoC modules ship with preloaded OS images, SDKs, and drivers for common peripherals. This enables software teams to start development immediately, without the need for extensive platform setup or hardware abstraction.

SoC modules combine the modem and application processor on a single silicon die, eliminating the need for an external host CPU



Adoption drivers

As noted, SoC-based cellular IoT module shipments grew 35% in 1H 2025 and reached 45% market penetration for cellular IoT modules in general. Three factors are driving this market performance: 1) edge intelligence and local data processing, 2) system complexity and integration challenges, and 3) cost optimization and total cost of ownership (TCO) considerations.

1. Edge intelligence and local data processing

IoT is shifting from a connectivity-only model to one that includes real-time computing. As connections scale, many deployments now require not just data transport but local decision-making at the edge. Edge computing brings processing closer to the data source, reducing latency and reliance on the cloud. By embedding compute capabilities directly into the SoC, edge systems can respond instantly to events in industrial, automotive, and critical monitoring environments.

2. System complexity and integration challenges

SoC modules cut IoT integration complexity. Legacy IoT architectures often rely on multiple discrete components, such as separate processors, modems, power management, security, and sensor interfaces. This creates integration complexity across hardware, software, power sequencing, and timing. It also increases the effort required for validation, certification, and long-term maintenance. Discrete designs add risk across drivers, OS bring-up, and validation. SoC modules reduce this by shipping with pre-integrated stacks and a single build flow. Teams start from a working image instead of assembling parts, which reduces design complexity and shortens system integration time.

> **Example:**
>
> *"This pre-integration eliminates the complexity of assembling discrete components. Customers previously had to integrate and go through all the interface integration between a host processor and the modem, while in SoC Modules, that's already done for you. The SoC development starts with access to a GitHub repository, where integrators can download a complete environment for building their own OpenWRT Linux image for the module's applications processor."*
> **Dave Dixon**, Product Manager at Semtech

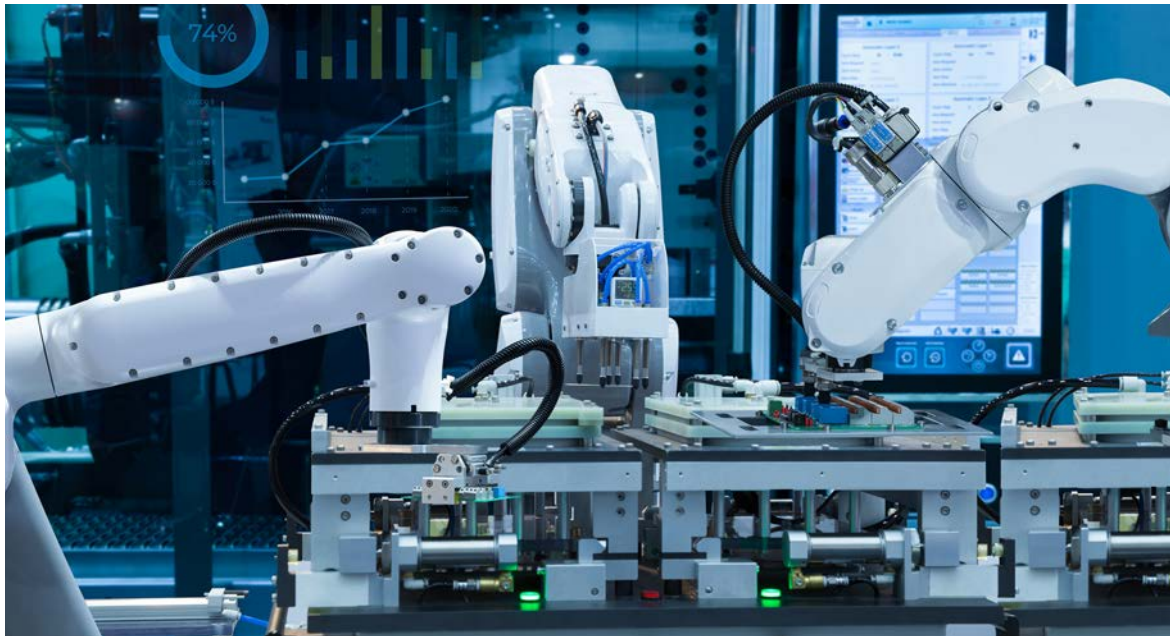
3. Cost optimization and TCO considerations

