BEREC Report on M2M and permanent roaming

05 December 2024

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Executive Summary

Machine-to-machine (M2M) communications are used across numerous sectors, with solutions often focusing on location tracking, proactive maintenance and status readouts of industrial machines, and technical incident reporting. Given ongoing technological advancements, the importance of machine-to-machine communications is expected to grow, and permanent roaming is increasingly important for many use cases of M2M/IoT, as many devices remain connected to a network outside of their home network/home country permanently. In this context, wholesale agreements are essential to ensure connectivity, and BEREC has accordingly observed an increase in the number of dedicated M2M wholesale agreements between access providers and access seekers.

According to the input collected, the main solutions currently available for wholesale access on the M2M market are wholesale roaming direct access, wholesale roaming resale access, sponsored International Mobile Subscription Identity (IMSI) roaming, and the use of local profiles in countries where permanent M2M roaming is not allowed or restricted (e.g. by national legislation in some non-EU/EEA countries). Sponsored roaming is not a widely favoured solution among MNOs acting as access seekers; however, MVNOs use it more frequently, typically when no other solution is available or suitable to meet their needs or to extend the reach of global connectivity services.

When it comes to the technology used for wholesale access for M2M services, according to the input received, standard cellular mobile technologies are the most popular, followed by LTE-M and NB-IoT. Both MNOs and MVNOs have reported that, in most cases, they have access to all these technologies. However, some MVNOs mention facing restrictions for access to NB-IoT and LTE-M technologies. M2M communications can also occur through satellite connectivity or through applications operating on unlicensed frequencies.

Due to the nature of certain M2M services (e.g. automotive, shipping, transport), the provision of permanent roaming in commercial agreements may be of particular relevance for access seekers. From an access seeker perspective, half of respondents have entered into agreements (within the framework of the Roaming Regulation) that include clauses that prevent permanent roaming, while the rest indicated that they do not have such clauses. The number of agreements allowing permanent roaming has increased since 2021.

However, most access seekers (mainly MVNOs) have highlighted obstacles to negotiate permanent roaming for M2M both within the EU/EEA and outside it. Several MVNOs have noted that negotiations for M2M permanent roaming access are difficult in those Member States with MNOs from big groups that have their own IoT business. From the perspective of MVNOs, M2M services are unduly restrictively defined in EU legislation, hindering the development of the EU Single Market for Internet of Things (IoT). Therefore, MVNOs have made some suggestions on how to improve the legal framework in this respect.

Regarding pricing models for wholesale M2M services, respondents indicate a mix of charging mechanisms, predominantly volume-based charges, charges based on the number of devices (IMSI fee), or a combination of both mechanisms. About half of the respondents (including

both access providers and access seekers) also reported the presence of minimum financial commitments in their agreements.

When it comes to Quality of Service (QoS) and Service Level Agreements (SLAs) for M2M services, the survey indicates that QoS/SLA provisions are not widespread in current relevant roaming agreements. However, as innovative time-critical services with higher transfer rates and lower latency emerge (e.g. autonomous driving and medical services), the need for QoS agreements for certain M2M services beyond basic connectivity may become critical in the future.

BEREC has also collected input from the respondents regarding the challenges and opportunities associated with providing M2M services when permanent roaming is required. MVNOs and smaller MNOs have raised a number of competition concerns, such as high minimum financial commitments, high prices per IMSI, restrictions of access to specific M2M technologies, and clauses preventing the sale of services to domestic customers in the home Member State of an MNO acting as access provider. They have called for regulatory intervention to address M2M connectivity under permanent roaming. In contrast, large group MNOs oppose any relevant regulatory intervention, arguing that domestic competition from low-cost MVNOs poses challenges in the context of expected growth in M2M traffic volumes and devices, which may result in increased signalling costs, low levels of revenue, and potentially risks to network integrity.

Another topic raised in the survey is the importance of a pan-European footprint, seen as both an opportunity and a challenge. MVNOs noted that separate negotiations for wholesale roaming access for M2M make it more difficult to achieve a complete footprint for these services.

Numbering has also been identified as an issue by survey respondents, with some advocating for the harmonisation of administrative rules and procedures among Member States to manage numbering resources as allowed by Article 93 of the EECC.

1. Introduction

1.1. M2M and permanent roaming

Machine-to-machine (M2M) communications are used across numerous sectors including automotive, construction, building management, aerospace, agriculture, shipping, transport, sensors, etc.[1] In most of these sectors, solutions are focused on location tracking, proactive maintenance and read-outs of industrial machines' status, as well as technical incident reporting. Given the technological developments, the importance of machine-to-machine communications is expected to further increase in the future.

Machine-to-machine services are provided over standard cellular mobile technologies (i.e. 2G, 3G, 4G, 5G) as well as over low power wide area (LPWA) technologies for cellular networks (i.e. LTE-M, NB-IoT). In addition to terrestrial cellular technologies, satellite 5G technologies, and technologies using unlicensed frequencies (e.g. LoRaWAN, Sigfox, Wize) are being used (mostly complementary to cellular mobile technologies) for the provision of machine-to-machine services. In addition, there is a variety of shorter range wireless protocols that are also used for M2M and IoT applications such as WIFI / 802.11 (e.g. for domestic use such as NEST), Bluetooth (e.g. for smart watches), Zigbee (e.g. for Hue lamps). However, because such protocols are primarily used on short ranges to extend other fixed and/or wireless networks, they are outside the scope of this report.

Permanent roaming is becoming increasingly important for many use cases of M2M/IoT as many devices remain permanently connected to a network outside of their home network/home country. A common scenario is that the device is assembled and tested in one country, the product in which the device is installed is assembled and tested in another and put on the market in a third country. The decision on which product is shipped to which destination is not always known during the assembly stage. Having unique production lines to distinguish between SIM cards used would be very costly. This complexity is greatly reduced by using roaming instead of local access, therefore roaming can contribute to pan-European and global deployments.

1.2. Relevant legal provisions

According to recital 249 of the EECC[2] and recital 21 of the Roaming Regulation[3] machine-to-machine services are "*services involving an automated transfer of data and information between devices or software-based applications with limited or no human interaction*". Internet of Things (IoT) is not defined in EECC or Roaming Regulation but it is mentioned together with machine-to-machine services. For example, recital 68 of the Roaming Regulation mentions "*In the medium term, facilitating machine-to-machine roaming and internet-of-things (IoT) roaming should be recognised as an important driver for digitising the Union's industry*

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[1] It should be noted that, whilst these sectors represent important growth areas for M2M communications, these same sectors may also benefit from other types of electronic communications services. For example, the automotive sector may also benefit from in-vehicle connectivity services provided for the purposes of an internet access service, (e.g. to set up a mobile wireless hotspot), which would not be considered to be an M2M communications service.

[2] Directive (EU) 2018/1972 of 11 December 2018 establishing the European Electronic Communications Code, available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L1972

[3] Roaming Regulation (EU) 2022/612 of 6 April 2022 on roaming on public communications networks within the Union, available at: https://eur-lex.europa.eu/eli/reg/2022/612/oj

and should build on related Union policies in sectors such as health, energy, environment, and transport. The Commission should regularly assess the role of roaming in the market for machine-to-machine connectivity and in the IoT market. If appropriate, the Commission should also provide recommendations, after consulting BEREC. BEREC should also collect the necessary data to allow the monitoring of the elements to be assessed in the Commission's reports on the development of machine-to-machine roaming and IoT devices provided for in this Regulation, taking into account cellular connectivity solutions based on unlicensed spectrum".

1.3. BEREC relevant work

The topic of machine-machine communications and IoT services has already attracted BEREC's interest. In 2016, BEREC prepared a "*Report on Enabling the Internet of Things (IoT)*"[4], in which it assessed the state of play on IoT services in terms of sustainable competition, interoperability of electronic communications services and consumer benefits. That report presented the most common characteristics of IoT services and concluded on whether IoT services might require special treatment regarding regulatory issues. In general, in 2016 BEREC concluded that no special treatment of IoT services and/or M2M communication was necessary, except for roaming, switching and number portability.

In addition, BEREC pointed out in its Wholesale Roaming Guidelines[5] that: *"According to Recital 21 Roaming Regulation M2M communications are included in the scope of the Roaming Regulation. M2M communications are therefore subject to the limitations of permanent roaming foreseen by the regulation and reasonable requests for regulated wholesale roaming access to offer M2M communications should be met if connected devices are periodically roaming"*. It also stated, *"If M2M communication services are used on a permanent basis in a visited network, for example in cases of prevailing roaming consumption and presence according to the Commission Implementing Regulation (EU) 2016/2286 (CIR), wholesale roaming access should be subject to commercial negotiations"*. Commercial negotiations might be required given the fact that the wholesale charges defined in Articles 9 to 11 of the Roaming Regulation do not apply in case of permanent roaming.

In October 2023, BEREC organized an online workshop titled "*Internet of Things: perspectives and competition*" to assess the state of the art for the delivery of IoT services, their evolution in recent years in view of the technology and regulatory developments and discuss if new competition or provisioning bottlenecks have arisen or if the issues identified in 2016 have been solved. About 150 participants, representing BEREC members and different types of stakeholders, took part in the event. In general terms, the participants shared some common views on the regulation considerations, but expressed diverse perspectives, particularly concerning the diverse bottlenecks that MVNOs and MNOs may face to offer IoT services (e.g. permanent roaming or access to satellite connectivity).[6]

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[4]   https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-enabling-the-internet-of-things

[5] BEREC Guidelines on the application of Article 3 of Regulation (EU) 2022/612 of 6 April 2022 on roaming on public communications networks within the Union (Wholesale Roaming Guidelines), available at: https://www.berec.europa.eu/en/document-categories/berec/regulatory-best-practices/guidelines/berec-guidelines-on-the-application-of-article-3-of-regulation-eu-2022612-of-6-april-2022-on-roaming-on-public-communications-networks-within-the-union-wholesale-roaming-guidelines

[6] BoR (24) 37 Summary report of the Workshop in Internet Of Things: Perspectives and Competition
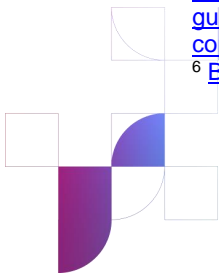
1.4. Methodology of the report

In order to monitor how the market for M2M communications and permanent roaming is evolving, BEREC launched a call for input in November 2023, which concluded on 26 January 2024. The goal was to gather information from relevant stakeholders and prepare a draft report for public consultation.

The questionnaire included a set of common questions as well as specific sections for *access seekers* (i.e. operators requesting wholesale roaming services in order to serve their customers using M2M devices outside of their home country) and *access providers* (i.e. operators serving as visited network operators for M2M devices used abroad).

The feedback provided valuable insights into the current landscape of M2M communications, helping to understand this rapidly evolving field. This feedback is summarised in this report. According to the Roaming Regulation, the European Commission shall, after consulting BEREC, submit, by 30 June 2025, the first assessment report on the functioning of the Roaming Regulation to the European Parliament and to the Council, followed, if appropriate, by a legislative proposal to amend this Regulation. The issues and proposals expressed by the respondents for this report will be used for the analyses BEREC will conduct for the preparation of the Opinion on the Roaming Regulation BEREC intends to provide to the European Commission according to Article 21 of the Roaming Regulation.

The call for input was answered by 29 stakeholders, with the majority (26) being telecommunications providers (including MNOs, MVNOs, resellers). The respondents ranged from small national providers to large telecommunications groups, ensuring a good representation of the market. Three Brussels-based industry associations – GSMA, MVNO Europe, and ETNO – that represent a significant number of telecommunications providers also submitted their responses. In terms of the roles of the operators participating in this survey, the following figure displays the distribution of responses categorized by operator type[7].

Figure 1: Number of operators by role

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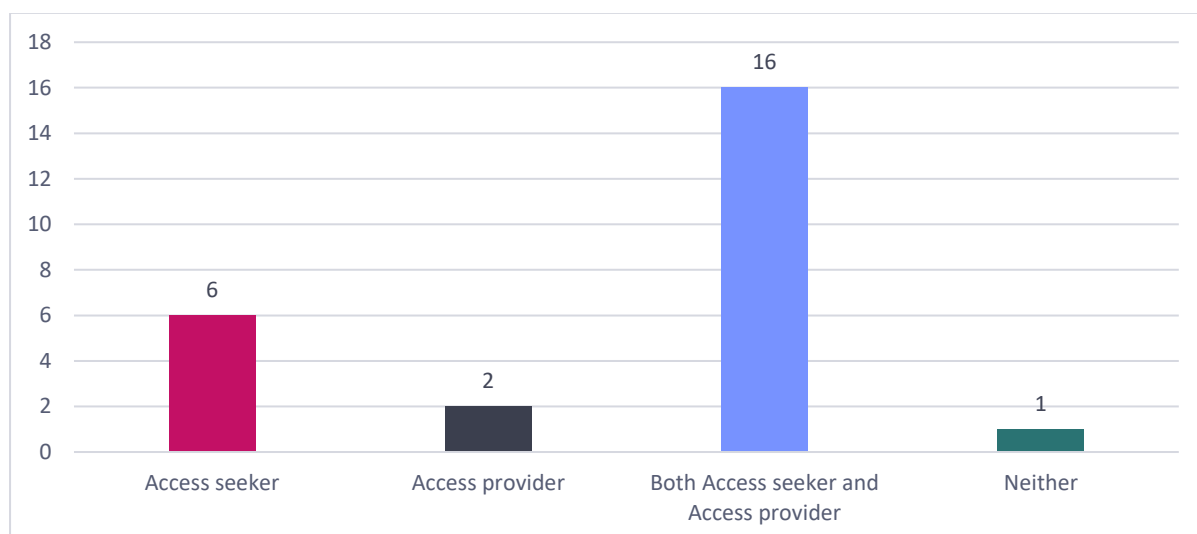
[7] MVNO category includes MVNEs and resellers. Please note that one MVNO did not specify its role, the number of operators therefore adds up to 25, not 26.

Figure 2: Type of provider vs. role
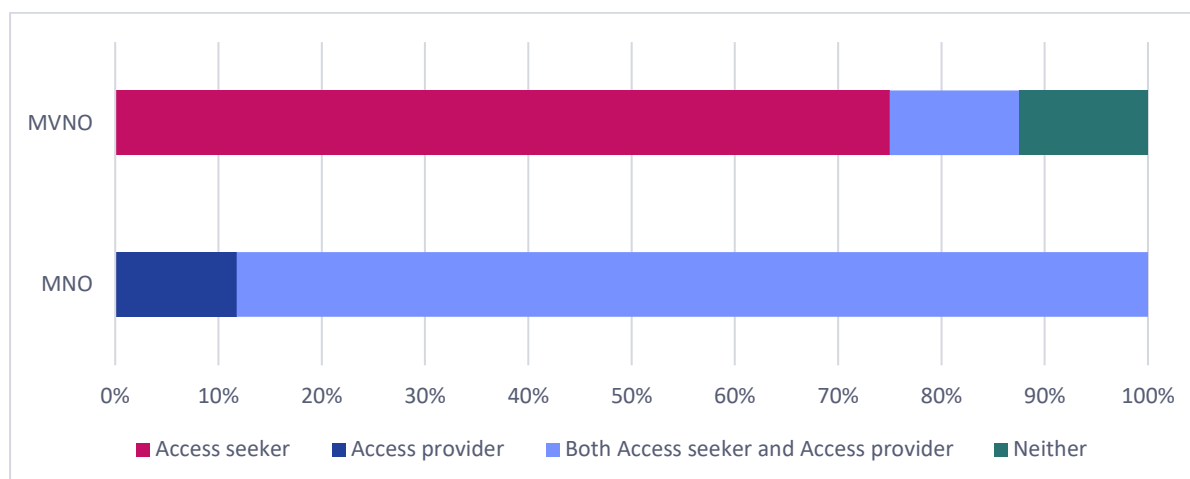
The draft report prepared following the aforementioned call for input was approved during the Board of Regulators meeting on 6 June 2024 (BoR (24) 96) and subsequently published for public consultation, which concluded on 23 August 2024. Relevant comments and insights from contributing stakeholders were incorporated into this final report, where considered appropriate by BEREC, and are documented in the *BEREC Report on the outcome of the Public Consultation regarding the Draft BEREC Report on M2M and permanent roaming*.

