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The Cellular IoT Connectivity Playbook

Connectivity is seen as the most significant untapped opportunity for IoT businesses to improve operational efficiencies. When moving deeper into the implementation phase, the extended value of reliable connectivity will reveal itself more when you run into device issues, or when you need to go-to-market in a new region.

The aim of this IoT Connectivity Playbook is to help shed light on connectivity decisions that align with your business objectives. Here we'll move past jargons, simplify your choices, and guide you through the complexities of IoT connectivity in these critical decision points:

- **Understanding network technologies:** We'll cut through the technical details of 4G, LTE-M, NB-IoT, and other options to help you select the ideal technology for your specific needs.
- **Simplifying SIM selection:** We'll break down the nuances of different SIM card types and technologies, ensuring you make the right choice for your deployment scale and device requirements.
- **Navigating the network provider landscape:** We'll equip you with the knowledge to evaluate and select a network provider who understands the unique demands of IoT and can support your long-term growth.

Whether you're in the testing, deployment, or scaling phase, you're not alone in feeling overwhelmed by the sea of connectivity options. With practical, actionable advice to guide your IoT connectivity decisions, by the time you finish this playbook, you'll have the confidence to launch, manage, and scale your IoT solution.

Let's get started.

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Are you overlooking a critical IoT design decision?

Connectivity is crucial both in the early stages of IoT development and during deployment. Scoping out connectivity from the start is essential because it significantly impacts your device's design, capabilities, and overall performance.

Benefits of choosing the right connectivity:

Pre-deployment:

- Device size and form factor
- Power consumption and battery life
- Data throughput capabilities
- Coverage range and reliability
- Hardware and operational costs

During deployment:

- Reliable data transmission
- Ability to perform over-the-air (OTA) updates
- Scalability across different regions
- Consistent performance in various environments

If you don't consider connectivity early on, you may face:

- Design limitations that are difficult to overcome later
- Unexpected costs for hardware or network services
- Coverage gaps in your target deployment areas
- Inability to meet power consumption goals
- Challenges in scaling your solution

Connectivity is not just about linking devices to the internet; it's about creating a foundation for transformative IoT solutions that can adapt, grow, and deliver value over time.

The next sections of this playbook will help you select the right connectivity solution by going through key connectivity elements — **network technology, SIM**, and **connectivity provider.**

Choosing the right IoT network technology: A practical guide

When it comes to selecting the perfect network technology for your IoT project, it's easy to get lost in the technical weeds. But here's the thing: the best place to start isn't with the tech specs — it's with your business case.

Let's break down how to approach this decision, starting with the most important factors and working our way to the nitty-gritty details.

Start with your use case

Before diving into the world of cellular bands and data rates, ask yourself these key questions:

- What problems are you trying to solve with your product?
- How much data do you need to transmit, and how often?
- Where will your devices be operating?

The answers to these questions will guide your technology selection far more effectively than comparing specs alone.

Understanding your project requirements

The next step is to clearly define your project's key metrics:

- **Throughput and latency:** Determine how fast data needs to be transmitted and the acceptable delay.
- **Reliability:** Assess the necessary network stability.
- **Power efficiency**: Consider battery life requirements based on device usage (high or low data needs affect power use, as well as OTA device updates)
- **Mobility and roaming:** Think about how devices will move and need connectivity (would devices be stationary or moving? Is movement high-speed or slow? Would devices need to cross borders?).
- **SMS or voice capability:** Decide if messaging features are important.
- **Deployment environment**: Examine the physical and network conditions where devices will be deployed.
- **Device size:** Small is always preferred but how compact can you get your device without compromising overall reliability?
- **Cost of hardware:** Weigh total bill of materials (BoM) costs, including device provisioning, updates, maintenance, and plans for scaling.

Evaluating network availability

Now that you have a better understanding of your use case and requirements, then you can do a preliminary investigation on what network is available for you.

Crucially, the kind of network technology you use is highly reliant on what's available in your region of deployment (which can be made more complicated if it's different from what's available from where you build or test your device).