SoC modules lower ownership costs despite tradeoffs. Reducing the total cost of ownership is one of the strongest drivers for the adoption of SoC-based smart modules. By integrating the modem and application processor into a single silicon package, SoC modules remove an additional piece of hardware and simplify board design. Fewer components mean lower bill of materials (BOM) cost, shorter certification cycles, and less engineering time. Procurement and lifecycle management also improve because the entire system comes from one supplier. Only one module, one software stack, and one certification process need to be maintained. This lowers project risk and reduces ongoing support costs. Simpler design and procurement come at a tradeoff. However, since the application processor is embedded in the SoC, customers cannot freely choose from a family of CPUs. The module defines the available compute performance, which limits flexibility but significantly reduces cost and time to deployment.

Example:

"We're working to reduce the bill of materials, decreasing the total cost of ownership. We can speed up customers' time to market because everything is already pre-integrated into the SoC itself. The chipsets already include the processor. Adding a separate processor that adds cost is unnecessary in a many cases."

Dave Dixon, Product Manager at Semtech



Types of SoC modules

The integration of the modem and application processor has remade the IoT module landscape into three main categories: 1) LTE, 2) LPWA (NB-IoT/LTE-M), and 3) 5G/RedCap. Each class serves distinct performance and power needs while sharing the same SoC foundation—integrated connectivity, compute, and power management in a single package.

LTE SoC modules (Cat-4 and above)

LTE smart modules enable integrated multimedia computing. LTE smart modules target mid-range IoT devices such as POS terminals, handhelds, and telematics units that require responsive user interfaces and multimedia processing. These modules combine a multi-core applications processor, GPU, and LTE modem within a single SoC, enabling Android or Linux to run natively and eliminating the need for an external host CPU.

> **Example:**
>
> *Semtech's WP76xx LTE modules based on Qualcomm's chipsets integrate a 1.3 GHz Cortex-A7 processor with 256MB Flash/128MB RAM and LTE modem with multiple GNSS systems. Running embedded Yocto Linux with secure boot, they enable IoT developers to build Linux-based products on a single module, ideal for IoT applications such as public safety, industrial gateways, transportation and mission-critical networking applications.*

NB-IoT/LTE-M SoC modules (LPWA)

LPWA SoCs optimize size and battery efficiency. LPWA SoC modules focus on ultra-low-power operation and compact design for applications like smart meters, city sensors, and asset trackers. They integrate the modem, MCU, and power management into a single chip, reducing PCB size and extending battery life in power-saving and extended discontinuous reception modes.

> **Example:**
>
> *The Semtech HL7900, powered by the Sony ALT1350 5G LPWA chipset exemplifies next-generation SoC adoption with its OpenMCU architecture. The SoC integrates an ARM Cortex-M4 processor running at 130MHz with FreeRTOS, LTE Cat-M1/NB2 modem, power amplifier, iSIM, Secure Element and short-range radio (900 MHz & 2.4GHz) on a single die, allowing metering and control applications to run directly on-chip without an external host MCU. With 1.3MB NVM and 768KB RAM plus support for external PSRAM and NOR Flash, it eliminates the need for multiple discrete components including GNSS, wireless MCU, SIM, TPM, and application processors. Its industry-leading PSM standby current of 1µA and eDRX current below 10µA enable up to 4x the battery life compared to previous generation modules, supporting device longevity into the 2040s. The module supports 3GPP releases 14-17, enabling future-proof deployment with Release 17 support for LPWA over satellite. Certified across major North American and international operators, it demonstrates how advanced SoC-based LPWA modules with edge processing capabilities deliver cost optimization, reduced board size, and long-term reliability in utility and industrial IoT environments.*

