



GSMA Intelligence

ANALYSIS

Understanding SIM evolution

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Executive summary

The SIM provides secure, identifiable and authenticated access to mobile networks

Since its inception in the early 1990's to the present day, the SIM card provides secure, identifiable and authenticated access to mobile networks. It is also the primary piece of operator supplied equipment used by consumers when connecting to the mobile network.

The SIM will need to continue to provide secure access to mobile operator networks – regardless of how any evolution occurs.

Recent evolution of the SIM card has focussed around Embedded and Remote Provisioning solutions

Alternative SIM solutions have recently been deployed in some M2M devices and tablets compared to the traditional SIM card approach (a removable SIM card issued by one operator). The main new characteristics of these solutions are:

- **Embedded solutions:** SIM cards that are fixed in the device and cannot be removed
- **Remote provisioning:** SIM cards that can be updated over the air and store one or more operator profiles

Embedded SIM cards and Remote Provisioning SIM cards are not 'Soft SIM'

The recent evolutions in Embedded SIMs and Remote Provisioning cannot be considered to be 'Soft SIMs' – the term 'Soft SIM' should not be used to describe any of the solutions identified in this report. The physical hardware element is always present and adds an indispensable layer of security.

A 'Soft SIM' would be a solution with no SIM hardware and where all SIM functionality is carried out by a software layer.

The industry is working towards one solution for the consumer market

Following the recent developments in Embedded SIMs and Remote Provisioning (specifically the GSMA Embedded SIM Specification and Apple SIM), the industry is working towards one solution for the consumer market which will need to be consistent with the M2M solution and interoperable between different suppliers.

Operators will continue to play a key role in how the SIM develops, the pace of evolution and the associated business models. The pace and the extent of SIM evolution will depend on criteria, requirements and acceptance at a market by market level – widespread deployment will take a number of years, it will not happen overnight.

History of the subscriber identity module (SIM)

In 1991, Giesecke and Devrient supplied the first commercial SIM card to a Finnish Network operator. The SIM card was originally designed to work on the nascent GSM network and was similar in size to a credit card.

The primary role of the SIM card was twofold, both of these benefits remain valid today:

1. **Identity:** the SIM card contains a unique reference number that identifies the SIM card and therefore the subscription that accompanies that SIM card. The mobile network can recognise the reference number and ensure that associated costs incurred are allocated correctly
2. **Authentication:** in order to ensure that the identity is valid, the mobile network uses a security mechanism to allow access to the network. This is achieved by the network issuing a challenge (similar to a security question) that only that particular SIM card can answer from the information it has stored in its memory. Once validated, access to the network is granted

Additionally, if the SIM card becomes damaged or the security compromised, it can easily be removed and replaced with a new SIM card. Therefore, the secure connectivity can be restored without replacing the entire handset. Similarly, if a consumer wishes to change network provider, they can do so through replacing the relatively inexpensive SIM card rather than the entire handset (assuming the device is not locked to a particular operator). The SIM card also brings secondary benefits for the end user:

1. **Portability:** as the identity is stored on the SIM card, it can easily be moved to a new device when the consumer upgrades or replaces their handset
2. **Memory:** the SIM card provides memory for additional services such as storing contact details/SMS. As these are stored in the SIM card memory, they can be retained if the SIM card is moved to another device. Over time, some of this functionality such as SMS storage and the address book has moved from the SIM card to the device memory

The physical SIM card itself has significantly reduced in size — driven by a combination of smaller devices and the requirement to use the available space within a device for an increasingly complex set of features and functionality. The 4FF SIM is the smallest possible size whilst retaining the ability for users to confidently insert and remove them. At the same time, the SIM itself has developed to take on more complex functions (e.g. NFC, see definitions page for an explanation of NFC).

Figure 1 shows how the size of the SIM has reduced from the original credit card size 1FF (FF stands for form factor) SIM to the 4FF SIM (or “Nano SIM”) that is widely used in new smartphones today.



Variant	1FF	2FF (“Mini SIM”)	3FF (“Micro SIM”)	4FF (“Nano SIM”)
Year of launch	1991	1996	2003	2012
Dimensions (mm)	85.6 x 53.98	25.0 x 15.0	15.0 x 12.0	12.3 x 8.8

Figure 1: GSM SIM card evolution

Source: GSMA Intelligence based on Justin Ormont’s work

There are also standard SIM sizes for permanently embedding into devices and used in machine-to-machine (M2M) applications, MFF1 and MFF2 were designed for this purpose¹. Despite the changes in technology and size, the fundamental elements of connectivity, identity and authentication are still core to the role of the SIM card today.