2. Evolution of M2M market

Quantitative information on the evolution of connected objects is extracted from the BEREC International Roaming Benchmark Data and Monitoring Report.[8] The data includes, amongst others, the number of connected objects, categorized as either domestic-only or roaming-enabled, along with their respective domestic and roaming usage. The data set spans eight quarters, from Q4 2021 to Q3 2023, covering 29 countries, i.e. all EU member states plus Norway and Liechtenstein.[9] For each item, a constant sample is used, ensuring the composition of countries does not vary over reporting periods. Therefore, if a country reports a given item only for the data collection Q4 2022 – Q3 2023, it will be excluded from the figure (each figure includes information on which countries are excluded because of this limitation). Whether the composition of operators within a country remains the same over all periods cannot be tracked for all countries, which is an additional cause for volatility in the figures.

The data shows that the total number of reported connected devices varies from 86 million to 104 million between Q4 2021 and Q2 2023. Based on the data collected, the country with the largest number of reported connected devices is Italy, followed by Germany and Austria. The reported number of domestic-only connected objects is significantly lower than the number of roaming-enabled objects, and ranges between 10 and 21 million in the constant sample (Figure 3).

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[8] Some values in the graphs of this report vary from the data that BEREC has published in the context of the 29th and 30th Roaming report due to recent data updates provided by NRAs and due to the exclusion of some countries from the totals for the reasons mentioned in the Report.
[9] The full list includes Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

Figure 3: Evolution of roaming-enabled and domestic-only connected objects, EEA totals
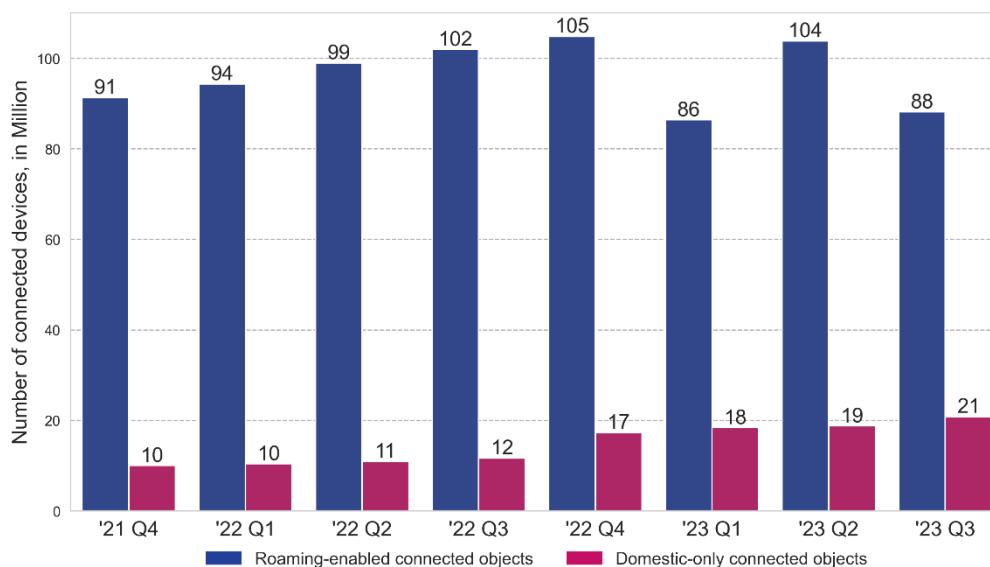
Notes: The series "Roaming-enabled connected objects" includes all countries that submit data for the BMK report, except for Cyprus, Liechtenstein, and Spain. The series "domestic-only connected objects" includes all countries that submit data for the BMK report, except for Cyprus, France, Germany, Liechtenstein, Lithuania, the Netherlands, Slovenia, and Spain. One operator that reported 15-20 million roaming-enabled connected devices in Q4 2022 and Q2 2023 did not report any in Q1 2023 and Q3 2023. This may explain the drop between quarters.

Between 20 million and 32 million connected devices are effectively roaming, as shown in Figure 4. In the third quarter 2023, the percentage of devices roaming at least once over all roaming-enabled devices amounted to more than 36 %.

Figure 4: Evolution of connected objects roaming at least once, EU/EEA total
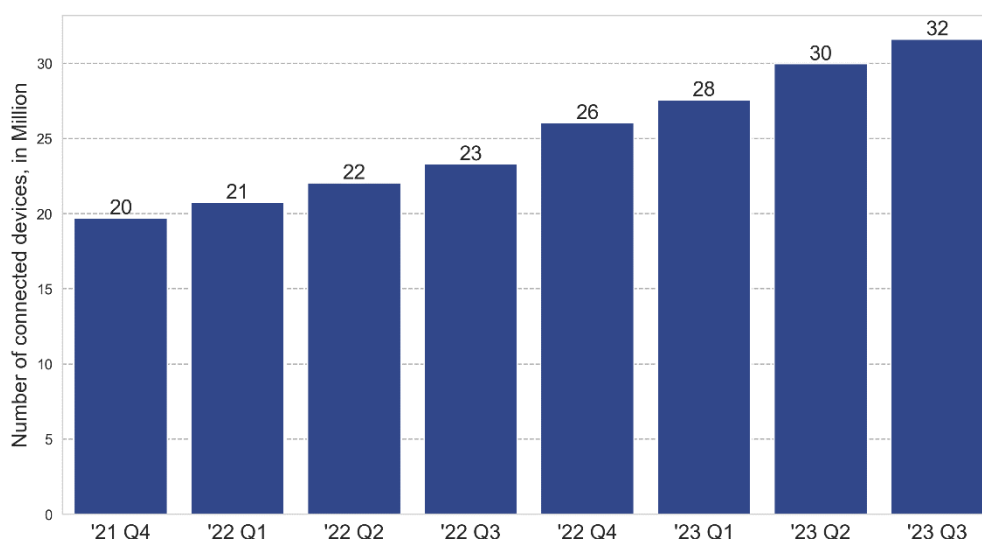
Notes: The series "connected objects roaming at least once" includes all countries that submit data for the BMK report, except for Cyprus, France, Liechtenstein, Lithuania, and Spain.

The reported number of connected objects that are roaming permanently in the EU/EEA has decreased during the sample period, from more than 4 million in Q4 2021 to 3.2 million in Q3

2023. (Figure 5). This finding seems to be due to the changing composition of operators who report this metric in the data collection (see note of the figure for additional explanation).

Figure 5: Evolution of connected objects roaming permanently, in the EU/EEA total
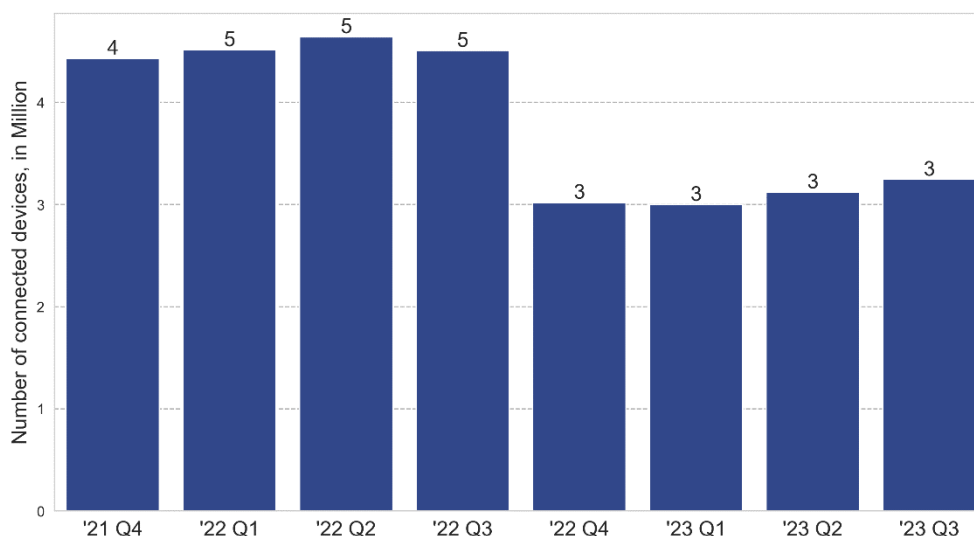
Notes: The series "connected objects roaming permanently" includes all countries that submit data for the BMK report, except for Belgium, Croatia, Cyprus, Estonia, Germany, Italy, Liechtenstein, Lithuania, Norway, and Spain. One operator accounting for a large share of objects that are permanently roaming did not report in the last four periods which explains the drop between Q3 2022 and Q4 2022. The actual figure is even higher but one operator which accounts for approximately 10 million objects did not report in every period and was therefore excluded.

In recent quarters, data usage of roaming connected objects has been almost steadily increasing, while domestic data usage of connected objects has increased overall but with more volatility (Figure 6).

Figure 6: Evolution of domestic GB per connected object per quarter and EEA roaming GB per roaming connected object, EEA average
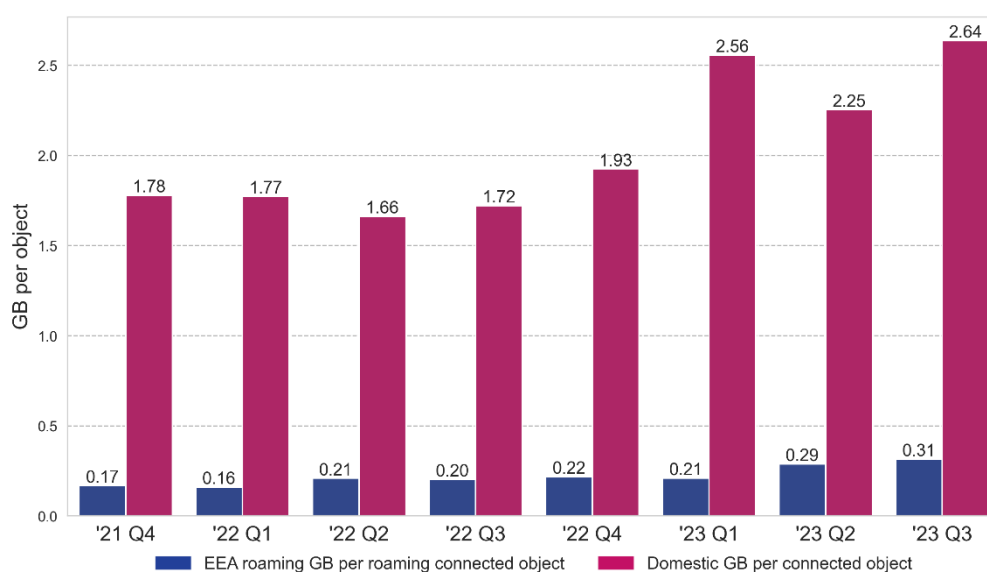
Notes: Both series include all countries that submit data for the BMK report, except for Cyprus, Liechtenstein, Lithuania, and Spain.

3. Wholesale access

3.1. Provision of M2M communications services

Most access seekers and access providers who responded to BEREC's survey have pointed out that they provide retail M2M communications services in their home country.

The provision of M2M communications services also extends beyond national borders. Most access seekers have confirmed that they provide retail M2M communications services abroad with their domestic SIM-cards or with non-geographical IMSI country code.

Only 5 out of 23 access seekers, most of whom are MNOs, indicated that they differentiate between M2M services offered in their home country and those abroad in terms of applied business models. In such cases, the differences pertain to the tariff models (e.g., with different charges based on various roaming zones), separate administrative customer management by distinct teams within the organization, and the deployment of different technologies that may not be available in some countries, particularly outside the EU/EEA.

The respondents have indicated that they primarily provide data connectivity to business users and often include related tailored IT integration services to meet business users' specific needs. They predominantly serve sectors such as automotive, construction, building management, aerospace, agriculture, shipping, transport, sensors, etc. In most of these sectors, solutions focus on location tracking, proactive maintenance and read-outs of industrial machines' status, technical incident reporting, etc.

3.2. M2M wholesale access agreements

The majority of respondents, including both MNOs and MVNOs, indicated they are part of a telecommunications group. With only one exception, all operators within a group highlighted that wholesale access agreements are negotiated at the group level.

Most access seekers (80 %) have concluded wholesale agreements for M2M communications services within the framework of the Roaming Regulation, whereas over 60 % of the access providers have used this framework for concluding agreements. The remaining wholesale agreements for M2M communications services are commercial agreements. In this respect, it appears from the respondents' data that the access providers tend to negotiate more commercial agreements (one-to-one agreements, mainly among MNOs) compared to access seekers (MNOs and MVNOs), where MVNOs tend to sign more agreements under the Roaming Regulation.

Over the last three years, the number of dedicated M2M roaming agreements signed by access seekers has increased from 115 in 2021 to 318 in 2023. While MVNOs/MVNEs/ Resellers accounted for most agreements in 2021 (63 %), MNOs signed the majority in 2023 (62 %). Among the access seekers, MNOs that have responded to BEREC's survey have signed, on average, 4, 7 and 18 dedicated M2M roaming agreements in 2021, 2022 and 2023, respectively. On the other hand, MVNOs/MVNEs/Resellers have signed, on average, 18, 19 and 24 dedicated M2M roaming agreements from 2021 to 2023, respectively.

Figure 7: Number of dedicated roaming agreements signed by access seekers in EU/EEA 2021-2023
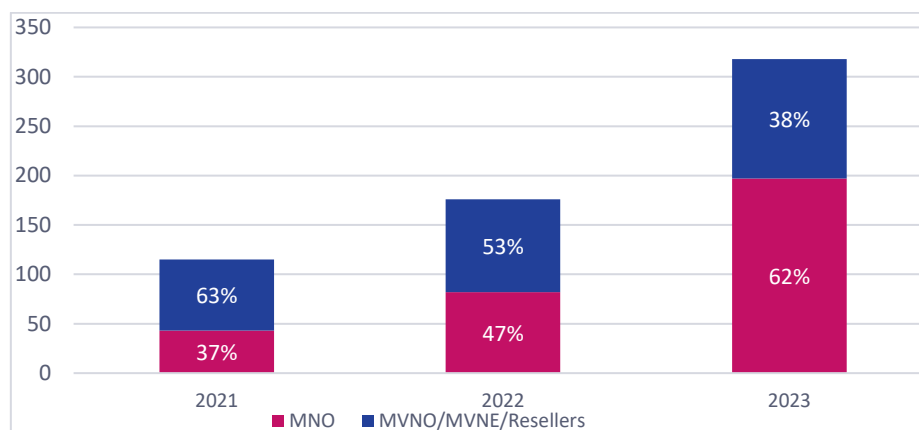
From the information gathered, some MNOs have indicated that no separate terms and conditions for M2M-roaming access are negotiated as access seekers; everything is carried out within the framework of the negotiations for the wholesale roaming agreement. Meanwhile, other MNOs have indicated that they have both types of M2M roaming agreements (terms and conditions for M2M roaming communications services on the same roaming agreement or negotiated separately).

Some of these MNOs have indicated that terms and conditions for M2M roaming communications services are not necessarily negotiated separately but it may occur, normally it depends on the visited network (access provider) whether M2M-roaming access is offered in the same agreement or negotiated separately.

However, most of the MVNOs pointed out that terms and conditions for M2M-roaming access are negotiated separately and they are not published in most roaming reference offers.

Some access providers (4 out of 12, all of them MNOs) reported that they impose certain requirements as a precondition for M2M/IoT devices to connect to their network for roaming purposes.