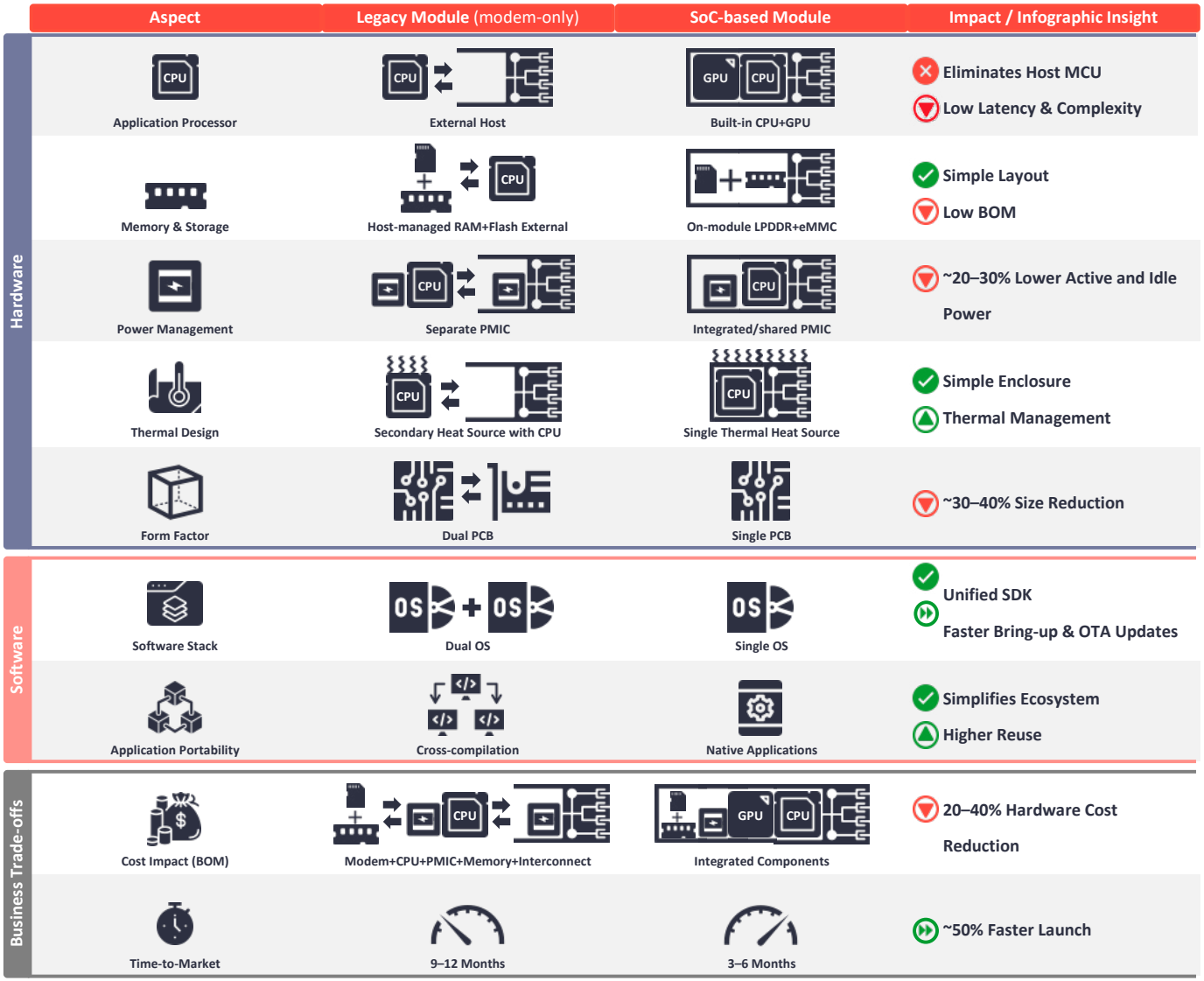
5G & 5G RedCap SoC modules

5G and RedCap SoCs scale IoT performance. 5G SoC modules deliver high performance for robotics, smart cameras, and connected vehicles, while RedCap variants serve cost- and power-optimized use cases. Both integrate CPUs, GPUs, and NPUs within the modem, achieving multi-gigabit throughput and on-device AI processing for real-time edge intelligence. RedCap reduces bandwidth and antenna count to balance performance and efficiency.