Before diving into specific technologies (which will be elaborated in the next section), first ensure compatibility and coverage:

+ Coverage: Verify network availability and reliability in your deployment area. Use our free coverage map to see network technology availability in your deployment region. The Coverage Map by GSMA also provides information on the extent of operator coverage.
+ Compatibility: Check that your IoT module supports the required cellular bands (like 2G, 3G, 4G, LTE-M, NB-IoT, LoRaWAN, etc.).

Exploring network technology options

Let's quickly go through some of the main IoT network technologies available in the market today, and highlight what works and what doesn't in each of them.

Cellular networks

Cellular networks offer several advantages and drawbacks for IoT projects.

Technologies: LTE cat 1, LTE cat 1 bis, 2G, 3G, 4G, 5G

Pros:

+ Global reach: They provide standardized, widely available connectivity.
+ Interoperability: Seamlessly integrate with existing infrastructure.

Cons:

— Historically higher power usage, though newer technologies are improving (however, could be the right backhaul connectivity solution).

— 2G/3G are sunsetting and the majority of global 2G and 3G networks will be phased out in the next 5 years or so. Check out 2G/3G shutdown dates in this list.

Low-Power Wide-Area Networks (LPWAN)

LPWAN technologies are designed for efficiency and cost-effectiveness required by many IoT uses.

Technologies: LTE-M, NB-IoT, LoRaWAN

Pros:

+ Power efficiency: Significantly extend battery life—up to 10 years.
+ Coverage: Excellent signal penetration, even in challenging environments.
+ Cost-effective: Leverage existing infrastructure for lower costs.

Cons:

— Uneven global rollouts.
— Limited data rates could make frequent over-the-air (OTA) device updates tricky

Making network tech work for your business needs

Some network technologies suit your specific needs more than others. While there are no hard-and-fast rules to which network technology is the one true choice for any use case, there are certain network features that match your priorities better. Similarly, cases can be made where using complementary connectivity solutions will cover your needs (dual-band modems are becoming more readily available).

A key step is to recognize what are the main points of considerations for your application. Is range a higher priority for your device? How about roaming? Are you in R&D phase with tight budgets?

Align your technical requirements with the features offered by different LPWAN and LTE cellular technologies by referring to the table below.

Choosing the right IoT network technology

See which network technology matches the most with your needs by going through these feature highlights.

Feature requirements	**LTE-M** (LPWAN)	**NB-IoT** (LPWAN)	**LoRaWAN** (LPWAN)	**LTE Cat 1 bis** (LTE)
Throughput	Low data needs (up to 1 Mbps)	Low data needs (up to 250 kbps)	Low data needs (up to 50 kbps)	Moderate data needs (up to 10 Mbps)
Latency	Low	Low to medium	Variable	Low
Reliability	High	High	Variable	High
Range	Up to 11 km	Up to 15 km	Up to 15 km (rural), 2-5 km (urban)	Up to 10 km
Mounting location	Outdoor, indoor	Outdoor, deep indoor	Varying indoors	Outdoor, indoor
Power consumption	Low, supports PSM, eDRX (network-implementation dependent)	Low, supports PSM, eDRX (network-implementation dependent)	Very low	Low to medium, supports PSM, eDRX (network-implementation dependent)
Mobility	Full mobility (supports handover)	Limited (stationary or slow-moving)	Limited	Full mobility (supports handover)
Device size	Compact modules	Small modules	Small, compact modules	Small modules
Coverage	Urban, rural, not all countries	Urban, rural, not all countries	Only in certain places	Urban, rural, global coverage
Cost of hardware	Low to medium	Low to medium	Lowest	Medium
Capacity	Moderate device density	High device density	High device density	Moderate device density
Voice	Supported	Unsupported	Usually unsupported	Supported
SMS	Supported	Limited	Possible, requires extra setup	Supported
Roaming	Supported	Unsupported	Supported	Supported
Security	LTE encryption and authentication	LTE encryption and authentication	AES-128 encryption	LTE encryption and authentication

Additional resources on IoT network technologies:

- A complete guide to LTE-M for IoT
- An extended guide to NB-IoT
- LTE Cat 1 bis: An ultimate guide with practical examples
- Beyond LoRaWAN vs Cellular: A guide to integrated IoT connectivity

Best practices and other future-proofing considerations

Combined solutions are becoming increasingly popular in the IoT world, and for good reason. They offer unparalleled flexibility and adaptability. Let's dive into some key scenarios where a hybrid approach shines:

1. **Macro and micro networks: The best of both worlds**
   Sometimes, you need to think both big and small. A hybrid approach lets you do just that. For instance, you might use Bluetooth for device-to-device communication in a small area, then leverage cellular IoT to send aggregated data to the cloud. Another example is LoRaWAN for edge device communication, paired with cellular for transmitting larger data packets to and from the cloud. This approach maximizes power efficiency at the edge while ensuring robust, long-range communication when it counts.