¹ MFF1/2 are the same size, the difference being one is soldered and the other inserted into a chip holder

Current SIM deployments

In this section we will first explain what is meant by “Traditional SIM card approach,” “Embedded SIM” and “Remote Provisioning.” Following these definitions, we will look at the different device segments and the SIM solutions currently being deployed in each.

Traditional SIM card approach

The traditional SIM card is a piece of hardware that a consumer can remove from the device. The SIM card stores an operator defined profile which is programmed during manufacture. The operator profile is the information that enables identification and authentication of the SIM card with the selected mobile networks.

From a technical perspective, the traditional SIM is built on Smart Card (UICC) technology, just like bank cards. The UICC is a physically secure computing device that can be used across multiple vertical sectors including mobile telecommunications.

The UICC conforms to the specifications written and maintained by the ETSI Smart Card Platform Project².

Embedded SIM

An embedded SIM is one which is physically integrated into the device — i.e. it cannot be removed from the device and replaced with another SIM.

Remote provisioning

Remote Provisioning is the ability to remotely change the SIM profile on a deployed SIM without having to physically change the SIM itself. This technology can be implemented on any SIM form factor, including removable and soldered SIMs.

In order to achieve this, the SIM has extra memory and is therefore capable of holding more than one operator profile (rather than only one on the traditional SIM).

When a consumer purchases a service package from a specific operator, the operator profile is downloaded and saved onto the SIM memory. If a second operator package is subsequently purchased, the new operator profile is downloaded and also saved to the SIM – both operator profiles are now saved on a single SIM card and there is an ability to swap between the two installed profiles. This swap effectively mimics the actions a user would undertake when swapping the SIM card in a device.

The term eUICC³ is being used to represent a SIM card that can be remotely provisioned.

² For further details on UICC see the ETSI [technical specification](#)

³ For further details on eUICC see the ETSI [technical specification](#)

Device categories

We will now look at the different device segments to understand how the current SIM deployments are being used:

1. Handsets/smartphones

Handsets and Smartphones currently use a traditional SIM card model i.e. a physical SIM card that stores a single operator profile. The SIM card itself can be removed from the device and placed into another device, transferring the identity and authentication functionality. Alternatively, the SIM can be swapped for a new SIM card in the original device (for example, if the handset changes ownership or the SIM card becomes damaged).

An operator is able to lock a SIM card so that it can only be used in conjunction with a specific device (or vice versa). This is commonly used when a device is subsidised at the time of purchased - and therefore helps to ensure the operator can recoup the subsidy.

2. Machine-to-machine (M2M)

Whilst many M2M devices use the traditional SIM card approach, M2M devices present unique challenges to the role of the traditional SIM card. The devices are often located across very diverse, unsupervised locations and subject to external influences such as weather (e.g. remote sensors / vending machines), and temperature and vibration (e.g. automobiles).

In such cases the SIM card needs to be protected and kept in a secure part of the device where it will not be damaged or open to theft.

Furthermore, the lifespan of M2M devices is often tens of years and, for various reasons, the owner may wish (or be forced) to change the operator providing the cellular connectivity.

Replacing the SIM card would be impractical and expensive, for example:

- Many devices in diverse geographical locations
- The SIM card being embedded in a hard to reach, protected part of a vehicle

The GSMA has worked with leading operators and SIM hardware providers from around the world to develop a practical solution to the unique challenges in the M2M market.

The resulting GSMA Embedded SIM Specification⁴ enables a SIM card to be fully embedded in an M2M device but also have Remote Provisioning functionality.

This specification ensures that the SIM card is protected from theft and external elements by being physically integrated within the device. The Remote Provisioning aspect allows

⁴ For further details on the GSMA Embedded SIM specification, see [GSMA technical specification](#)

the mobile network provider to be changed without removing the SIM (i.e. it cannot be removed from the device, but a user can change to a new network provider if needed, or hold multiple operator profiles if the user needs to swap between networks).