Comparison: Legacy modules vs. SoC modules

Legacy modules relied on discrete processors and modems, resulting in higher integration effort, power consumption, and latency. SoC-based modules consolidate these components, reducing bill of materials, board size, and certification complexity while enabling on-module computing, intelligence, and faster deployment. Figure 4 outlines the key differences.

A design evolution: Legacy modules vs. SoC-based Modules



Source: Transforma Insights, 2025

Use cases and applications for SoC modules

SoC-based modules are enabling diverse IoT applications across industries by merging communication, compute, and power management in compact designs. Their local processing capabilities reduce cloud dependence and latency, allowing faster decisions and lower operating costs.

Utilities: Smart grid and remote infrastructure management

Utilities embed edge analytics for grid efficiency. Utilities are increasingly using SoC-based modules to enhance grid visibility and operational efficiency. Smart meters, monitoring units, and control nodes process metering data and anomalies locally before transmission, reducing bandwidth usage and server reliance. On-device analytics also support faster load balancing and outage recovery, improving grid reliability. By embedding edge processing directly in field equipment, utilities achieve lower latency, reduced maintenance cycles, and improved reliability across large distributed networks.

Smart cities: Connected street lighting

Edge-enabled lighting cuts energy and service costs. Street lighting networks are evolving into intelligent, connected systems that adjust dynamically to conditions. SoC-based LPWA modules allow each controller to manage sensing, communication, and diagnostics locally. This enables adaptive dimming, predictive maintenance, and reliable operation even during network disruptions.

> **Example:**
>
> *The Semtech HL7900 (based on Sony Altair's ALT1350 SoC) combines MCU, modem, and power management for ultra-low-power operation and secure local processing, ideal for large-scale lighting and municipal IoT deployments.*

Networking: Routers and gateways for primary or backup connectivity

SoC modules streamline enterprise router design. Routers and industrial gateways rely on high-speed, always-on connectivity. SoC-based LTE and 5G modules integrate the modem and multi-core processor in one package, allowing router OSs such as Linux or OpenWRT to run natively on the module. This reduces PCB complexity, BOM, and certification time while enabling advanced functions like VPN, content filtering, and remote management directly on the module.

Edge AI: Robotics and autonomous equipment

5G SoC modules boost robotic autonomy. Industrial robots and autonomous systems require low latency and local decision-making to operate safely in dynamic environments. Legacy designs utilized separate CPUs or cloud servers for image processing and control, resulting in increased latency and power consumption. 5G SoC modules, however, integrate CPU, GPU, and NPU capabilities, enabling on-device vision processing, motion control, and AI inference. By processing data locally, they reduce response times, network traffic, and privacy risks while increasing autonomy.

Case studies: Smart retail point-of-sale device integration

A Germany-based industrial and retail electronics manufacturer set out to modernize its next-generation point-of-sale (POS) terminals. The goal was to unify cellular, Wi-Fi, and Bluetooth connectivity within a compact, reliable, and globally deployable design.

Challenges

Initial designs used discrete CPU, modem, and Wi-Fi modules. Each required separate firmware, power domains, and interface validation, resulting in lengthy integration cycles and instability during testing. Multiple firmware stacks and complex PCB routing slowed development, diverting engineering effort from application innovation.

Solution

The company adopted a SoC-based cellular IoT module that combined modem, application processor, and wireless connectivity in a single package running a general-purpose OS. The pre-validated platform removed the need for an external host CPU and enabled faster, unified software development focused on the retail application layer.

Benefits

Development time reportedly fell by 65%, and hardware complexity was significantly reduced. The integrated architecture improved product stability and simplified certification, allowing engineers to focus on user experience and feature innovation rather than hardware debugging.