2. **Fallback technology: Keeping devices connected**
   Network downtime? No problem. A hybrid approach provides a backup plan to keep your devices online and your data flowing. For example, LTE with 2G fallback is a robust solution for many IoT applications. It's particularly valuable for global deployments where network availability can vary wildly between the home region and the region of deployment. Consider this: while NB-IoT is available in your business's HQ in Europe, in some parts of the world, 2G is still the only available option. A hybrid solution ensures your assets stay connected wherever there's a cellular network, be it 2G, 4G, or beyond.

3. **Future-proofing: Staying ahead**
   The only constant in tech is change, and an integrated approach helps you stay confident even when things go differently. Take LTE Cat 1 bis with 2G fallback, for example. It's not just a solution for today — it's transitional tech for tomorrow. Businesses currently relying on 2G can deploy these devices and leverage existing infrastructure. As 2G networks get shut down, these same devices can seamlessly switch to 4G. This solution can help with long-term connectivity without the headache of a complete system overhaul.

By embracing robust connectivity solutions, you're not just solving today's connectivity challenges, you're building a flexible foundation that can adapt to whatever the future of IoT might bring — whether you need reliability, scalability, or future-proofing (or all three!).

Best practices for choosing the right IoT SIM

The role a tiny SIM plays in building an interconnected world cannot be understated. But with so many options out there, how do you know which one is best for your IoT devices?

Let's break down the key factors to consider when choosing an IoT SIM in 4 steps. The aim is to help you go through the complexities of connectivity with ease and set your deployment up for long-term success.

4 steps to select the right IoT SIM for your application

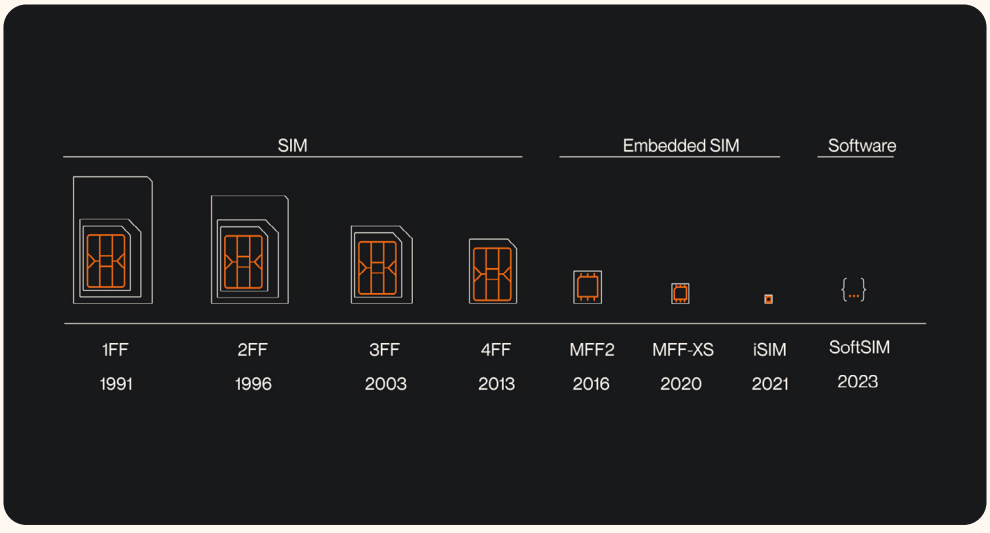
Step 1: Understanding IoT SIM requirements – It's not one-size-fits-all

Let's face it: not all SIMs are created equal. Before diving into the technical specs, it's essential to understand your project's unique needs. Here are some key factors to consider:

+ **Coverage performance:** Does the SIM offer robust connectivity in all your deployment areas? This one seems basic but tests show that SIM performance varies considerably.
+ **Durability:** If your devices operate in harsh conditions, industrial-grade SIMs are a must.
+ **Management:** Look for SIMs that support OTA updates and remote management for maximum flexibility and control.

