# What is the Difference between eSIM and Embedded SIM in IoT?

There is a new kid on the SIM block: the eSIM. But don't confuse this with embedded SIMs! Oh and there's eUICC, and 1FF, 2FF, and 3FF, too. And what is an MFF2? This post will help. Let's dive right in!

## What is a SIM?

A SIM (Subscriber Identity Module), also called a Universal Integrated Circuit Card or UICC, stores information that uniquely identifies a cellular subscription. For about three decades now, the SIM has been what lets us connect ("attach" in tech speak) our devices to the cellular networks of the world. It holds the credentials and security keys necessary to identify a subscriber. That identity comes in the form of a so-called IMSI number, or International Mobile Subscriber Identity, which is unique for every user or device on or off the network. SIMs also run an application that passes that identity information to an onboard cellular modem. The modem in turn conducts the actual attachment operation to the network. The application that the SIM card runs, by the way, is also referred to as UICC; the acronym is often used synonymously with the card or chip itself.

SIMs started as truly card-like hardware (the first-ever form factor, or "1FF"), but shrunk over time into several different, and increasingly smaller, form factors:

The rightmost one looks a little different – that's because this is a chip soldered directly onto your electronic circuit board that makes up your device, vs. the bigger versions you insert manually into a slot. This smaller form factor was needed for our ever-shrinking consumer and IoT devices. You could say it is "embedded" into a bigger circuit board. So if the MFF2 form factor is "embedded", is this tiny SIM what we call an "eSIM"? Unfortunately, no. Some do, but it's imprecise. While the "e" in eSIM does stand for embedded (you will also find the reading "electronic SIM" out there), what is meant with eSIM is really a different "kind" of embedded – not the hardware kind.

## What is an eSIM?

**In simple terms, an eSIM is a SIM that can load new carrier profiles digitally, over the air, which means you no longer need to physically swap SIM cards in your devices.**

In more technical terms, an eSIM is any piece of hardware that runs an application called eUICC, which has storage to hold multiple SIM profiles at the same time (but only one can be active), and can be provisioned remotely, over the air (OTA).

This means a couple of things:

- The profiles stored on an eSIM can be modified (downloaded if not yet present, or activated if dormant) remotely, through software and API calls, without needing to physically swap SIMs

- An eSIM can hold multiple SIM profiles (keys and identities) at the same time, which can give your device access to multiple completely different carriers – but only one SIM can be active at a time
- An eSIM doesn't need to come along only in the form of any of the known form factors (2FF, 3FF, 4FF, MFF2) – anyone can design their own hardware chip, as long as it runs an application that conforms to the eUICC standard

While the eSIM concept simplifies things for the consumer, it is a game changer for cellular IoT deployments. eSIM lets you avoid lock-in to any mobile network operator (MNO), as it decouples the hardware from the decision of which MNO to use. You can deploy your devices globally with the same hardware, and make decisions on which carrier to use at a later point.

eUICC/eSIM is standardized by the GSMA, an industry organization that represents the interests of mobile network operators worldwide. Here is a whitepaper that introduces the standard: "eSIM Whitepaper: The what and how of Remote SIM Provisioning"

So now you know that when you hear someone speak of eSIM, you should ask whether they mean "embedded SIM" in the sense of the form factor (MFF2, pre-soldered onto a circuit board and pre-equipped with one SIM profile), or in the sense of supporting remote SIM provisioning.

Note: Just as the term "UICC" is often used synonymously with both the SIM hardware and the SIM application running on the SIM hardware, "eUICC" is also used for both the hardware and the specific application. When talking casually about the matter, we use "eSIM" and "eUICC" to mean the same thing.

## Two different architectures of eSIM

While a technical detail at the end of the day, it might make sense to briefly describe the two different, non-competing architectures of eSIM/eUICC: Consumer Profiles, and M2M Profiles.

### Consumer Profiles

As the name suggests, these are eSIMs for devices meant for consumers. It is assumed that a human being is present to use the device, which allows for a SIM configuration approach that is based on "pulling" new profiles (i.e. downloading manually, when needed by the user), vs. "pushing" (i.e. loading remotely as a forced action, when needed by the operator). This architecture makes sense for devices such as smartphones or tablets, but also wearables such as watches, or small attached devices such as pet trackers. However, the architecture is actually powerful enough to support ANY IoT deployment, whether the use case targets consumer devices or not. There is a piece of software called LPA (Local Profiles Assistant) that does the pulling. Any app can easily communicate with it to trigger a pull – so no more consumer action is needed. The name is, alas, again a bit misleading, as with so many things in the IoT ecosystem...

### M2M Profiles

M2M, or Machine-to-Machine, is another term for what is now known as IoT, the Internet of Things, i.e. connected devices that enable remote control, monitoring, or tracking. With eSIM's M2M Profiles architecture, the key difference to Consumer Profiles is that loading a new SIM profile is a push operation by design, not a pull. In this model, all of the profile management is controlled remotely with orders to add, remove, or change profiles "pushed" to the eUICC.

It is important to note once more that despite the names, though, both types of eSIMs can be used for IoT applications. It might in fact very well be that "Consumer Profiles" is the architecture that will eventually prevail for IoT use cases.

## The relevance of eSIM in IoT

It was probably Apple that made eSIM popular when equipping their 2018 iPhone models with this capability. Users could now buy and sell their phones without dealing with physical SIMs anymore. It is still an emerging capability in the consumer space.

The same is true for IoT applications, but we're seeing an increase in its adoption and demand. eSIM makes particular sense for three kinds of IoT device types:

1. **Long-lived**: Devices that stay in use for many years, such as automobiles, medical devices, or home automation systems, but could frequently change ownership and thus deployment region
2. **Space-constrained**: Devices that need to optimize for space, such as wearables, and thus need the smallest possible form factor, which implies that the device can't be opened later to swap out SIMs
3. **Remotely installed**: Devices that are deployed in remote or not easily accessible locations, such as billboards, air quality or forest fire monitors, and where the swapping of physical SIMs would be costly

As mentioned before, eSIM is a game changer for cellular IoT, as it makes global deployments of large fleets so much simpler, removes any cellular vendor lock-in, and thus adds a new dynamic to the IoT industry, which in turn should foster more success and with that growth.

## Twilio offers Super SIM on eSIM

Twilio now offers Super SIM, our flagship cellular IoT connectivity platform, as an eSIM profile, supporting the *Consumer Profile* architecture. Super SIM is a *Multi-IMSI* solution. That means that devices equipped with Super SIM can already change the carrier any time, without needing the eSIM mechanism. So why support eSIM? It gives you the best of both worlds. eSIM on its own has the drawback that you potentially end up paying multiple carrier bills, are dealing with multiple different (carrier-dependent) ways to manage your SIMs, and multiple different network capabilities, which are dependent on how the carriers implemented their so-called mobile core. But it gives you the over-the-air download! Super SIM on eSIM gives you the over-the-air download, but also just means one bill for you, one management framework (through our APIs and our Console), and one common set of capabilities, no matter which carrier is actively serving your devices.