Among these preconditions, one MNO mentioned some technical requirements and tests for roaming with LTE-M or NB-IoT technologies. Another access provider emphasized the necessity for access seekers to comply with common standards (such as those defined by 3GPP) and to accept commercial terms designed to encourage the removal of harmful or unused devices from the network, aiming to avoid capacity issues and prevent network overload. One MNO requires access seekers to sign clauses aimed at reducing the impact of signalling, depending on the number of connected devices and their technology.

3.3. Different types of wholesale access agreements

There are different types of wholesale agreements for offering roaming M2M communications services. The main solutions currently available in the market include wholesale roaming direct

access, wholesale roaming resale access contracts, and sponsored IMSI roaming[10] (used where previous wholesale access solutions are not available or suitable to meet customer's needs), along with the use of local profiles in countries where permanent M2M roaming is not allowed or restricted (for example by national legislation in some countries outside EEA).

Several MVNOs have pointed out the use of SIM cards to roam globally based on shared mobile country code issued by the International Telecommunications Union (ITU), while MNOs have indicated that they mainly rely on direct roaming agreements.

Most MNOs, as access seekers, have not signed agreements for sponsored roaming for M2M/IoT. On the other side, most MVNOs, as access seekers, have pointed out that they have signed agreements for sponsored roaming for M2M/IoT. An MVNO association has indicated that while sponsored roaming is used in some cases (alongside other solutions), it should be considered that IoT MVNOs use sponsored IMSI roaming where no other solution is available or suitable to meet their needs or to extend the reach of global connectivity services. From MNOs' perspective, sponsored roaming is an additional approach to provide connectivity and, it should be up to the parties involved to agree on the commercial terms applicable to sponsored roaming.

The main advantages of sponsored roaming agreements highlighted by respondents are that a single agreement enables the resale of multiple local roaming partner type agreements, thereby avoiding the need to negotiate several local wholesale access agreements (reducing the negotiation burdens) and providing global coverage.

On the other hand, according to the respondents, the main disadvantages of this type of agreements include uncertainty regarding pricing (any changes in the wholesale price of the visited network are passed on by the sponsor roaming), and the ineffectiveness of disputes against the visited network due to the lack of a direct agreement. Once a sponsored roaming agreement is in place, the using company does not have control over the quality of service and faces data limitations. It has also been pointed out that these agreements tend to incur higher wholesale charges for data and voice services. However, according to an MNOs' association, the host offering sponsored roaming faces the same quality of service challenges as the sponsored roaming party. Additionally, the user can decide to swap IMSIs, and choosing a different host may influence the quality of service and/or data limitations.

Sponsored roaming agreements may further add complexity to the design of IoT and M2M devices, thereby increasing manufacturing cost. Managing two SIMs can increase power consumption, thus increasing the environmental impact of IoT and M2M devices. Additionally, dual SIMs may introduce a second entry point for cyberattacks. However, the MNOs' association mentioned above observes that sponsored roaming can occur either via the use of the identity of the using operator or by using the IMSI of the host MNO. If a user of sponsored roaming changes IMSIs frequently, it will result in additional functionality used (change of identity) that is not available to non-sponsored roaming devices.

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[10] Sponsored roaming is a wholesale solution where an MNO or MVNO uses a dual IMSI solution, where one IMSI range belongs to the sponsor network. The effect of this dual IMSI solution is that the MNO or the MVNO's end users have a second identity while roaming and they can make use of all the roaming agreements belonging to the sponsor network.
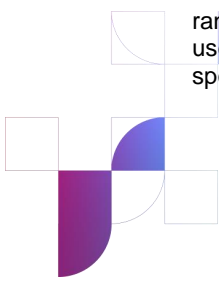
3.4. Access to technologies

The development of mobile technologies and technical capabilities has given the access providers a range of possibilities to support a variety of M2M and IoT applications' service demands.

Most access providers respondents offer all available technologies.[11] This means that wholesale agreements by default cover all technologies that their network can support. One access provider highlighted that NB-IoT holds a special standing as the only technology for which the market requests special commercial conditions due to its nature of permanent roaming and very low data volume consumption.

Regarding access seekers, MNOs have informed that they have agreed to use standard cellular mobile technologies for M2M/IoT communication services (e.g. 2G, 3G, 4G, 5G standards for M2M/IoT, etc.) at least in 353 agreements. In addition, they have signed 142 agreements with LTE-M technology, 135 agreements with NB-IoT technology and 20 agreements offering both technologies at the same time (NB-IoT and LTE-M) without further distinction.

The majority of MVNOs, as access seekers, have responded that they have agreements to use, at least, standard cellular mobile technologies (e.g. 2G, 3G, 4G, 5G standards for M2M/IoT, etc.). Also, all of them indicate that they have agreed to use LTE-M and NB-IoT. However, some MVNOs mention restriction of access to these technologies. Both MNOs and MVNOs have increased the number of roaming agreements for M2M communications services from 2021 to 2023.

Figure 8: Number of agreements signed by technology

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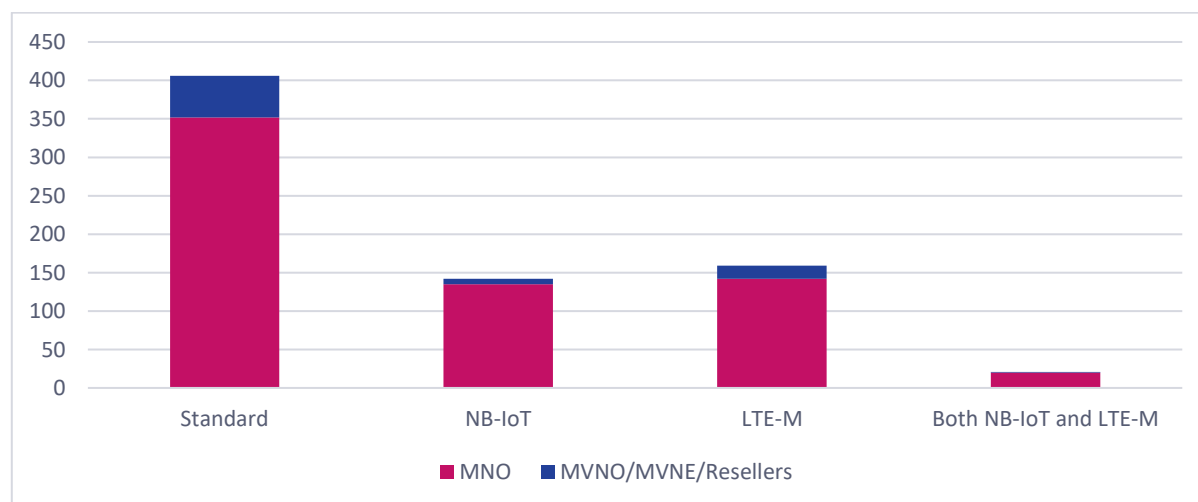
[11] It may be worth recalling that BEREC has also studied the practices and challenges of phaseout of 2G and 3G mobile technologies. Indeed, some of the challenges identified by BEREC in that study concern continuity of connectivity services for M2M/IoT devices hosted on legacy networks. In particular, BEREC observed that access providers were working with their partners to address the market needs and stakeholder engagement was advanced by the report, see here: https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-2g3g-phaseout-practices-and-challenges

Besides standard cellular mobile technologies and low power wide area technologies, M2M communication can also take place via satellite connectivity or through the use of applications operating on unlicensed frequencies.

Regarding satellite communication, a majority of access seekers (14 out of 22) and some access providers (5 out of 15) reported having already concluded or anticipate concluding agreements with providers that offer roaming via non-terrestrial networks using new satellite 5G technologies for M2M/IoT connectivity.

Conversely, a substantial majority of respondents, including both access seekers and providers, reported that they do not offer M2M/IoT communication services employing technologies that operate on unlicensed frequencies (such as LoRaWAN, Sigfox, Wize, etc.) in their respective countries. When employing these technologies, especially LoRaWAN, the operators cited use cases such as asset tracking, metering, parking management, smart city applications, agriculture, and technologies for monitoring climatic values, including temperature, humidity, and air quality.

Most respondents are of the opinion that situations in which these unlicensed frequency technologies displace mobile technologies in the licensed spectrum for M2M/IoT connectivity are quite infrequent. Given the distinct applications, the use of unlicensed and licensed frequencies is generally viewed as complementary rather than as substitutive. In scenarios involving roaming beyond national borders, respondents typically prefer the use of licensed frequencies.

3.5. Permanent roaming agreements

Due to the nature of certain M2M services (e.g. automotive, shipping, transport), the provision of permanent roaming in commercial agreements may be of particular relevance. According to the answers received, around 60 % of the responding access providers indicate explicitly that they allow permanent roaming in their wholesale roaming offers. The MNOs that have signed such agreements specify that permanent roaming is mainly for M2M communication, but if the roaming partners can agree commercially, they will consider including all type of traffic (voice, SMS and data) on a permanent roaming basis.

One MNO explained that MNOs, as access provider, must have the possibility to manage permanent roaming on their networks via contractual clauses. In the view of the respondent, an uneven playing field emerges when MNOs or MVNOs enter national markets based on regulated cost-based roaming prices, as such prices risk to not account for all the potential costs with providing permanent roaming access. According to this MNO, national differences in quality of networks, coverage, license fees and license-based rollout obligations support the need for contractual clauses to manage permanent roaming. The MNO further argues that therefore, MNOs must be free to define commercial terms that make hosting SIMs in permanent roaming a profitable business for the access provider. As long as this freedom stays with the MNOs, negative side effects should be manageable. Moreover, MNOs must have the freedom to charge for SIMs to cover network costs and to be able to monetize network CAPEX as otherwise the customer experience of their own local customer base would deteriorate.

From the access seeker's perspective, half of the respondents have entered into agreements (within the framework of the Roaming Regulation) with clauses that prevent permanent

roaming in their roaming agreements, while the rest have pointed out that they do not have that type of clauses (see chapter 3.6). Most of them have signed commercial wholesale agreements allowing permanent roaming for their M2M customers. Half of the respondents have indicated that permanent roaming agreement is only for M2M/IoT, while the rest of respondents stated that it is for all services (voice, SMS, data, M2M/IoT).

Those access seekers that have entered into agreements with clauses to restrict permanent roaming have mentioned clauses that: (i) limit the number of M2M devices in a given month, (ii) limit (for permanent roaming) the total number of M2M devices (or share of M2M traffic) versus total number of devices (or traffic), (iii) apply a different commercial pricing model depending on certain conditions (e.g. the amount of devices) and (iv) other restriction aimed to prevent the sale of services to domestic customers in the home Member State of the MNO providing access.

From the access providers' side, the clauses included to prevent permanent roaming are (i) the definition of a ratio between M2M/IoT volume versus consumer traffic which should not exceed 10-15 % of the total volume generated by the visiting devices and (ii) commercial penalties such as different pricing when permanent roaming is used for cases other than M2M.

Only two access providers informed that they had seen the need to take legal or technical measures against access seekers to deal with issues caused by permanent roaming of such devices. These two MNOs had either suspended the roaming service in the actual case, or forwarded the case to the local NRA. In one of the cases, it involved an access seeker using foreign IMSIs for a domestic customer whose M2M-devices were of a fixed nature – and the devices were already covered by an access agreement with another domestic network.

Among the access providers that had signed wholesale agreements allowing permanent roaming, the number of signed agreements for M2M/IoT with permanent roaming have been increasing year by year since 2021. In 2021 each MNO signed between zero and 115 agreements. The numbers increased to between zero and 121 agreements in 2022, and between zero and 124 agreements in 2023 per MNO.

In the last three years, the number of M2M/IoT agreements with permanent roaming in the EU/EEA, from respondents acting as access seekers, has increased from 169 in 2021 to 280 in 2023.

On average, MNOs that have responded to BEREC's survey have signed 11, 13 and 16 M2M agreements with permanent roaming from 2021 to 2023, respectively. Whereas MVNOs/MVNEs/Resellers have signed, on average, 15, 19 and 27 M2M agreements with permanent roaming from 2021 to 2023 respectively.

3.6. Obstacles negotiating permanent roaming

Most of the access seekers have pointed out that there are obstacles to negotiate permanent roaming for M2M within EU/EEA or outside EU/EEA[12] (between MVNOs and MNO). However, ten respondents (most of them MNOs) have mentioned that they didn't find obstacles to negotiate permanent roaming agreements for M2M.

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[12] See section 3.8 for more information about outside EU/EEA.
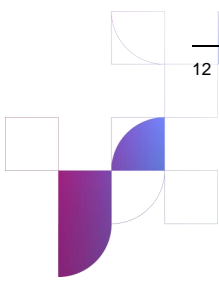
Several MVNOs have pointed out that M2M permanent roaming access negotiation is difficult in those Member States where MNOs from large groups have their own IoT business.

The main obstacles identified include the lack of definition of permanent roaming and M2M in the Roaming Regulation, high financial commitments, high prices per IMSI, restriction of access to specific M2M technologies such as NB-IoT and LTE-M, and clauses preventing the sale of services to domestic customers in the home Member State of the MNO providing access. This last obstacle arises from some MNOs' perspective that consider this permanent roaming provision as an unfair competition against its services. Indeed, they view that this is an issue already affecting the M2M market, which is progressively extending to other markets such as Mission Critical Communications.

From MVNOs' perspective, "Machine-to-Machine" (M2M) is unduly restrictively defined in EU legislation (by way of Recitals only), which hinders the development of the EU Single Market for Internet of Things (IoT). To address this, they propose that the relevant EU legislation should be amended through:

(i)   unequivocal removal of restrictions on permanent roaming for IoT,

(ii)   removal of restrictions on the services to be provided and bandwidth made available (i.e. ensuring that it is not less than that of the host MNO's own retail services),

(iii)   removal of restrictions on which customers services can be provided under the contract (e.g. excluding the home country of the host MNO, excluding types of customers, traffic profiles, etc.),

(iv)   unequivocal wholesale access to all (existing and future) cellular technologies and a prohibition on bandwidth restrictions imposed through wholesale contracts, and

(v)   maximum harmonisation of authorisation, numbering, and related compliance and reporting requirements to NRAs.

3.7. Methods to measure permanent roaming of M2M devices

Methods for measuring or monitoring permanent roaming do not appear to be very widespread, with only one-third of access providers having implemented such methods. In most cases, access providers either did not respond to related questions or directly acknowledged that they do not have such methods in place. Those that have indicated that they have implemented them focus on monitoring the presence and mobility of IoT devices on their network but recognize that, in certain use cases, it can be difficult to distinguish permanent roaming of an end-user from an M2M device. Indeed, one respondent considers that, at wholesale level, it is impossible, for the visited network, to detect a permanent roaming M2M SIM. That stakeholder believes that any definition of permanent roaming based on prevalence of traffic and/or presence in roaming can be easily circumvented using steering techniques. In its opinion, permanent roaming SIMs should be declared as such by the access seeker during negotiations, with the definition of "permanent roaming" being agreed upon by the parties involved in the wholesale agreement. In this context, the respondent suggests that M2M traffic should use a predefined numbering range and a separate APN (Access Point

Name) from P2P traffic, previously negotiated between access seeker and access provider (see more details in section 4.2).

Among the MNOs that currently haven't implemented a method to measure or monitor permanent roaming, only three are planning to do so in the future

3.8. M2M communications outside the EU/EEA

Most access seeker have signed wholesale roaming agreements for M2M communications outside the EU/EEA.

However, they have experienced some differences when negotiating dedicated M2M roaming agreements within the EU/EEA compared to those outside the EU/EEA. In other areas of the world, negotiations for permanent roaming for M2M services are either refused or prohibited by regulations (e.g. Brazil, India, Turkey, the United Arab Emirates, and the Kingdom of Saudia Arabia). Furthermore, access seekers report having to accept clauses limiting the possibility of permanent roaming for M2M outside the EU/EEA (e.g. shaping, traffic blocking or extra-charge may be applied).