Step 2: Selecting the appropriate SIM form factor

Choosing the right SIM form factor depends on your device's design and operational needs. Here's a quick rundown of your options:



SIM form factors:

- **Full-Size, Mini, Micro, Nano:** These are the standard sizes. Select based on your device's slot specifications, considering ease of replacement and availability.
- **Embedded SIM (eSIM):** These are soldered onto the device, offering durability and space-saving benefits. They're perfect for devices with long lifecycles or those in hard-to-access locations.
- **SoftSIM:** Completely software-based, SoftSIMs are cost-effective and flexible, ideal for projects where minimizing hardware costs and size is a priority. This eliminates physical provisioning, which streamlines manufacturing and makes time-to-market faster. It also removes the issue of aging SIMs, which would require physical SIM swapping when the SIM card starts to malfunction due to wear-and-tear.

Step 3: Considering SIM Technology

SIM technology has come a long way. Here's what you need to know:

- **Traditional SIMs**
  Carrier-specific and in most cases, require physical swapping to change networks. Not ideal for large-scale IoT deployments.
- **eUICC and UICC SIMs**
  - **eUICC** (Embedded Universal Integrated Circuit Card): eUICC allows multiple network profiles on a single SIM. This enables remote provisioning and switching between carriers without physical changes, making it ideal for global and scalable IoT deployments.
  - **UICC** (Universal Integrated Circuit Card): This is the standard technology used in SIM cards, providing secure storage for network-specific information. While UICC typically restricts SIMs to a single operator profile, our proprietary core network setup uniquely enables seamless OTA operator switching. This capability sets us apart from other providers using standard UICC setups, who cannot offer such flexibility.

    Read more about eUICC and UICC in this guide that also talks about Multi-IMSI SIMs.

- **The eSIM IoT standard**
  In 2023, the GSMA released the eSIM IoT specifications (SGP.31, SGP.32, and SGP.33). With the full ecosystem launch by the end of 2024 or early 2025, the eSIM IoT standard is anticipated to become the new standard for IoT SIMs. This is because it makes remote provisioning at scale possible, a technology that is largely lacking in the IoT industry.

  The eSIM IoT Alliance is working on a free, open-source platform to support it. If you're planning for the future of IoT, this is definitely something to keep on your radar. Our comprehensive guide on eSIM for IoT deep dives into the topic, and it also comes with a free cheat sheet to know how to get ready for the technology.

Solving the global challenge of permanent roaming

Traditional roaming setups were designed for mobile phones, not IoT devices. They typically allow devices to remain outside their home network for only 30-45 days before being classified as "permanently roaming" and potentially losing connectivity. This poses operational challenges for global IoT deployments, where devices may be permanently stationed in foreign countries or constantly moving across borders.

In contrast, our non-steered setup provides a more flexible and IoT-friendly approach. By integrating directly with over 590 radio access networks (RANs) globally, we eliminate the concept of a single "home" network. Our SIMs can connect to any supported network without being considered as roaming, effectively solving the permanent roaming issue.

This non-steered approach offers several advantages for IoT projects:

- Global connectivity
- Simplified device management with a single global APN
- Reduced complexity in the supply chain and deployment
- Enhanced visibility and control over device connectivity

By adopting a non-steered setup, IoT projects can overcome the limitations of traditional roaming, ensuring reliable, long-term connectivity for devices regardless of their location.

Step 4: Evaluating pricing models

IoT SIM pricing often differs from consumer SIMs. Here's what to watch out for:

+ **What to look for:** B2B IoT SIMs with cost models based on actual data usage. If your immediate deployment plans are on a smaller scale, make sure that you can have the flexibility to match your ramp up plan as your business grows.

— **Avoid:** Be wary of hidden, additional fees per SIM that can impact your overall budget. Some SIMs would have you pay extra for activation and deactivation fees, roaming fees, other costs related to limited SIM card lifespan, and different costs depending on countries.

Avoid these common IoT SIM pitfalls

— **Custom code:** Be wary of SIMs with proprietary code that can lock you into a single vendor. This limits flexibility and may incur additional costs.