Conclusion and future directions

IoT is evolving towards edge and edge AI-driven automation and efficiency. The IoT industry is rapidly evolving from basic connectivity to intelligent, AI-driven automation, driven by advancements in 5G IoT, edge computing, and AI integration. The convergence of these technologies is reshaping industries such as telecom, automotive, utilities, and manufacturing, enabling real-time decision-making, resource optimization, and reduced cloud dependency.

Key findings and use case outcomes

SoC modules reshape connected device efficiency. SoC-based modules are redefining cellular IoT design by merging connectivity and compute within a single platform. Case studies show clear gains in cost efficiency, integration speed, and performance consistency. Across use cases, LPWA modules deliver multi-year battery life for utilities, LTE smart modules accelerate product development in retail, and 5G/RedCap modules enable real-time edge processing for networking and robotics. This shift from discrete to SoC-based architectures represents a significant improvement in the efficiency of building and deploying connected devices.

Supply chain considerations

Chipset suppliers dictate module innovation pace. The adoption of smart modules is closely tied to the availability of integrated SoCs from key chipset suppliers such as Qualcomm, MediaTek, UNISOC, and Sony. Module vendors rely on these upstream partners and differentiate mainly through software, SDKs, and form factor design. Supply or certification delays at the chipset level can directly impact product roadmaps, making ecosystem diversification essential for stability. This dynamic reinforces that the pace of innovation in SoC-based modules ultimately depends on the direction and capacity of leading silicon providers.

Trends toward edge AI modules

AI-integrated SoCs shift intelligence to the edge. The next stage of smart module evolution is the integration of AI processing within the SoC itself. Vendors are embedding NPUs and dedicated accelerators, enabling edge-AI functions such as vision analysis, anomaly detection, and predictive maintenance to run directly on the device. This reduces reliance on cloud computing, cuts latency, and improves data privacy. Between 2026 and 2028, AI-capable RedCap and 5G SoCs are expected to become standard, marking a shift in the IoT value chain as intelligence moves from the cloud to the module and ultimately to the edge.

> *"The next phase of SoC module adoption hinges on consistent OS and lifecycle support. Without that, industrial customers face rising maintenance costs and uncertain platform viability. As SoC-based modules take over edge IoT designs, the ecosystem must evolve beyond fragmented stacks. Vendors who offer unified SDKs, long-term software support, and a path to on-device AI will lead. AI-capable RedCap SoCs are already shaping this trajectory."*
> **Satyajit Sinha**, Principal Analyst, IoT Analytics

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Three Decades of Cellular IoT Innovation

For over 30 years, Semtech (formerly Sierra Wireless) has been at the forefront of cellular IoT innovation, delivering field-proven solutions that power mission-critical deployments worldwide.

Semtech's comprehensive module portfolio spans the complete spectrum of cellular technologies—from ultra-low-power LPWA to high-performance 5G—all designed for long-lasting reliability:

- LPWA Modules: Ultra-low power consumption enabling up to 20 years of battery life
- LTE Modules: Mid-tier performance optimized for IoT applications
- 5G RedCap Modules: Mid-tier 5G with reduced complexity and power consumption
- 5G Modules: High-bandwidth, low-latency connectivity for demanding applications

Every module in Semtech's portfolio is pre-certified across major global carriers and regulatory bodies, reducing your time to market and integration risk.

Ready to Future-Proof Your IoT Deployment?

Semtech's IoT experts are ready to help you leverage SoC modules for your next-generation IoT solutions, thereby eliminating external application processors and enabling edge intelligence directly on the module:

- Reduce System Complexity: Integrated modem and application processor in a single module
- Lower Total Cost: Eliminate discrete components and simplify board design
- Accelerate Development: Pre-certified platforms with full access to integrated compute
- Enable Edge Intelligence: Run custom applications on Linux/OpenWRT directly on the module

Want to learn more about Semtech's SoC offerings?

Contact our team at **sales@semtech.com**.
For more information about Semtech's cellular IoT please visit **www.sierrawireless.com**.