Regarding the development of signed agreements with operators outside EU/EEA countries, the numbers show a similar trend to those within the EU/EEA, with a growing number of respondents who confirmed entering into agreements with operators from outside the EU/EEA from 2021 to 2023. This underlines the notion that M2M communication services are evolving into a more global market.

3.9. Summary of the main findings

The M2M communication services wholesale market seems to have gained momentum during the last 3-4 years. Agreements are being established between access seekers and access providers, with a growing focus on truly global solutions as well – not just within the EU/EEA. Well over 65 % of respondents say they use the Roaming Regulation as a basis for their agreements.

BEREC has observed that the most widely used technology in M2M wholesale agreements continues to be data with standard cellular mobile technologies, regardless of the nature of the access seekers (MNO, MVNO, etc). However, it is observed that for all technologies (i.e. cellular mobile, NB-IoT, LTE-M), currently MNOs have more agreements than MVNOs. On the one hand, a reason could be the type of agreements, while MNOs do not usually use sponsored roaming, MVNOs use it more, which would reduce the number of agreements for MVNOs. Another reason could be that MVNOs, unable to offer reciprocal access services to MNOs, may have more difficulties to reach agreements involving specific M2M technologies such as NB-IoT or LTE-M.

In general, MNOs have indicated that no separate terms and conditions for M2M-roaming access are negotiated and usually do not face difficulties pursuing permanent roaming agreement. About 60 % of the access providers allow permanent roaming and have signed agreements permitting it for M2M/IoT. Methods to measure or monitor permanent roaming are not very widespread, with only one-third of the access providers having implemented such methods.

However, MVNOs tend to indicate that they have to negotiate separate terms and conditions for M2M-roaming access and may encounter clauses to prevent or limit the use of permanent roaming. Access seekers have pointed out several provisions in wholesale roaming offers designed to prevent permanent roaming, which are based on controlling volumes or increasing prices.

Most access seekers confirmed that they provide services with their domestic SIM cards or with ITU code sharing outside their countries. However, one of the clauses to prevent permanent roaming is to prohibit the sale of services in the same country as the visited network. On this regard, other terms are incorporated as well to prevent the access seeker from interfering with domestic customers and hence engaging in the national market of the access provider. There are also examples of wholesale agreements that use conditions of time-limited presence from the regulated roaming services as starting points for wholesale M2M agreements. This could present challenges for access seekers, depending on how the M2M devices move between networks.

The evolution of wholesale agreements for the provision of M2M communications is very similar outside the EU/EEA, as they are growing and including all the technologies available for M2M communication services in permanent roaming. However, the main limitation arises in certain countries where regulations do not allow permanent roaming.

4. Wholesale pricing

M2M communications services can have very different consumption patterns compared to traditional roaming services like voice, text and data, and these patterns can vary depending on the specific M2M service that is provided.

While usage/volume is the key driver of network load and hence of the prices for traditional periodical roaming by individuals, this might not be the case for M2M services/devices. Some M2M use cases do not consume any wholesale data at all but utilize network resources in the form of signalling. This might lead to cost for the visited network owner not being recovered when charges are based on volume. Access providers therefore argue that parties need to have the freedom to commercially agree how to charge depending on specific use cases. On the other hand, access seekers argue that such freedom leads to restrictive and discriminatory wholesale access pricing practises that impact competition to the detriment of consumers.

4.1. Wholesale pricing models for M2M

A large majority of both access seekers and access providers have, at least, agreed on **volume-based** charges. Around half of them have also agreed on charging mechanisms based on the **number of devices (IMSI fee),** or a combination of both. The IMSI fee compensates for the limited data volume generated by some services (e.g. sessions of less than 10 kilobytes). The respondents argue that such services require a different charging approach: this could be an IMSI fee for specific IMSI ranges, or per dedicated Access Point Name (APN).

In relation to IMSI fees, respondents exposed that the price per IMSI and additional fees can be imposed, including or excluding usage, per day or per month. Another option is to establish fees based on active IMSIs and then agree on a tiered charge model. This would mean that

there is a certain charge up to a specific number of devices, and a different charge above this number.

Per IMSI fee in addition to volume-based charges is specifically mentioned for NB-IoT. This could be due to the inherent properties of permanent roaming, for devices that use this access technology.

Around half of the respondents (both access providers and access seekers) have also mentioned a minimum **financial commitment.** This could be by volume, or less frequently, a defined QoS, or by APN. Financial commitments could be based on revenue or volume (e.g. minimum annual consumption, or minimum IMSI fees). If the financial commitment is not reached the difference is to be paid. One respondent indicates that the revenue commitments translate into the amount of traffic at unitary rate that respects the revenue committed, while in a volume commitment, the deal structure is based on a unitary basis depending on the overall volume commitment.

Access providers substantiate such minimum financial commitments by emphasizing their need to ensure that access seekers entering the market have a credible foundation and that the wholesale access requests put forward are realistic and economically viable, as in any other commercial agreement. Additionally, access providers argue that each wholesale agreement requires individual negotiation, implementation, and follow-up. Recovering set-up and operational costs requires a minimum level of commitment from the wholesale access seekers.

Furthermore, one respondent states that QoS-based charges are non-existent, because QoS Service Level Guarantees for wholesale roaming are non-existent at this time and network slicing remains underdeveloped. The respondent says that they are aware of some announcements by MNO Groups, but the functionalities have not been extended to MVNOs. This could indicate that terms and pricing solutions offered by the access providers will vary, based on the particular access seeker.

One access seeker specifically described the charging mechanism for sponsored roaming for M2M, which was priced as follows:

1. Upon signing the contract, Service Implementation Fees are paid.
2. Volume of each type of traffic consumed in each monthly cycle in each network within coverage (DATA, VOICE MO, VOICE MT, SMS MO),
3. Unit monthly fee per IMSI Donated, used in each cycle,
4. Commitments apply for minimum annual consumption (MPC).

Overall, it seems that a mix of charging mechanisms are adopted and used.

4.2. Wholesale tariff schemes for M2M/IoT communications services in permanent roaming

8 of the 11 MNOs that have signed agreements allowing permanent roaming for M2M/IoT indicated that the tariff schemes for M2M/IoT communications services in permanent roaming are the same as those for periodic roaming. Since the majority of respondents indicated that volume-based charging mechanism applies for M2M, and sometimes also charging

mechanisms based on the number of devices (IMSI fee), it can be assumed that this is the prevailing charging mechanism also for M2M/IoT services in permanent roaming.

Among the MNOs that indicated that the tariff schemes for M2M/IoT in permanent roaming are different, one MNO explained that specific commercial considerations often could apply for permanent roaming (i.e. the same tariffs up to a certain threshold, above which a different price applies).

Different tariff schemes and financial restrictions are also reported by one of the industry associations where members' experiences indicate that such restrictions on M2M/IoT permanent roaming are widely applied by MNOs/MNO Groups providing wholesale access. They argue that wholesale roaming/wholesale resale roaming contracts, and sponsored IMSI contracts, often contain restrictions on permanent roaming, higher wholesale data charges for permanent roaming, large up-front payment/minimum commitment requirements, per-IMSI fees over and above traffic-related charges, etc., which result in practice in wholesale data roaming expenditure being in excess of the wholesale caps set by Art. 11 of the 2022 EU Roaming Regulation.

The industry association explains that per-IMSI (periodic) fees over and above traffic-related charges are widely demanded by MNOs/MNO Groups. These are particularly problematic where devices (e.g. shipping containers, vehicles) cross multiple national borders per day or per week, causing the overall wholesale charges to far exceed the wholesale roaming data caps set by Art. 11 of the EU Roaming Regulation.

The effect of various restrictions can be to require the wholesale access seeker to introduce a Fair Use Policy to avoid being penalized financially or even cut off by the wholesale access provider.

The same industry association concludes that several of the restrictions, obligations, wholesale pricing approaches, and other stratagems widely employed by MNOs/MNO groups can resemble a constructive refusal to supply wholesale roaming access/resale. From the perspective of access seekers, such strategies aim to protect the market positions of MNOs/access providers and their own IoT businesses from competition by MVNOs. Furthermore, they argue that these restrictions undermine the EU Single Market, disrupt business processes, and limit the ability of European companies (both MVNOs and their business customers) to compete globally in digitized markets. Ultimately, this practice harms European consumers.

During the consultation, concerns were raised by access providers regarding the potential introduction of one common model for IMSI (International Mobile Subscription Identity) fees. They argue that IMSI fees are introduced to ensure fair compensation for visited networks when dealing with M2M/IoT applications that show low data consumption, as charging purely based on data usage would not sufficiently cover the costs. According to these arguments, IMSI fees are a relatively recent development, and various charging models are being explored to ensure fair compensation based on network utilization - rather than an arbitrary

aggregation of unique IMSIs[13]. Finding one common model that encompasses and supports all IoT applications would be very challenging due to their different traffic patterns.

The consultation also brought forward arguments highlighting the need to distinguish M2M traffic from person-to-person (P2P) traffic. This distinction would be important for access providers in agreements where different tariff schemes are applied for the two categories of terminals and/or users. For M2M traffic, it could also be used for distinguishing between traffic that is due to devices being in permanent roaming from those in occasional roaming. It was further argued that such solution for distinguishing between traffic sources could enable the visited network to detect fraud related to illicit routing of traffic. One respondent to the consultation mentioned that the use of dedicated APNs and pre-declared IMSI ranges for certain types of traffic through such an APN could be a possible solution.

4.3. Evolution of average wholesale revenues

In addition to information on the number of roaming-enabled devices and their respective usage, the BEREC International Roaming Benchmark Data and Monitoring Report also includes information on wholesale roaming revenues/payments[14] for connected objects. This section provides an overview of average wholesale roaming revenues for inbound data roaming.[15] Information on wholesale revenues for calls and SMS for inbound roaming, as well as data on average wholesale payments per minute, SMS, and GB for outbound roaming, can be found in the appendix.

We find that the reported average wholesale revenues per GB have decreased by more than 150% during the sample period, from 2.14 Euro in Q4 2021 to 36.3 Euro cent in Q3 2023 (Figure 9).

Wholesale revenues for inbound roaming of connected objects from outside the EEA per GB have decreased from 2.41 Euro in Q4 2021 to 0.33 Euro in Q3 2023 (Figure 10).

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[13] There is a significant difference in the charges based on monthly aggregation of unique IMSIs in the case of the same unique IMSI visiting daily versus 30 different unique IMSIs, as the first will result in 1 time the IMSI fee and the second 30 times the IMSI fee even though the daily network utilisation is the same.

[14] Information on units and revenues is collected for wholesale inbound roaming and information on units and payments is collected for wholesale outbound roaming.

[15] Caveats: The data shown here spans over two data collection cycles. If a country reported a given item only in one of the two reporting cycles, its data is excluded in order not to skew the sample. Therefore, average wholesale revenues shown here can differ from EEA averages reported in the original report. Moreover, the data shown here includes data updates which can also lead to differences with respect to the BMK data report. Please note that the composition of operators may not be the same across periods which we cannot observe directly.

Figure 9: Evolution of wholesale revenues per GB for roaming objects within the EEA, inbound roaming
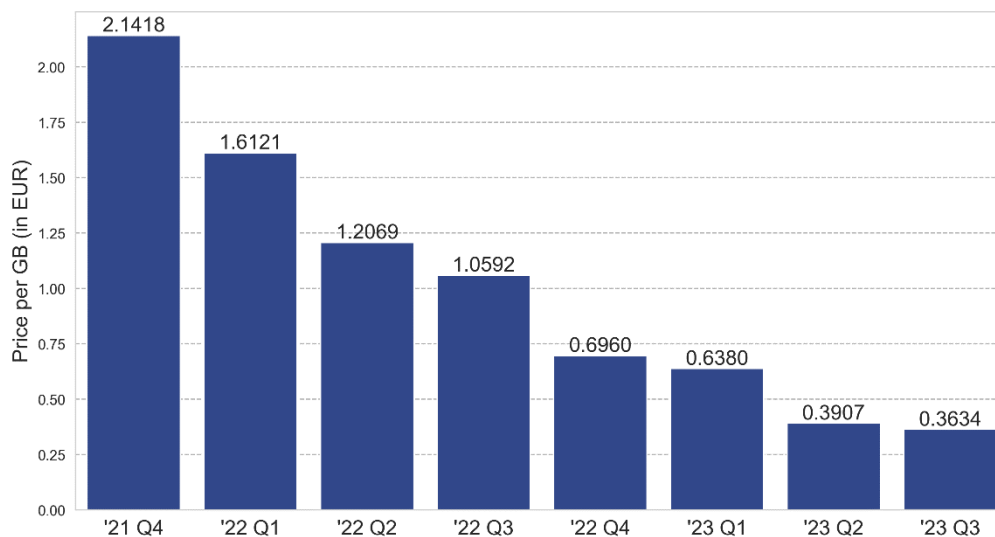
Notes: The series includes data from Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, Greece, Hungary, Italy, Latvia, Malta, Norway, and Slovenia.

Figure 10: Evolution of wholesale revenues per GB for roaming objects from outside the EEA, inbound roaming
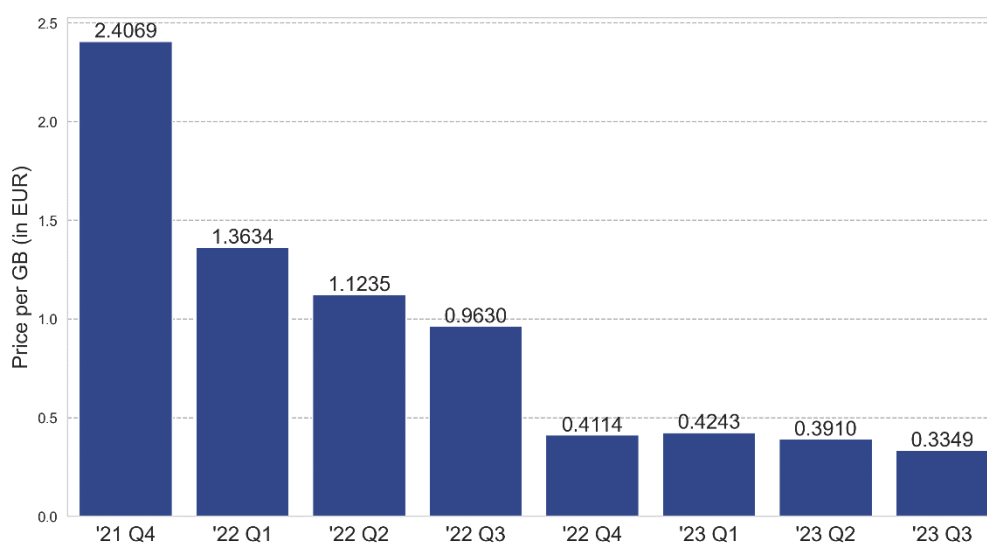
Notes: The series only includes data from Bulgaria, Denmark, Estonia, Finland, Greece, Italy, Latvia, and Norway. Drivers of significant reduction in revenues between Q3 2022 and Q4 2022 have been confirmed.

4.4. Summary of main findings

Various pricing models are used for M2M: volume-based charges, charges based on the number of devices (IMSI fee), financial commitments based on volume or revenue, or combinations of such mechanisms.

From the input received, it appears that relatively few agreements between access seekers and access providers put definitive restrictions on the use of permanent roaming for M2M devices. However, about half of the access seekers, including large industry associations, reported that commercial practices and related contractual terms that, in one way or another, limit such usage – i.e. through use of conditions that in effect puts financial pressure on the access seeker, are widely used. Some examples provided include the application of a different commercial pricing model depending on specific conditions (e.g. the number of devices).

These conditions would typically discourage the access seeker from either placing a very large number of devices in a visited network, or from maintaining them there over extended periods of time. Financial penalties stipulated in agreements mean that the access seeker need to closely evaluate the business case and determine what future costs will arise based on the mobility patterns of the M2M devices in which its IMSIs are used.

Overall, the feedback collected through the questionnaire suggests that access providers are inventive in setting specific terms that, in practice, lead to bilateral agreements for each individual access seeker approaching them.