— **Operator lock-in:** If possible, negotiate to retain control over crucial keys like IMSI, Ki, and OPC to ensure you can switch operators if needed. Otherwise, make sure your SIM supports the freedom to leave when you need to change network providers due to costs, performance, or contract changes.

— **SIM steering**: Non-steered SIMs allow devices to select the strongest available network, improving performance.

The bottom-line: implement future-proof solutions

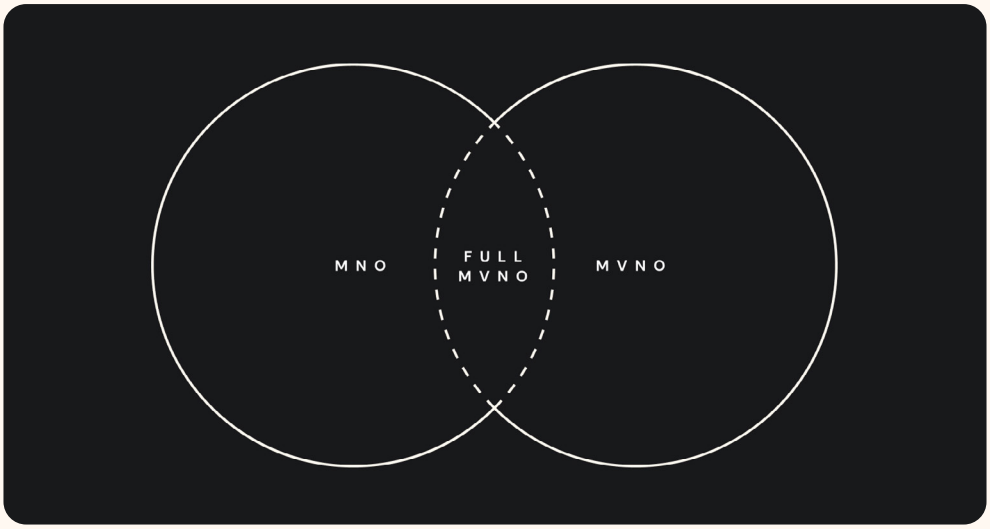
Choosing the right IoT SIM involves considering technical requirements, environmental conditions, and future scalability. But selecting the right IoT SIM is about more than just connectivity — it's about setting your project up for long-term success.

Preparing ahead, the right IoT SIM should support remote provisioning and management, and enhance device performance without hidden costs. Ensure your SIM solution is adaptable, allowing for easy updates and network changes as your needs evolve.

From provider to partner: How to find the right IoT network operator

Deploying your IoT solution across multiple locations can quickly turn into a logistical nightmare. Managing a patchwork of network providers for each deployment region means juggling countless contracts, navigating varying service levels, and facing potential compatibility issues. This fragmented approach to connectivity not only creates administrative headaches but also undermines your ability to deliver a seamless and reliable user experience across your entire IoT ecosystem.

The connectivity landscape: MNOs, MVNOs, and full MVNOs



Here's a quick overview of the different types of IoT connectivity providers in the market.

	MNOs	MVNOs	Full MVNOs
Ownership	Owns and operates radio network spectrums and infrastructure.	Does not own radio spectrums; uses MNO infrastructure.	Operates its own core network while using MNO's radio access.
Pros	Direct control over network quality and coverage.	Often more flexible and cost-effective.	Offers flexibility similar to MNOs and advanced tools.
Cons	Typically more expensive.	Limited control over network infrastructure.	Network changes may require coordination with infrastructure owners.

Onomondo is a full Mobile Virtual Network Operator (MVNO) for IoT connectivity. We've built an extensive network that integrates deeply with 590+ networks across 180 countries.

Our full core integration connects local radio access networks to our own core network infrastructure. This gives us end-to-end visibility and control, allowing us to create unique tools for businesses worldwide to efficiently develop, launch, and manage their IoT solutions.

Is your connectivity provider holding your IoT business back?

Connectivity can be more than a technical need, it can make your business more efficient, reliable, and cost-effective. But a deeper dive reveals hidden pain points that create frustrations and missed opportunities. Let's unpack these overlooked hurdles in IoT connectivity:

- **SIM card management**
  Managing connectivity for distributed devices isn't as straightforward as activating a mobile phone. If you're one of the many IoT businesses getting tangled with a web of monthly SIM fees, activation/deactivation complexities, and escalating costs for inactive devices — this inefficient approach directly impacts your bottom line.