Initially designed for the automotive sector, the GSMA Embedded SIM Specification has been widely adopted and become the de-facto approach for embedded SIMs in M2M devices.

Companies who have launched or committed to launch GSMA Embedded SIM Specification compliant solutions include América Móvil, AT&T, China Mobile, NTT Docomo, Ericsson, Etisalat, Gemalto, Giesecke & Devrient, Jasper, KDDI, Orange, Oberthur, Telefónica, Telenor, Telit, Safran, Sierra Wireless, Tele2 and Vodafone⁵. In March, the GSMA announced that operator members of leading M2M alliances including the Global M2M Association (GMA) and the M2M World Alliance will deploy services using the GSMA Embedded SIM Specification for the remote over-the-air provisioning of machine-to-machine (M2M) devices.

3. Wearables

As the form factors and functionality of the wearables segment evolve, we believe that a fully embedded SIM card with remote provisioning will prove to be an attractive option to provide flexibility and connectivity.

Whilst wearables are still a nascent market, these devices highlight the need for further evolution of the SIM to accommodate smaller devices addressing new consumers segments.

Currently, the majority of cellular enabled wearable devices use the traditional SIM method outlined above. However, moving to an Embedded solution with Remote Provisioning will eliminate the need for incorporating SIM housing components and help maximise the space available in the device. Remote Provisioning would allow flexibility in choice of mobile network operator without the need to remove the SIM.

4. Tablets

4.1 Traditional SIM card

The majority of cellular capable tablets available today use the same SIM approach as is used in handsets and smartphones – i.e. a physical SIM card that stores a single operator profile. A user can switch between operators (if the tablet itself is not locked to an operator) but this does require removing the SIM card and replacing it with a SIM card from the new operator.

⁵ [Leading M2M alliances back the GSMA Embedded SIM specification to accelerate the Internet of Things](#), GSMA, March 2015

2.2 Removable SIM with Remote Provisioning

With the launch of the most recent iPad Air and iPad Mini models, Apple also introduced the Apple SIM which uses Remote Provisioning, rather than the traditional SIM card approach.

It is important to note that the Apple SIM is a physical, removable SIM (in the same way that traditional SIM's can be removed from handsets or smartphones). This is not a 'Soft SIM' – a 'Soft SIM' would have no hardware layer and all functions would be performed at the software layer (more details of what is meant by the term Soft SIM can be found later in this report).

Apple SIM reduces the barriers for consumers to purchase and use cellular connectivity when the device is purchased through non-operator retail. It could encourage consumers to purchase the, higher priced, cellular enabled tablets (rather than the versions that only have Wi-Fi connectivity).

The consumer can purchase prepaid data packages from more than one operator for use at different times or locations and then select which package to use through the device settings.

The Apple SIM is currently available in the United Kingdom and USA – (EE in the United Kingdom and AT&T, Sprint and T-Mobile in USA). Apple states that the line-up of operators is subject to change so new countries / operators could be added.

The Apple SIM may increase take up of cellular connectivity in iPads (rather than purchase of Wi-Fi only models). However, it may impact a limited amount of international roaming revenue as consumers would be able to purchase local operator packages without having to replace the SIM card. Of course this only applies where local operators support Apple SIM.

If the iPad is subsidised (e.g. purchased with a contract), it is unlikely the consumer would be able to purchase data packages from alternative operators – instead they would need to continue using data under the home network agreements.

What is meant by the term Soft SIM?

A 'Soft SIM' would be a collection of software applications and data that perform all of the functionality of a SIM card but does not reside in any kind of secure data storage. Instead, it would be stored in the memory and processor of the communications device itself (i.e. there would be no SIM hardware layer).

None of the solutions identified so far in this report can be considered a Soft SIM. Whether the SIM itself is removable or embedded in the device it is still a combination of cryptographic hardware and software that enables cellular connectivity and, amongst other functionality, stores the operator profile(s) required to use the mobile network.

Whilst we have highlighted the evolution of the SIM through embedded and remote provisioning developments, the concept of a separate security assured, combined hardware and software element being used has remained.

Operators are very concerned about the security of their credentials and the potential reduction in security that could arise through the use of Soft SIM. It is well known that Operating Systems are more likely to be subject to hacking than hardware and therefore could leave the operator profile open to the threat of hacking activity.