5. Quality of Service

5.1. Current situation

This sub-section focuses on the current developments in Quality of Service (QoS) related to roaming M2M services. The main outcome of the input provided is that QoS is generally not developed as a requirement for the M2M services, which are mostly provided as best effort services. In other words, in the roaming agreements no specific commitments establish service level agreements, there are no specific QoS conditions applied to the provision of each traffic and commitments on QoS related to M2M services depend on criteria applied by each Roaming Partner.

Indeed, operators do not notice that any different treatment, leading to separate QoS terms for M2M services, is needed, with the only exception of product lines where the available bandwidth is throttled at a lower level. In addition, for the time being, latency is not a requirement and/or most services are not considered critical.

When QoS-related terms for M2M services are considered, the QoS commitments applied to M2M are the same defined in the general agreements, since operators are not used to define separate roaming agreements for M2M services. Operators mostly refer to the QoS parameters defined by GSMA standards, including an escalation matrix for best-effort time resolution. Based on these standards, operators can define different traffic classes for the treatment of data services, differentiating parameters of each class. Some parameters refer to all the technologies, like ARP (Address Resolution Protocol), maximum bit rate for uplink and downlink and guaranteed bit rate for uplink and downlink, while some others are technology specific. However, these parameters are not specific for QoS applied to M2M services, as they are defined for general (aspecific) data flows.

Most SLAs are not specific for M2M services, even because definition and monitoring of specific Key Performance Indicators (KPIs) is challenging. Therefore, SLAs for retail service are applied to M2M services as well. However, the lack of specific SLAs could be
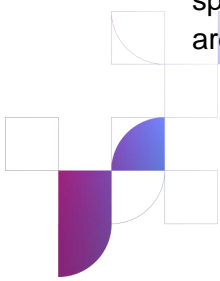
compensated in cases where the access seeker has redundant agreements, allowing for switching visited mobile networks in case of incident. Although no specific SLA is defined for M2M services, consequences for failing to meet SLAs may differ from those defined for retail services. When SLAs are defined, they are negotiated bilaterally and could depend on the severity of faults. One access seeker highlighted that SL-type agreements regulate response times in incident cases and operational management.

Stating the above, generally, operators do not apply QoS-based charging systems for M2M services tariffs. Moreover, the treatment of M2M traffic is generally not differentiated based on the class of the service (e.g. specific use cases such as low data intensity IoT applications with high volume of devices like smart meters or mission critical M2M/IoT applications) and there are no separate agreements for specific classes, or differentiated by the mobile technology generation standard (e.g. 2G, 3G etc). However, specific requests could be dealt with on a case-by-case basis.

Although QoS is mostly not yet developed, some issues related to quality of services have been reported by the access seekers, mentioning issues related to transparency. Access seekers report that, in some cases, access providers activate specific steering profiles on M2M lines, which often limit the quality of service. In other cases, line purging policies are applied in networks without transparently communicating the criteria to the counterpart. Therefore, access seekers mention the need for higher transparency related to QoS of M2M services and equal treatment between own M2M devices and visiting M2M devices.

5.2. Future development

The input received has shown that there are only very few explicit Quality of Service (QoS) parameters or Service Level Agreements (SLAs) regarding the provision of M2M services in (permanent) roaming scenarios.

Nevertheless, future services will change, and innovative time-critical services with higher transfer rates and lower latency (like autonomous driving, services in medicine, etc.) will make QoS agreements necessary.

This sub-section focuses primarily on the potential need for QoS and SLAs, taking into account key findings and recommendations from responding MNOs and MVNOs that address critical aspects of M2M services and reflect the promotion of a robust and fair M2M environment.

Respondents advocate the enforcement of transparent QoS levels in future agreements to ensure the provision of high quality M2M services. There is a focus on discouraging control measures, promoting equal treatment of own and visiting M2M devices, and implementing purging policies to optimise network efficiency in a transparent way.

In the evolution from GSM/UMTS/LTE to 5G, respondents cite the need for improved availability, particularly in aspects such as M2M/IoT portal functionality and specific qualities inherent in each technology. Faster resolution times, higher transfer rates and the evolving need for low latency are highlighted, with the understanding that QoS may not be a predominant concern in agreements until the maturity of 5G Standalone (SA). Indeed, 5G SA allows the development of network slicing, which is currently not fully developed and not available to access seekers. When slicing will be implemented, operators could be able to offer an increasingly differentiated product to M2M customers.

Ensuring the reliability of M2M services is an objective. Some responding mobile providers indicate that direct access to wholesale level information (like service outages, etc.) would be helpful to facilitate effective M2M operations. In future, MVNOs, in particular, should not have to learn of M2M-service outages through customer complaints. Any future SLAs should outline response times, troubleshooting, suppression/resolution times and penalties or compensation structures that could ensure fair and accountable provision of M2M services. Although to a certain extent MVNOs are able to monitor M2M services, a timely information on the functioning of, for example, high-quality and time-critical M2M services could be negotiated in commercial agreements. Distinguishing M2M from P2P traffic, potentially through the use of separate APNs or other mechanisms, could facilitate the establishment of different QoS standards.

Recognising the diversity of future M2M use cases, some respondents propose differentiated QoS measures tailored to specific applications, including traffic shaping mechanisms and threshold management. In addition, a framework for M2M services in roaming is proposed to mirror that of the home market to ensure consistency and predictability.

For future M2M services, the need to develop Key Performance Indicators (KPIs) was emphasised, as was the importance of setting and measuring negotiated KPIs, especially for latency and high-density scenarios. BEREC concludes that more sophisticated M2M/IoT use cases, such as autonomous vehicle connectivity, security applications, etc., require additional QoS elements in wholesale agreements beyond mere connectivity.

6. Competition aspects

Apart from the lack of definition of permanent roaming and M2M in the Roaming Regulation, high financial commitments, high prices per IMSI and restriction of access to specific M2M technologies such as NB-IoT and LTE-M, it appears that the inclusion of clauses to prevent the sale of services to domestic customers in the home Member State of the MNO is one of the main obstacles in the negotiation of permanent roaming agreements for M2M. This is due to some MNOs' perspective that consider this permanent roaming provision as an unfair competition against their services. Indeed, MNOs consider that this is already an issue on the M2M market, which is progressively extending to other markets such as Mission Critical Communications. Several MVNOs have pointed out that negotiating M2M permanent roaming access is difficult in those Member States where MNOs from large groups have their own IoT business.

Thus, from the MVNOs perspective, restrictive commercial practices of MNOs and related contractual terms, such as restrictions[16] on the services to be provided, less available bandwidth than that of the host MNO's own retail services or contractual partners' retail services, refusal to supply wholesale roaming access/resale, limiting roaming up to ninety (90) days including for M2M and IoT services, present a challenge. As a result of these clauses, access seekers are unable to provide ubiquitous services to customers located anywhere in the EU, to the detriment of consumer choice and innovation.

From some MNOs' perspective, domestic competition from low-cost MVNOs poses a challenge in the context of an expected growth in M2M traffic volumes and devices, where

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[16] e.g. excluding the home country of the Host MNO, excluding types of customers, traffic profiles, etc.

many might only have a single IMSI profile yet require pan-EU/EEA coverage. For these MNOs, this growth may lead to increased signalling costs, low levels of revenue, and the growth may potentially hamper network integrity. Thus, they argue that regulated access would inhibit them from rolling out networks and competing based on quality and coverage, and signals to potential investors that their investments will lose value because permanent roaming will remain an opportunity only as long as the pricing and terms of permanent roaming can be negotiated flexibly.

6.1. Specific roaming agreements to provide M2M communication services at national level

Almost half of the respondents (MNOs and MVNOs) indicated that specific permanent roaming agreements are used to provide M2M communication services at the national level, which has competition implications as new electronic communications services providers may enter the market of the visited country. Some of these respondents stress that the coverage of all networks is critical and fundamental to reaching the IoT/M2M market and meeting the needs of business customers who require reliable IoT solutions, especially for certain use cases (e.g., connected cars as a result of the obligation to provide eCall).

Regarding local in-country access agreements, a non-EU/EEA MNO calls for regulatory frameworks that prevent monopolistic practices and encourage local access agreements to promote competition and provide greater choices for consumers. It cites past challenges in negotiating localized M2M resale arrangements with local MNOs and suggests that a regulatory framework that mandates or encourages local access would facilitate competition among service providers and ultimately offer greater choices for the public.

In contrast, the MNOs' association clarified that roaming agreements should not be used for national market competition and emphasised that these agreements do not cover the costs associated with building national networks or fulfilling local regulatory obligations.

6.2. Respondents' proposals for regulatory intervention

Several large MNOs advocate for maintaining the freedom for commercial negotiations to conclude permanent roaming agreements, as the current framework reflects the needs of the market which is growing. This freedom enables operators to continue applying different pricing models adaptable to the specific need of M2M/IoT suppliers, having the wholesale roaming regulation to continue explicitly allowing permanent roaming for M2M and IoT services. They also consider that imposing permanent roaming, without the flexibility to negotiate the related economic conditions for the mutual benefit of the involved parties would risk disrupting national markets, especially when an access seeker consecutively reassesses its marketing strategy to a sole country whereas it had previously called for an international bid.

Thus, for them, there is no need for extended EU/EEA regulatory intervention as the market for IoT/M2M connectivity solutions is competitive, dynamic, innovative and broadly servicing. According to these large MNOs, suppliers have no barrier to entry when looking for connectivity solutions as they can negotiate agreements on commercial basis for permanent roaming with several different providers in each Member State. They also note that European
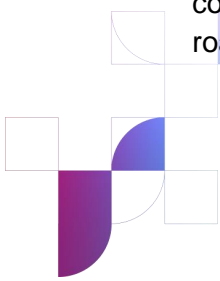
suppliers of IoT/M2M solutions face strong competition from global players, and that for every EU-rule that is not applicable outside the EU for IoT/M2M solutions, global players would be able to gain scale faster than EU suppliers, having also in mind that scale brings increased competitiveness and market foothold for such global players.

MNOs also caution against extending the regulation for M2M, as this could create an imbalance between negotiation parties within the EU/EEA and outside the EU/EEA. Even though the roaming regulation is applicable only within EU/EEA, sponsored roaming offered by EU/EEA-providers might enable non-EU providers to access wholesale M2M services within EU/EEA at regulated prices without having to invest in network infrastructure.

On the other side, MVNOs consider that this current framework enables large MNOs Groups to introduce contractual restrictions aimed at crippling M2M/IoT development by independent providers such as MVNOs. These MVNOs call in particular for removal of restrictions on permanent roaming for M2M/IoT, prohibition on bandwidth restrictions imposed through wholesale contracts, and reduction of regulated wholesale roaming data caps.

Smaller MNOs also consider that unregulated permanent roaming raises competition issues and that as such permanent roaming should be regulated to satisfy both the objective of developing EU wide services but also preserving a fair competition and the incentives to invest in infrastructures. Hence, more regulatory involvement in the direction of facilitating M2M wholesale market (e.g. by imposing permanent roaming) is essential to foster pan-European markets and to enable efficient connectivity for a world that is digitalizing quickly. At a global worldwide level, group MNOs can bear unbalanced profits and losses in some countries by selling services with low margin, as they can compensate this with the balanced profits and losses in other countries. Where they sell services with low margin, it might create unfair competition situation for resident MNO/MVNO.

Price practices represent also a challenge, as well as protectionism from incumbent MNOs. The following protectionist practices have been depicted:

- refusing permanent roaming which depends on each operator's view, some advancing that M2M/IoT is out of scope of the regulated roaming wholesale access obligations,

- procrastinating to offer permanent roaming or blocking non-geographic IMSI range that by definition is permanently roaming: some MNOs identify them as expensive satellite numbers, which is especially an issue for IoT services provided to automotive original equipment manufacturers and which require voice services for eCall. MNOs' association clarified the potential confusion between shared telephone numbers and IMSI ranges and believes that the potential blocking of ITU numbering ranges by some MNOs is problematic, especially in the context of ensuring that eCalls are available to vehicles supporting eCalls. They argue that this issue should be addressed by BEREC and its members to ensure that ITU numbering ranges are not unduly blocked by national operators within the EU.

To address the imbalances in roaming partner agreements, some operators advocate for regulatory recommendations (and if not effective, other type of actions) that promote the application of market and price practices that encourage competitive behavior and ensure return on investments. Nevertheless, for a substantive part of the respondents, regulatory intervention is needed to prevent protectionism from domestic MNOs protecting their market

and market shares. According to these respondents[17], the scope of regulatory intervention should especially target the following aspects:

- Definition of a framework for all the players:

    o better definition of IoT;

    o introduction of a simplified definition of permanent roaming;

    o review the definition of "roaming day" which is too restrictive and cumbersome in case of absence of traffic.

- Incorporate M2M/IoT as part of the current wholesale deals (alternatively, agree on dedicated M2M/IoT roaming agreements).

- Removing restrictions on permanent roaming for IoT.

- Prohibiting MNOs from setting up commercial or technical barriers for M2M and IoT permanent roaming.

- Roaming pricing to avoid both eviction price practices but still maintain the proper incentive to invest, that could be a commercial model based on volume and revenue generated (separated for M2M/IoT).

- Allow access to all operators at a national level for M2M/IoT as an alternative to permanent roaming scenario.

- Make sure that equivalent national roaming agreements for specific use cases can be negotiated to avoid the eviction by pan-European groups of smaller operators.

- Differentiating wholesale data roaming charges based on the type of usage, the type or the location of the customers being served should not be permitted going forward.

- Further substantial reduction of regulated wholesale roaming data caps.

- Differentiated (i.e. higher) wholesale roaming caps for M2M in permanent roaming use, per-IMSI fees, signalling fees, up-front and recurring fees should not be permitted in wholesale contracts.

7. Other issues

7.1. Roaming footprint

Achieving a broad roaming footprint is considered important for the provision of M2M services. Roaming and permanent roaming allow mobile M2M service providers to achieve a complete footprint for these services.

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[17] The proposals are not ranked or assessed by BEREC. Some of them were supported by more than one respondent. Furthermore, some suggestions may not be possible to be combined with the rest.

Having to negotiate separately wholesale roaming access for M2M makes it harder to achieve a complete footprint for these services. There is no clear picture how many visited MNOs negotiate separate terms and conditions. Most MVNOs reported they must engage in separate negotiations. Among MNOs, only one reported having separate terms and conditions. A third of the total (both MNO and MVNO) stated that it depends on the visited MNO if a separate negotiation is necessary.

Some respondents reported that there are issues (e.g. delays) in the handover between mobile communications networks at border crossings for M2M services. One respondent explained that there is no seamless border handover yet, which causes short period without home or visited network signal. Only a small minority of respondents reported noticing a difference between crossing internal EU/EEA borders and crossing borders between EU/EEA and non-EU/EEA countries. Looking ahead at future perspectives, other technological developments, like Low Earth Orbit Satellite technology, will impact M2M roaming and introduce larger availability of footprint/coverage for end-users using M2M devices.

7.2. Challenges and opportunities arising from expected growth in M2M volumes and devices

The vast potential of IoT to drive economic growth and improve societal welfare across various sectors, including automotive, utilities, healthcare, public safety, and agriculture, has been highlighted by a non-EU/EEA MNO. This Operator believes that the global nature of M2M communications is a strong asset that allows cross-border opportunities and creates economic benefits for EU/EEA countries, enabling successful exports and enhancing the global competitiveness of European businesses. This respondent calls for regulatory policies that facilitate market entry by diverse participants and encourage the development of innovative M2M technologies and business models. They argue that supportive M2M policies must be based on the premise that the new business models for IoT differ significantly from those of traditional mobile phone and tablet segments.