- **Subscription overheads**
  Here's a sobering thought: you're likely paying for data your devices aren't even using. Traditional connectivity models often lock you into rigid subscription plans that fail to reflect the dynamic data needs of IoT deployments.

- **Development and testing bottlenecks**
  Developing robust IoT solutions requires rigorous testing, but transitioning from R&D environments to real-world deployments can be fraught with challenges. The inability to seamlessly leverage production networks for testing creates delays, increases costs, and introduces unnecessary risk.

- **Troubleshooting time sink**
  Imagine 200 devices unexpectedly going offline in a remote location. With traditional connectivity providers, this scenario often translates into your business spending huge resources on support tickets, prolonged downtime, and costly on-site visits. Without remote monitoring tools, providers keep you in the dark when you need device and network visibility the most.

- **Power and data drain**
  You've optimized your device's power consumption, but have you considered the impact of inefficient data transmission protocols? A seemingly insignificant data packet can balloon in size during transmission, rapidly depleting battery life and increasing operational costs.

- **Security that supports performance**
  Data is vulnerable to breaches, unauthorized access, and potentially devastating consequences. Failing to prioritize security can damage your reputation, erode customer trust, and expose your business to significant financial and legal risks.

- **Global coverage**
  Your device connectivity should go where your business takes you. Patchy coverage, inconsistent connectivity, and performance issues across borders can lead to frustrating user experiences, missed opportunities, and ultimately, a business model that doesn't support growth.

Beyond the basics: What sets great providers apart

By understanding what you need to look for in a network provider, you can find a partner that aligns with your IoT business's needs, setting the stage for long-term success.

Challenges	What to look for	Our tools and solution
SIM management	• Simplified SIM provisioning and handling • No-fee SIM activation or deactivation	• IoT Connectivity Management Platform (CMP)
Subscription overhead	• No hidden fees for inactive SIMs • Freedom from fixed-term contracts and useless monthly fees	• Pay-as-you-go pricing • Magic Mode
Development and testing	• Testing on live global networks • Deep network insights • Support for a wide range of network tech (2G, 3G, 4G, NB-IoT, LTE-M)	• Insight Tools • API and Webhooks • Free testing available
Troubleshooting	• Real-time transmissions data • Self-service logs and diagnostics • SLAs (Service Level Agreements)	• Traffic Monitor • Network Logs • Signaling Logs
Power and data drain	• Simplified connectivity logic on the device • No SIM steering	• Cloud Connectors • Non-steered SIMs
Security	• Flexible end-to-end encryption • Off-device security solutions • Compliance with global data privacy regulations	• OpenVPN and IPSec • Unique keys for each device
Global coverage	• Extensive global coverage • Deep integration into multiple networks • Easy network switching capabilities across borders	• 1 unified core network with 590+ network integrations across 180 countries • 1 global APN • Freedom to leave

The true cost of connectivity

Here's where most businesses get it wrong: they focus solely on data costs. But the real expenses are hidden in inefficiencies across the entire IoT stack. From bloated development cycles and extended troubleshooting to power-hungry transmissions, traditional connectivity solutions are costing you more than you realize, significantly impacting your overall ROI.

Choosing an IoT connectivity provider isn't just a technical decision – it's a strategic one. The right provider doesn't just connect your devices; they become a partner in your IoT journey, enabling you to focus on what you do best: innovating and growing your business.

So if you're seeking to:

- **Optimize your entire IoT stack:** From device design and development to deployment and ongoing management, streamline operations while creating upsell opportunities. This comprehensive approach provides a competitive advantage, enabling enhanced value delivery to your customers and new revenue streams.
- **Reduce your total cost of ownership:** Eliminate hidden expenses and maximize efficiency by minimizing on-site troubleshooting. This allows your teams to focus on innovation and R&D, optimizing resource allocation.
- **Focus on providing value to customers and growth:** Without being held back by connectivity complexities.

Talk to us about our IoT connectivity solutions so you can develop, launch, and manage your business with confidence.

Get in touch

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