Any SIM approach not based on a certified hardware and software secure element would be subject to continual attack by the hacking community and, if compromised, would result in a serious loss of customer confidence in the security of operator systems.

There is greater security when there are two elements providing security, hardware and software, both providing protection.

How the existing Remote Provisioning and Embedded SIM solutions could develop

We will now look at how these recent developments could evolve further, including the potential for embedded SIMs in personal devices rather than just M2M devices.

Given the recent developments in terms of SIM evolution (GSMA Embedded SIM Specification for the M2M market and the Apple SIM remote provisioning capability for iPads), the industry is working on defining one industry solution for the consumer market. This solution will need to be consistent with the M2M solution, performant and interoperable between the different suppliers – a number of proof of concepts are under way⁶.

Figure 2 highlights potential development paths of the current SIM solutions. The numbers reference the scenarios that will be looked at in more detail on the following pages.

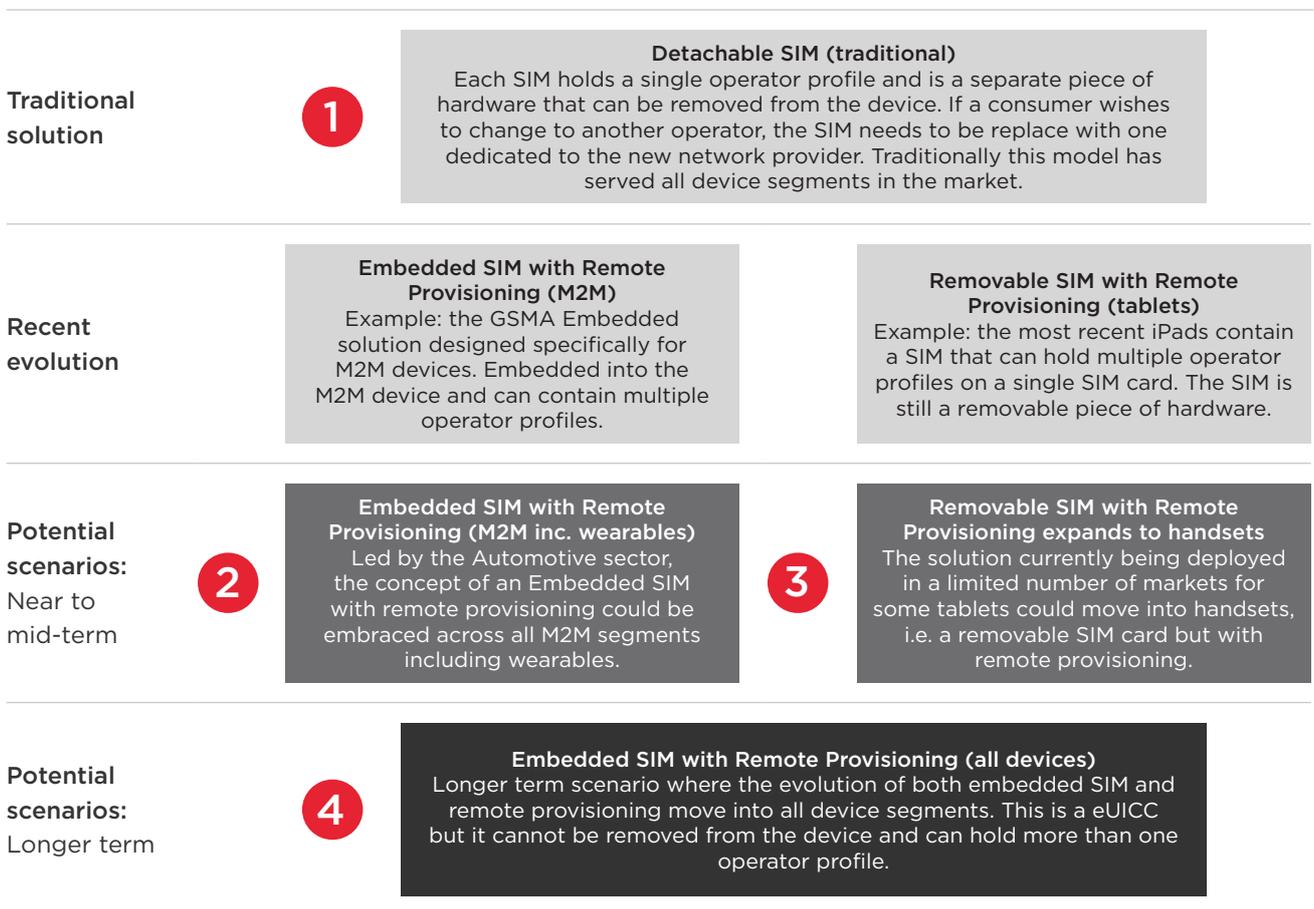


Figure 2: SIM development scenarios

Source: GSMA Intelligence

⁶ [GSMA announces mobile industry initiative to create a global Remote Provisioning Specification for consumer devices](#), GSMA, March 2015

1. Traditional SIM card approach continues as the mainstream solution

If the recent SIM evolutions around Remote Provisioning and Embedded SIMs are not widely embraced by operators, the traditional SIM card approach could remain the de-facto solution for the majority of cellular devices – i.e. a single operator, removable SIM card.

This scenario would have little impact on the mainstream market from an operator, vendor or consumer perspective and it would not directly change the current market dynamics (although a lack of evolution may hamper the growth of cellular connectivity in the new market segments).

2. Embedded, Remote Provisioning Solution adopted across M2M (including wearables)

The benefits that the GSMA Embedded SIM Specification offer (e.g. security / protection of the SIM and remote provisioning) could result in widespread adoption across the M2M market including wearables. Work is currently under way at an industry level to expand the approach to the consumer market, consistent with the GSMA M2M specification.

In terms of impact, the Embedded, Remote Provisioning SIM could help these relatively new markets grow and ensure cellular connectivity is used rather than other technologies (such as short range connectivity).

With the potential of billions of M2M devices incorporating cellular connectivity, lower distribution and management costs could benefit many parts of the value chain. Business models are, obviously, still being developed in this arena but longer contracts (for devices with long lifecycles – e.g. smart meters, automobiles), cellular connectivity included in the purchase price (e.g. wearables with low data usage) or bundled data allowances across handsets and wearables are entirely feasible.