Another EU MNO also highlights the diversity within the M2M market, ranging from consumer applications like home automation (e.g., alarm systems, appliances) to industrial uses such as automation systems and infrastructure monitoring, as well as the diverse needs of IoT applications. They suggest that flexibility in agreements is crucial to support different use patterns and technological requirements, and they advocate for a careful analysis of these different market segments before introducing any regulatory obligations. From their point of view, a one-size-fits-all approach could hinder the fair evolution of the M2M market, especially in terms of transparency obligations, which should be differentiated between large companies and consumer applications.

The expected increase in machine-to-machine traffic volumes and devices, along with efforts to establish a pan-EU/EEA footprint, is anticipated to significantly boost the number of permanently roaming M2M devices on networks. This development is viewed by responding MNOs and MVNOs as both a challenge and an opportunity, with opinions divided evenly between the two viewpoints.

In addition to the competition-related challenges discussed in the previous chapter, respondents noted an increased risk of misconfiguration in 4G and 5G networks. These technologies offer various implementation options that can differ between networks,
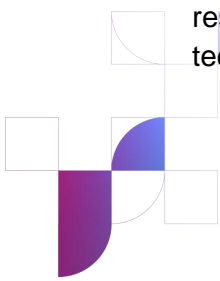
complicating seamless integration. Moreover, as described in section 7.4, certain M2M applications tend to produce high levels of signalling but low traffic volumes, presenting additional technical and economic challenges. There is also concern that the rapid increase in roaming devices, without proper capacity planning, could compromise the integrity of visiting networks.

Despite these challenges, many respondents acknowledge that permanent M2M roaming offers numerous opportunities and benefits. They highlighted that permanent roaming can be a significant source of recurring revenue for visited mobile network operators, aligning with market demands. It offers a mechanism for monetization, spurring investments in innovation, 5G deployment, and the advancement of future technologies. Given the nature of M2M/IoT cross-border connectivity, permanent roaming can also pave the way for expansion into foreign markets. Furthermore, by drawing more traffic, permanent roaming aids in developing more robust infrastructure. It also guarantees widespread connectivity for M2M/IoT devices produced within a global supply chain, contributing to further digitalization and economic growth. Finally, in sectors with critical use cases, such as security and health, permanent roaming agreements facilitate multi-operator capability, ensuring continuous and dependable connectivity.

A dedicated study for BEREC provides more information on related issues in terms of wholesale mobile connectivity, trends and issues for emerging technologies and deployments.[18]

7.3. Numbering

Some MNOs and MVNOs consider that numbering rules do not hinder access providers and/or access seekers against the backdrop of permanent roaming for M2M devices. However, from MVNOs' perspective, numbering has been an obstacle in negotiating permanent roaming agreements for M2M within the EU/EEA. This has led to a dispute where an MNO refused to grant an EU regulated roaming agreement to an MVNO on the basis that the Roaming Regulation did not apply when a shared mobile country code (901-XX) issued to an access seeker by the International Telecommunications Union (ITU) is used to provide the services. The NRA and BEREC were of the opinion that the Regulation applied to access seekers using a shared mobile country code[19]. As a result of this dispute, the MNO was required to provide the MVNO with a draft regulated roaming agreement.

Furthermore, the identification of M2M devices or usage when they are present in a network remains difficult as numbering ranges for M2M devices are inconsistent: there is no specific IMSI range specified within a specific M2M roaming agreement, not all use global numbering ranges as geographical IMSI ranges are also used for M2M services. There is no tool to distinguish M2M traffic and it remains impossible to monitor numbering ranges for M2M devices across all EU/EEA countries to identify M2M numbers assigned to specific MSISDNs, as M2M devices can be assigned regular end-user numbers. For a responding operator, resolving identification issues requires access providers to have contractual clauses to protect networks from disruption by M2M SIMs or to use IMEI (TAC) combined with traffic patterns. However, the lack of a consistent usage of IMEI for M2M devices, combined with the absence

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[18]   https://www.berec.europa.eu/en/document-categories/berec/reports/study-on-wholesale-mobile-connectivity-trends-and-issues-for-emerging-mobile-technologies-and-deployments
[19] BEREC Opinion on BNetzA request on providing wholesale roaming access, BoR (18) 98, 1 June 2018.

of a consistent and up-to-date IMEI database, makes this solution difficult to implement. One MNO suggests that M2M services should have a dedicated range of numbers to be easily identified, along with suitable safeguards for numbers (out of the dedicated range) used for early M2M services, and to evaluate the need for introducing a specific subrange for permanent roaming purposes.

Several MNOs call for the harmonisation of administrative rules and procedures between Member States to manage numbering resources allowed by article 93 of the EECC, as the use of ITU international numbering resources may pose challenges when an operator decides not to allow such traffic through its network. Some operators suggest that NRAs may ensure that regular information about ITU numbering resources are shared among national networks.

In conclusion, the use of numbering rules should be without prejudice to the application of the Roaming Regulation, including the rules preventing anomalous or abusive use of roaming services which are subject to retail price regulation and benefit from regulated wholesale roaming rates. Numbering should not be used to prevent access providers from concluding roaming agreements with access seekers, nor to impose different wholesale charges based on the number ranges used to provide M2M/IoT services, nor to prevent ITU assigned numbering resources from being used for specific uses cases. The use of a shared mobile country code (901-XX) should not be an obstacle to the conclusion of roaming agreements.

It is also noted that disputes can be filed at the NRA of the country in which the use of shared country code numbers (or any other EU numbering range) is considered a reason to refuse a roaming agreement.

The extra-territorial use of numbering resources remains under the jurisdiction of the NRA who assigns those numbers in accordance with Article 93(4) of the EECC. For example, if an NRA in the EU allows such usage then there is no reason to refuse negotiations based on the fact that there is extra-territorial use of numbering resources.

7.4. Signalling

M2M SIMs generate high levels of signalling and low levels of traffic, which means increased signalling costs. It's not a typical M2M wide problem but depends on the type of M2M application/device. For example, a known permanent roaming application is eCall. The signalling load of eCall is equal to the traffic load which is very limited (only when a car activates the eCall system). But M2M devices might act differently with a high signalling load compared to the traffic. Depending on the M2M application, roaming M2M devices have different implications for the signalling and traffic consumption. Therefore, the signalling load due to these roaming M2M devices is not predictable for the wholesale roaming access provider.

There are currently in the market no charging mechanisms in agreements for M2M services based on volumes of signalling traffic. However, signalling traffic caused by roaming M2M devices can be a potential burden when it leads to a signalling overload risking performance drops which impact retail roaming usage. MNOs aspire to take measures against signalling overload to keep ensuring network stability. MVNOs consider these measures as restrictive commercial practices and they consider that signalling costs are in practice lower than the ones claimed by MNOs. EC is currently working in updating the EC cost model for roaming services. In this update, EC will also try to assess the inclusion of signalling costs as well as

cost of M2M services in general in this model. The finalization of the model is expected in Q4 2024.

7.5. eCall

eCall services may be provided under conditions of permanent roaming. These services enable voice services for in-car emergency calling in the case of a serious accident.[20] Wholesale agreements serving the automotive industry include permanent roaming for voice services for eCall. The European Commission is involved in the regulation of emergency communications, eCall (and New Generation eCall), and related EU Type Approval Regulation for vehicles.

Some respondents noted that when these voice services are delivered using a non-geographic IMSI range that by definition is permanently roaming, an international non-geographic MSISDN is also used (+882, +883…). Some providers block this range as they mistakenly identify these as 'expensive' satellite numbers. The implication of such blocking is that call-back calls from the Public Safety Answering Point to the car in a serious accident will not function as expected, even if a roaming agreement is in place.[21]

One respondent points out that certain use cases (e.g. connected cars) may need to be supported by a minimum of two access networks because of the obligation on car manufacturers to provide eCall, and suggests a need for supports for permanent roaming at a national level in such cases. BEREC is not aware of any minimum obligation in the eCall regulation that requires eCall to be supported by a minimum of two access networks per country. eCall is an automated 112 call, and therefore, the general obligations for voice calls to 112 apply regarding access to networks. BEREC also notes that connected cars may feature other types of electronic communications services, which would not be considered an M2M service (e.g. the provision of mobile internet access service to car passengers through an in-car WiFi hotspot).

The success of NG eCall heavily depends on compatible VoLTE roaming profiles. It is therefore essential that appropriate roaming agreements are negotiated and compatible VoLTE roaming profiles are implemented for NG eCall. Rigorous end-to-end testing is also necessary. Public safety should not be impeded by refusals when negotiating a wholesale roaming agreement.

7.6. M2M devices used permanently in a different country from their home country

A significant number of respondents (9 out of 22) reported facing challenges when M2M devices, such as cars, move permanently from their home country to another. Some of these challenges arise from non-transparent policies and network access restrictions implemented by mobile network operators in certain countries outside the EU/EEA, creating uncertainty and

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[20] Automatic emergency 112 eCall by onboard vehicle systems – EU-wide interoperability specifications (europa.eu). However because versions of eCall are not compatible with newer generations of network technology other issues than described here may be of relevance, see also footnote **Error! Bookmark not defined.**.

[21] See also https://eena.org/blog/resolving-the-ecall-callback-issue/ or https://docdb.cept.org/download/4029

adversely affecting both service continuity and quality. Additionally, as mentioned in a previous section, there are countries where regulatory bodies explicitly prohibit permanent roaming.

A particular issue noted, especially with vehicles, is that the IP address of the home market is sometimes used to determine the content to be provided. This approach becomes problematic when a device permanently relocates, as the content may not be suitable for the new country, for example, due to language differences.

The feedback further points to difficulties in managing device use and location, alongside financial implications: when a device permanently relocates from the home country, the cost structure for the operator changes. A respondent pointed out that this may necessitate adjusting the costs charged to the customer, who might then decide to exercise the withdrawal clause.

Additionally, in this context, a respondent expressed the opinion that wholesale access seekers, who do not own and control the visited network, may lack sufficient incentives to ensure network integrity through capacity planning. For this reason, the respondent argued for the critical need to preserve the ability to negotiate permanent roaming agreements on a commercial basis. This would allow access providers to define binding contractual terms essential for safeguarding network integrity, crucial in a scenario with a high number of roaming devices, also stemming from a substantial influx of devices permanently relocating from other countries. According to the respondent, limitations on commercial freedom to agree on permanent roaming could lead to situations where network integrity is endangered and network resources are depleted, negatively impacting both roaming and domestic users.

8. Appendix

8.1. Figures on units per connected object

Figure 11: Evolution of domestic outgoing minutes and domestic SMS per connected object, EU/EEA average
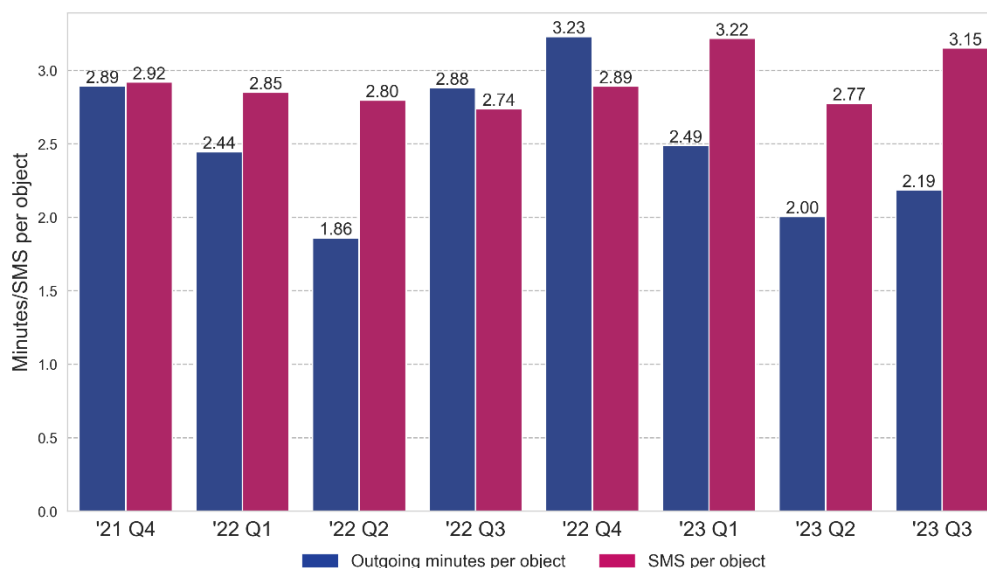
Notes: The series "domestic outgoing minutes per connected object" includes all countries that submit data for the BMK report, except for Belgium, Cyprus, Liechtenstein, Lithuania, and Spain. The series "domestic SMS per connected object" includes all countries that submit data for the BMK report, except for Cyprus, Liechtenstein, Lithuania, and Spain.

Figure 12: Evolution of EU/EEA outgoing roaming minutes and roaming SMS per roaming connected object, EU/EEA average
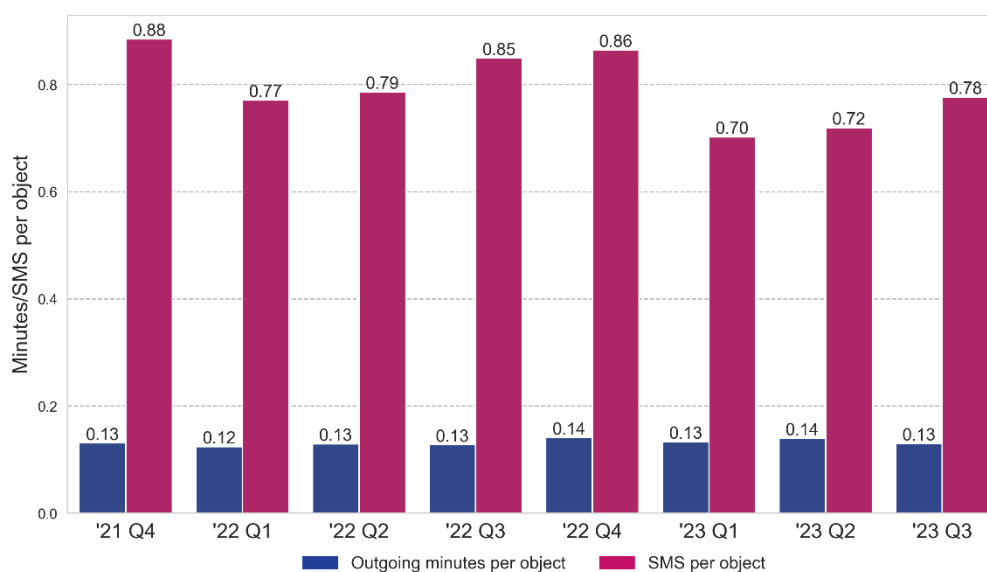

Notes: The series "outgoing roaming minutes per roaming connected object" includes all countries that submit data for the BMK report, except for Belgium, Bulgaria, Croatia, Cyprus, Denmark, Liechtenstein, Lithuania, Malta, and Spain. The series "roaming SMS per roaming connected object" includes all countries that submit data for the BMK report, except for Cyprus, Liechtenstein, Lithuania, and Spain.