In many cases, the distribution channel for M2M and wearable devices will be non-operator retail. In these channels, when the devices/SIM incorporate remote provisioning, it may become harder for the operator to maintain customer relevance at the purchase point. Operator selection could become increasingly driven only on a price basis – mobile operators will increasingly look to new ways of maintaining customer loyalty.

3. Remote Provisioning (removable) SIM expands into handset market

If Remote Provisioning is embraced across the value chain, it may move into the mainstream handset market.

The ability to purchase multiple operator packages would, of course, depend on the type of contract selected at the time of the device purchase.

If a subsidy is applied to the handset being purchased and a fixed term contract (e.g. 12 or 24 months) agreed, a consumer would still be tied to a single operator for the duration of the contract. As the ability to lock a SIM to a particular network remains, an individual operator will be able to determine which of its service offers allow remote provisioning.

Remote provisioning is, initially, likely to be a factor primarily in devices used with prepaid accounts (which are not typically locked to a single operator) or SIM only deals (where the SIM is used in conjunction with an unlocked device which has been purchased separately).

Regulators may also have a role to play in how remote provisioning is deployed- particularly when concerning devices sold in the open market (rather than through direct operator retail).

In this scenario, the impact is likely to be more widespread than when focussed on the newer device segments such as wearables or M2M. Below we highlight some of the areas where an impact could be seen:

- **Cost:** in this scenario, there would be less requirement for an operator to separately purchase and distribute SIM cards. The clearer separation of device and service purchase may also result in an increased proportion of handsets being sold through open distribution (rather than operator channels).

Both these factors have the potential to lower operator retail and distribution costs – which, in many countries, are the primary channel for device sales (both prepaid and post-paid).

- **Churn:** the ability to easily switch between operators without having to change the SIM could increase churn in the prepaid and SIM-only segments. Where national regulations allow, the selection of an operator package could be completed separately from the purchase of the actual device.

There could be an increasing focus on price competition as the main differentiator between service packages/operators. In this scenario, operators will need to look at new ways of maintaining customer loyalty (beyond price) and relevance at the purchase decision point.

Coverage, alone, may not be a differentiating factor as a consumer could keep multiple operator packages for use in different locations within a country (e.g. a cheaper package for use when network coverage is available and a secondary package from an operator with wider geographic coverage for use when needed).