8.2. Figures on inbound roaming, per minute and per SMS prices

BEREC notes that the reported average wholesale revenues per minute for EEA inbound roaming have been decreasing over the sample period, from 2 Euro cent in Q4 2021 to 0.67 Euro cent in Q3 2023 (Figure 13). During the same time span, average wholesale revenues per SMS have decreased as well, from 0.35 Euro cent to 0.06 Euro cent (Figure 14).
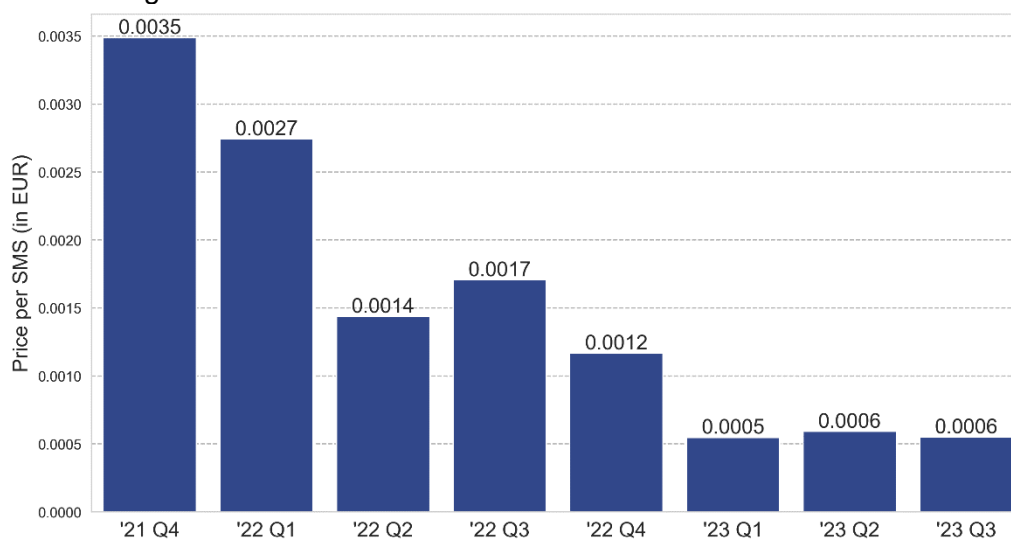
At the same time, wholesale revenues per minute charged for inbound roaming of connected objects from outside the EEA has decreased as well, from 7.88 Euro cent to 3.66 Euro cent (Figure 15). Outside-EEA inbound average roaming wholesale revenues per SMS have also decreased over the sample period, from 0.76 Euro cent to 0.41 Euro cent (Figure 16). Please note that the number of operators that consistently provide wholesale revenues is very limited and the figures reported below only reflect a subset of the European market.

Figure 13: Evolution of wholesale revenues per minute for roaming objects within the EEA, inbound roaming
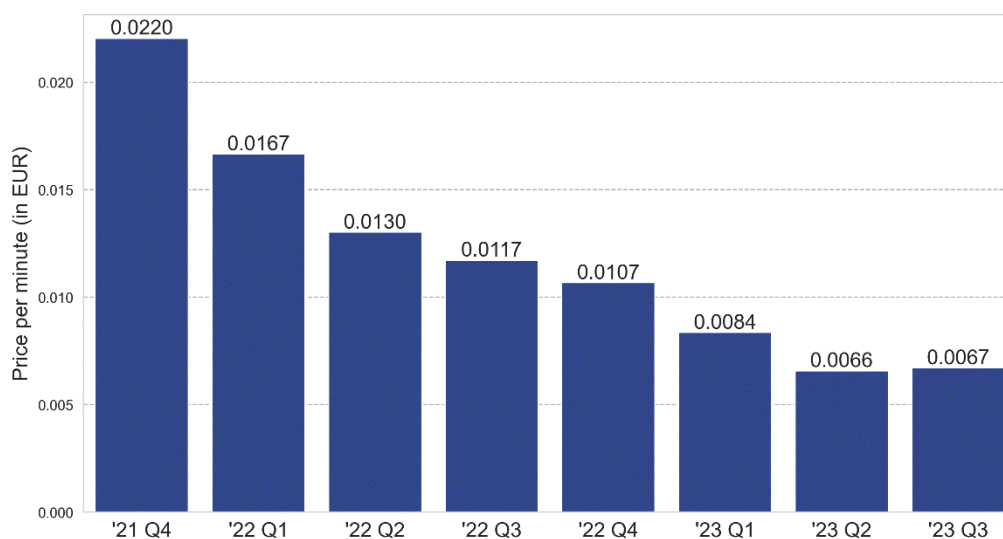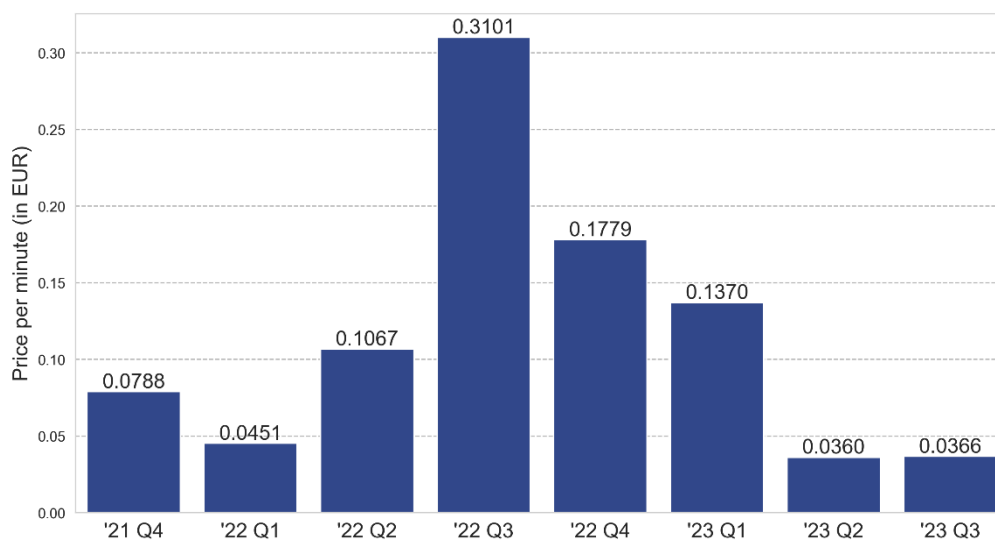

Notes: Figure includes data from Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, Italy, Latvia, and Norway.

Figure 14: Evolution of wholesale revenues per SMS for roaming objects within the EEA, inbound roaming

Notes: Figure includes data from Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, Greece, Italy, Latvia, and Norway.

Figure 15: Evolution of wholesale revenues per minute for roaming objects from outside the EEA, inbound roaming

Notes: Figure includes data from Bulgaria, Denmark, Estonia, Finland, Greece, Latvia, and Norway.

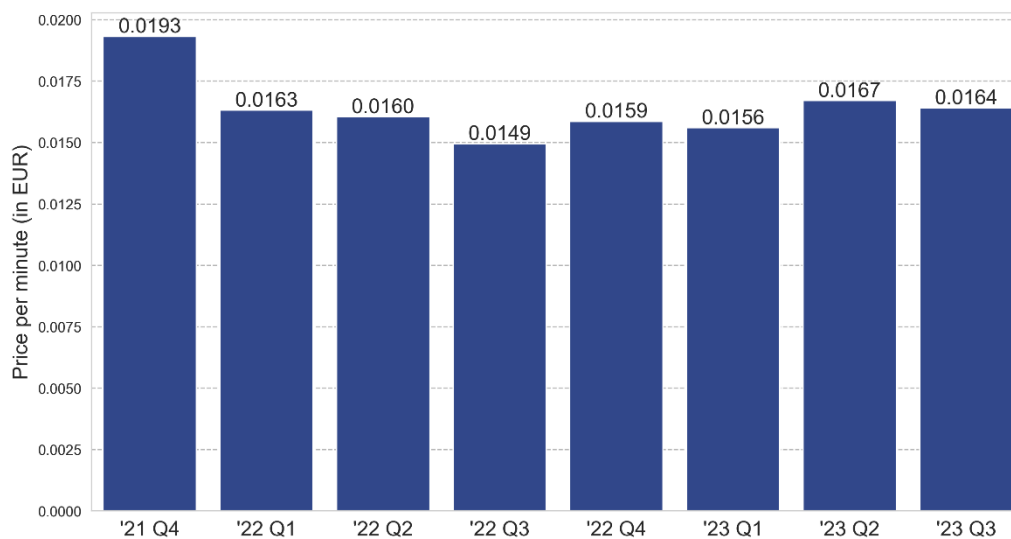Figure 16: Evolution of wholesale revenues per SMS for roaming objects from outside the EEA, inbound roaming
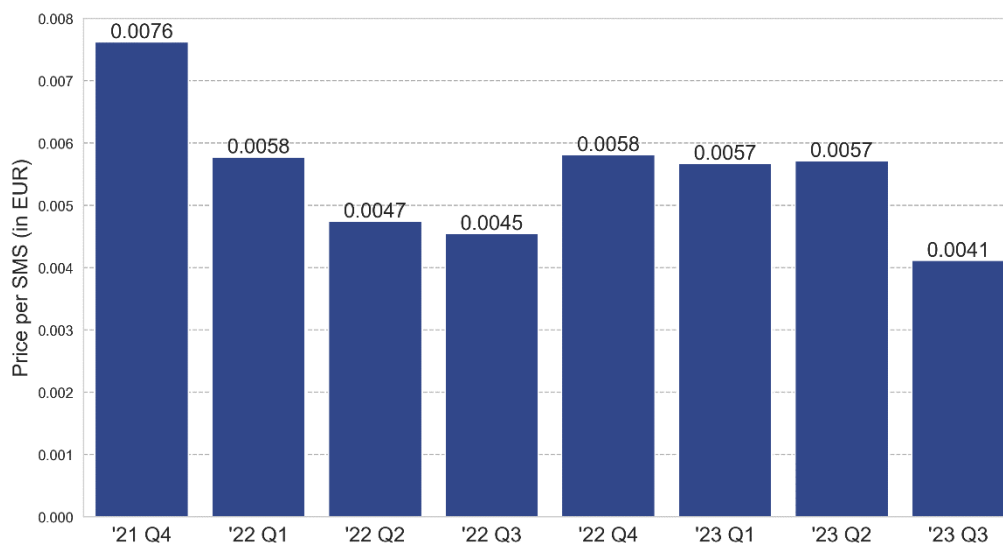
Notes: Figure includes data from Bulgaria, Denmark, Estonia, Finland, Greece, Latvia, and Norway.

8.3. Figures on outbound roaming

Wholesale payments per minute for outbound roaming within the EU/EEA vary little, over the whole period the values vary between 1.49 Euro cent and 1.93 Euro cent (Figure 17). Prices for SMS have more than halved over time (Figure 18). Outbound within-EEA roaming payments for data decreased as well, from 2.02 Euro in the fourth quarter of 2021 to 0.76 Euro in the third quarter of 2023 (Figure 19).

Wholesale payments per minute for roaming objects outside the EU/EEA are higher than wholesale prices per minute for outbound roaming within the EU/EEA and show a more than decrease over the sample period from 0.18 Euro in Q4 2021 to 0.14 Euro in Q3 2023 (Figure 20). Outbound roaming wholesale payments per SMS and GB outside the EU/EEA both decreased over the sample period, payments per SMS from 0.88 Euro cent to 0.63 Euro cent (Figure 21), and payments per GB from 3.33 Euro to 2.55 Euro (Figure 22).

Figure 17: Evolution of wholesale payments per minute for roaming objects within the EU/EEA, outbound roaming

Notes: Figure includes data from Austria, Denmark, Italy, Latvia, Poland, Slovakia, and Sweden.

Figure 18: Evolution of wholesale payments per SMS for roaming objects within the EU/EEA, outbound roaming
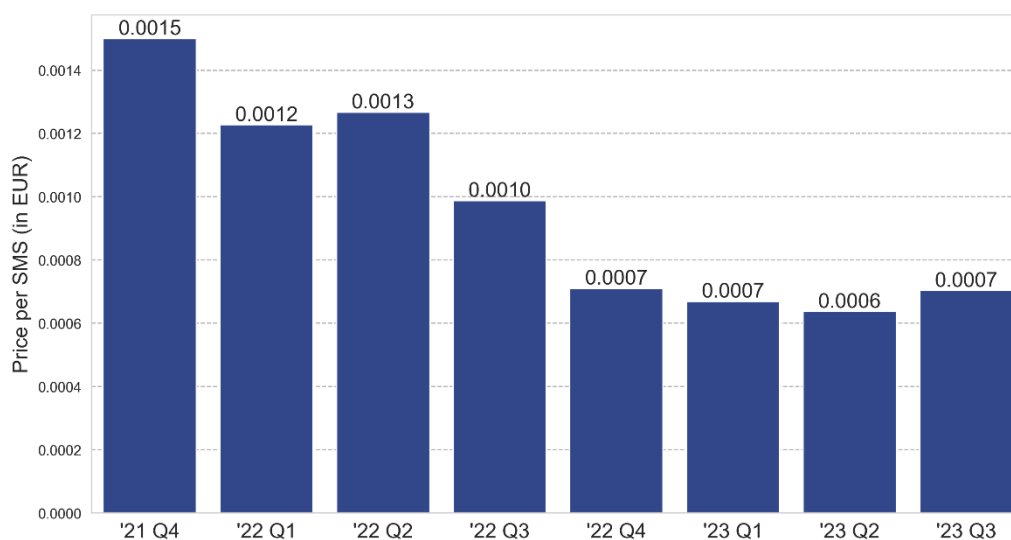
Notes: Figure includes data from Austria, Bulgaria, Denmark, France, Italy, Latvia, Malta, Poland, Slovakia, and Sweden. Austria is excluded for Q2 2022 due to an extreme outlier value.

Figure 19: Evolution of wholesale payments per GB for roaming objects within the EU/EEA, outbound roaming

Notes: Figure includes data from Austria, Belgium, Bulgaria, Denmark, France, Italy, Latvia, Malta, Norway, Poland, and Sweden.

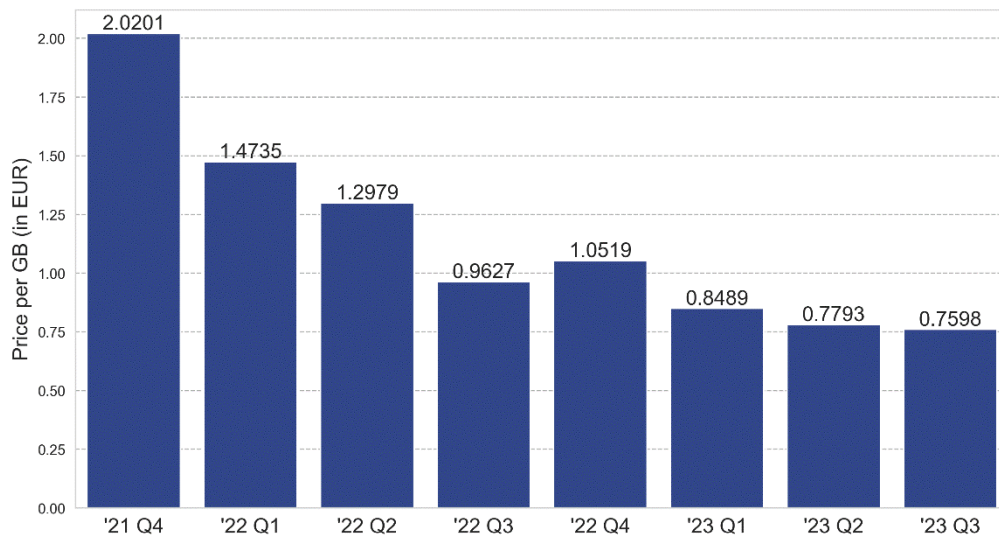Figure 20: Evolution of wholesale payments per minute for roaming objects outside the EU/EEA, outbound roaming

Notes: Figure includes data from Austria, Italy, Latvia, Poland, and Sweden.