As SIM locking is expected to continue for subsidised handsets on post-paid contracts (for the duration of the subsidy period), it is far less likely that churn in this part of the market will be affected. In this scenario, however, there could be an increase in other retailers (or device vendors) offering financing deals on handsets to spread the cost of the device.

- **Roaming:** widespread adoption of Remote Provisioning could make it easier for consumers to purchase prepaid services directly from a local operator when travelling internationally – rather than using their home network services.

Again, if the handset/SIM is locked to a single operator as part of a longer term contract, this would be less relevant. In these cases, it is likely that the consumer would continue to use the standard roaming agreements in place.

4. Handset market adopts embedded solution with remote provisioning

If Remote Provisioning were to be fully embraced by consumers, operators and hardware vendors then the SIM may become embedded in handsets.

In this case, a consumer would not be able to remove the SIM card from the handset and would only be able to use this type of device with operators participating in remote provisioning.

From an operator perspective, the impact is similar to the “*Remote Provisioning in tablets expands into handset market*” scenario already outlined.

Device costs could also be lowered as an embedded SIM no longer needed the SIM card housing currently used.

Conclusions

This report has highlighted the recent evolution of the SIM and identified potential future development paths. As with the SIM itself, business models will gradually evolve to adapt to new approaches and consumer expectations.

Key messages

1. The industry is working towards one solution that needs to be consistent with the M2M solution, performant and interoperable between the different suppliers
2. 'Soft SIM' should not be used to describe any of the solutions identified in this report. A Soft SIM would be a collection of applications and data, not a piece of physical hardware
3. The pace and the extent of SIM evolution will depend on criteria, requirements and acceptance at a market by market level – widespread deployment will not happen overnight
4. Remote Provisioning in handsets would have a more significant impact on the prepaid and SIM-only market than post-paid
5. Operators will continue to play a key role in how the SIM develops, the pace of evolution and the associated business models

Appendix: definitions

Term/acronym	Definition
SIM card	Subscriber Identity Module, a piece of hardware that stores the identity of the user and the related security keys that are used to authenticate users on a mobile network and validate the device being used.
Remote provisioning	Remote Provisioning is the ability to remotely change the SIM profile on a deployed SIM without having to physically change the SIM itself.
Profile	<p>A profile is defined as a combination of file structure, data and applications provisioned onto, or present on, a UICC or eUICC</p> <p>Operator profile: A profile whose primary purpose is to enable access to a specific operator network</p> <p>Operational profile: A Profile containing one or more Network Access Applications and associated Network Access Credentials and operators' applications (e.g. SIM Toolkit) and third-party applications</p> <p>Provisioning profile: Similar to an Operational Profile which, when installed on an eUICC, enables access to communication network(s), only to provide transport capability for eUICC management and Profile management between the eUICC and an SM-SR</p>
UICC	<p>A physically secure computing device that conforms to the specifications written and maintained by the ETSI Smart Card Platform project. The SIM card is just one example of a UICC. Some banking cards and identity cards are also based on UICC architecture. A UICC can be any form factor</p> <p>It is frequently referred to as 'Universal Integrated Circuit Card,' however, the UICC is defined and standardised by ETSI SCP that state that UICC is neither an abbreviation nor an acronym</p>
eUICC	A eUICC is the name given to a UICC capable of supporting remote provisioning such as the GSMA Embedded SIM Specification.
Machine-to-machine (M2M)	M2M technology connects machines, devices and appliances together wirelessly via a variety of communications channels, including IP and SMS, to deliver services with limited direct human intervention.
GSMA Embedded SIM specification	The 'GSMA Embedded SIM specification' enables remote provisioning and management of Profiles in a eUICC. In its current version it addresses the use cases that exist in M2M type scenarios (meters, automotive) where the operator contract is typically a business to business contract (B2B)
Soft SIM	A collection of software applications and data that perform all of the functionality of a SIM card, but does not reside in any kind of secure storage but in the memory and processor of the communications device
NFC	Near Field Communications (see also: NFC technical specifications)
Subscription	The actual contract between mobile operator and customer for services

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Relied on by a customer base of over 800 of the world's leading mobile operators, device vendors, equipment manufacturers and financial and consultancy firms, the data set is the most scrutinised in the industry.

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