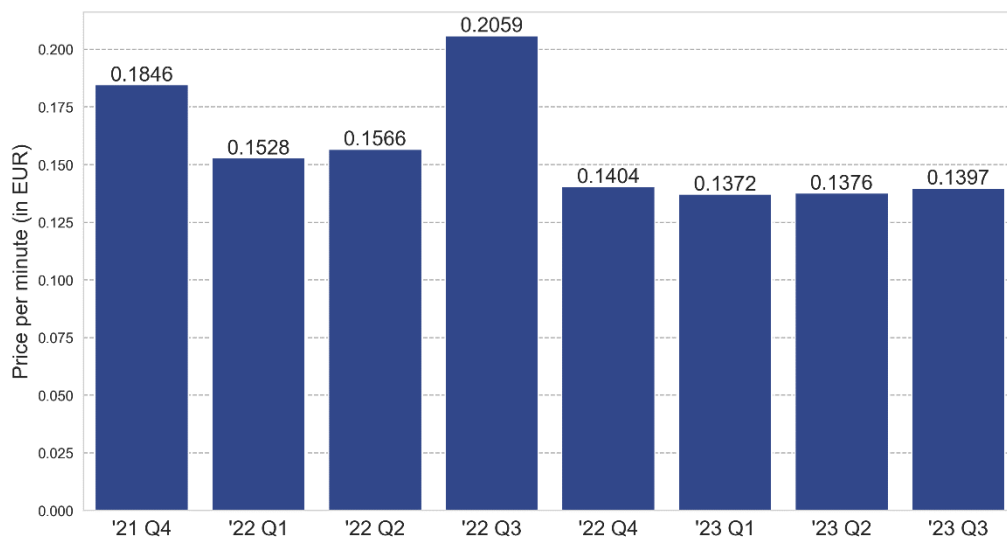Figure 21: Evolution of wholesale payments per SMS for roaming objects outside the EU/EEA, outbound roaming
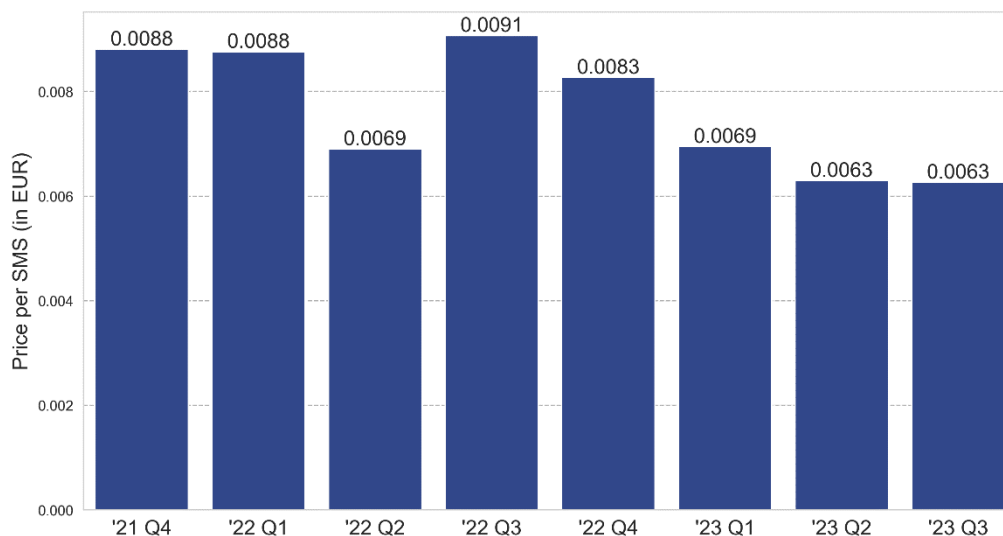
Notes: Figure includes data from Austria, Bulgaria, Denmark, Italy, Latvia, Norway, Poland, and Sweden.

Figure 22: Evolution of wholesale payments per GB for roaming objects outside the EU/EEA, outbound roaming
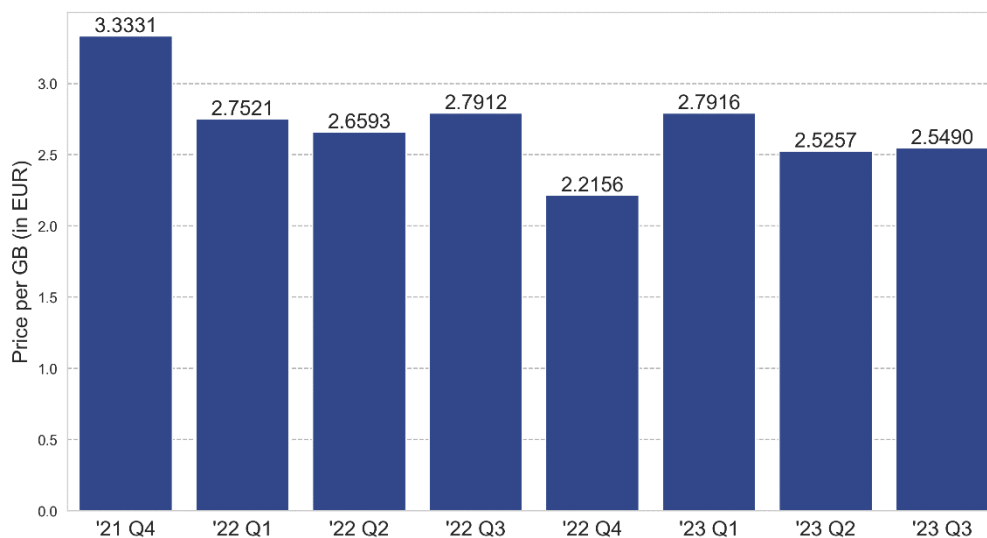
Notes: Figure includes data from Austria, Bulgaria, Denmark, Italy, Latvia, Malta, Norway, Poland, and Sweden. Austria is excluded for Q4 2022 due to an extreme outlier value. If it were included, the bar would be much higher, at 5.30 EUR per GB.

8.4. Survey Questionnaire

The survey could either be filled in on the EU Survey portal or offline in a document and then submitted via email to BEREC. Below you can find the offline version of the questionnaire.

Call for Input: M2M and (permanent) roaming

> Fields marked with * are mandatory.

As BEREC pointed out in its <u>Wholesale Roaming Guidelines</u>[(1)] (<u>Roaming regulation</u>[(2)]): *"According to Recital 21 Roaming Regulation **machine-to-machine (M2M)** communications are included in the scope of the Roaming Regulation. M2M communications are therefore subject to the limitations of permanent roaming foreseen by the regulation and reasonable requests for regulated wholesale roaming access to offer M2M communications should be met if connected devices are periodically roaming"* and also *"If M2M communication services are used on a permanent basis in a visited network, for example in cases of prevailing roaming consumption and presence according to the Commission Implementing Regulation (EU) 2016/2286 (CIR), **wholesale roaming access should be subject to commercial negotiations"***.

Permanent roaming is increasingly important for many use cases of M2M/IoT as many devices remain connected to a network outside of their home network/home country over an extended period.M2M communication refers to connectivity for IoT devices and connected devices as per Recital 68 of the Roaming Regulation. In order to monitor how the market for M2Mcommunications[3] and permanent roaming is evolving, BEREC has launched the following call for input. In addition to the relevant Report of BEREC to be prepared in 2024, the information shared via this call for input may be also relevant to the opinion provided by BEREC to the European Commission for the review of the Roaming Regulation.

This questionnaire includes a set of common questions and subsequently contains sections for *access seekers* (i.e. operators requesting wholesale roaming services in order to serve their customers using M2M devices outside of their home country) and *access providers* (i.e. MNOs serving as visited network operators for M2M devices used abroad). MNOs might have both roles (i.e. act both as access seekers and access providers for M2M services) and in such cases, they are requested to complete both categories of questions. Submissions by organisations or companies from other sectors are also welcome.

The deadline for submitting your input is **26 January 2024 CoB**.

The call for input includes a set of questions that you can answer directly via the fields provided[(4)]. You may also regard them as indicative questions on the issues BEREC would like to investigate and upload any input document that you would like to share with us.

Should you have any queries about the questionnaire please contact (<u>Int-roaming@berec.europa.eu</u>).

1.For all respondents

1.1.Name of stakeholder

---

* 1.2.Country of residence

☐ Austria
☐ Belgium
☐ Bulgaria
☐ Croatia
☐ Cyprus
☐ Czechia
☐ Denmark
☐ Estonia
☐ Finland

☐ France
☐ Germany
☐ Greece
☐ Hungary
☐ Ireland
☐ Italy
☐ Latvia
☐ Lithuania
☐ Luxembourg
☐ Malta
☐ Netherlands
☐ Poland
☐ Portugal
☐ Romania
☐ Slovak Republic
☐ Slovenia
☐ Spain
☐ Sweden

* 1.3.Type of organisation

☐ Telecommunications provider   ☐ Other

1.3.1.Type of provider

☐ MNO

☐ MVNO

☐ MVNE

☐ Reseller

1.3.2.Number of traditional customers

```
                                                                              
```

1.3.3.Market share in home country based on SIM cards

```
                                                                              
```

1.3.4.Number of M2M SIMs

```
                                                                              
```

1.3.5.Are you part of group?

☐Yes   ☐ No

1.3.5.1.If **Yes**, is roaming negotiated on a group level?
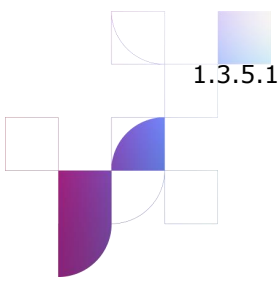
☐Yes　☐ No

1.3.6.If **Other**, write type of organisation

1.4.Specify your role

☐ **Access seeker**

☐ **Access provider**

☐ **Both** Access seeker and Access provider

☐ **Neither** for these two cases, but **I want to reply** to the questions addressed to **Access seekers**

☐ **Neither** for these two cases but **I want to reply** to the questions addressed to **Access providers**

☐ **Neither** for these two options but **I want to reply** to the questions addressed to **both Access seekers**

and **Access provider**

2. Questions for ACCESS SEEKERS[5]

2.1. General questions

2.1.1. Do you provide retail M2M communications services in your home country?

☐Yes　☐ No

2.1.2. Do you provide retail M2M communications services outside your home country (e.g. domestic SIM cards for M2M communications services offered abroad)?

☐Yes　☐ No

2.1.2.1. If **Yes**, please describe the business model.

2.1.2.2. Do you distinguish between M2M services in home country and outside your home country?

☐Yes　☐ No

2.1.2.2.1. If, **Yes** please elaborate further.

[ ]

2.1.3. Do you negotiate terms and conditions for M2M-roaming access separately or are the terms and conditions of the published wholesale roaming reference offers the only/final offer?

[ ]

2.1.4. Are there any obstacles to negotiating permanent roaming agreements for M2M within EU/EEA or outside EU/EEA?

☐Yes   ☐ No

2.1.4.1. If **Yes**, please elaborate on the answer. Are there any country specificities? If you have experienced obstacles, have you raised a dispute with your NRA?

[ ]

2.1.4.2. If **No**, please elaborate on the answer.

[ ]

2.2. Questions about wholesale agreements

2.2.1. Have you concluded (signed) wholesale agreements for M2M communications services within the framework of the Roaming Regulation?
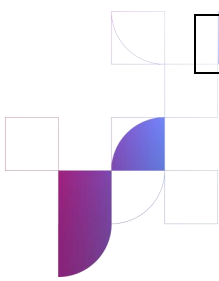
☐Yes   ☐ No

2.2.1.1. Please indicate the number of dedicated M2M roaming agreements in EU/EEA countries over the total amount of roaming agreements within the EU/EEA for the years:

2.2.1.1.1.Year of 2021

[ ]

2.2.1.1.2.Year of 2022

[ ]

2.2.1.1.3.Year of 2023

[ ]

2.2.1.2. In relation to wholesale roaming services for M2M communications, please indicate which technologies you have agreed to use and with how many operators (e.g. LTE-M, NB-IoT) standard cellular mobile technologies (e.g. 2G, 3G, 4G, 5G standards for M2M/IoT, etc.) for the years:

2.2.1.2.1.Year of 2021

2.2.1.2.2.Year of 2022

2.2.1.2.3.Year of 2023

2.2.1.3. Which charging mechanisms for M2M have you agreed (e.g. volume based charges, QoS-based charging schemes, different charges in case of network slices, based on the number of devices, per signalling, combinations of the above etc.)? If others, please describe them. Please elaborate on the answer.

☐ Volume based charges

☐ QoS-based charging schemes

☐ Different charges in case of network slices

☐ Based on the number of devices

☐ Per signalling

☐ Others

2.2.1.3.1. If **Others**, please describe them.

2.2.1.3.2. Please elaborate on the answer 2.2.1.3.

2.2.1.4. Do the agreements have clauses that prevent permanent roaming, e.g. limiting the number of days that M2M devices are allowed to visit the network, or limiting the number of devices that are allowed to roam?

☐Yes   ☐ No
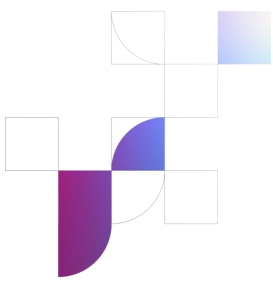
2.2.1.4.1. If **Yes**, please describe the clauses and what are the commercial/financial implications of those clauses.

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2.2.2. Have you signed wholesale roaming agreements for M2M communications outside the EU/EEA?

☐Yes   ☐ No

2.2.3. Have you experienced any difference when negotiating dedicated M2M roaming agreements within the EU/EEA compared to agreements for outside the EU/EEA?

☐Yes   ☐ No

2.2.4. Have you signed commercial wholesale agreements allowing permanent roaming for your M2M customers?

☐Yes   ☐ No

2.2.4.1. Please state whether permanent roaming is foreseen for any service (voice, SMS or data) or whether it is only for M2M/IoT communications.

<div style="border:1px solid black; height:40px;"></div>

2.2.4.2. Please indicate the number of agreements for M2M/IoT communications with permanent roaming in the EU/EEA, over the total amount of roaming M2M/IoT agreements in the EU/EEA for the years:

2.2.4.2.1. Year of 2021

<div style="border:1px solid black; height:40px;"></div>

2.2.4.2.2. Year of 2022
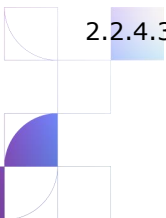
<div style="border:1px solid black; height:40px;"></div>

2.2.4.2.3. Year of 2023

<div style="border:1px solid black; height:40px;"></div>

2.2.4.3. Please indicate whether the tariff schemes for M2M communications services in permanent roaming are the same as those for periodical roaming.

☐Yes   ☐ No

2.2.4.3.1. If **No**, please explain how they differ.

```
_____
|                                           |
|                                           |
|_____|
```

2.2.5. Have you signed agreement for sponsored roaming[6] for M2M/IoT? What are the pros and cons related to sponsored roaming for M2M/IoT services?

☐Yes   ☐ No

2.2.6. What are the pros and cons related to sponsored roaming[6] for M2M/IoT services?

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_____
|                                           |
|_____|
```

2.3. QoS-related terms incorporated in roaming agreements

2.3.1. How are QoS-related terms incorporated in roaming agreements?

```
_____
|                                           |
|_____|
```

2.3.2. Do you have separate agreements for specific classes of M2M services? (E.g. for specific use cases such as low data intensity IoT applications with a high volume of devices like smart meters, mission-critical M2M/IoT applications as in the case of robotics where network reliability and low latency are critical, etc.)

☐Yes   ☐ No

2.3.3. Which kinds of QoS-related terms and conditions do you require? (If applicable: per types of M2M services)

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_____
|                                           |
|_____|
```

2.3.4. Have you encountered any obstacles when negotiating QoS-related terms?

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_____
|                                           |
|_____|
```

2.3.5. What kind of service-level agreements (SLAs) do you negotiate in roaming agreements?

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_____
|                                           |
|_____|
```

2.3.6. Which differences exist between the SLAs required for specific types of M2M services?

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_____
|                                           |
|_____|
```

2.3.7. Which processes are usually defined in SLAs for M2M roaming? Are these different from SLAs for end-user roaming?

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2.3.8. How are responsibilities for SLAs defined in border regions?

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2.3.9. Which obstacles have you encountered when negotiating SLAs?

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2.3.10. Which issues have you encountered with SLAs in practice?

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2.3.11. Do you encounter differences when negotiating QoS-related terms in roaming agreements for M2M services depending on whether roaming would be on a permanent or periodic basis?

<div style="border:1px solid #000; height:60px;"></div>

2.4. Other questions

2.4.1. In addition to terrestrial cellular technologies, given technological developments[7], please indicate whether you have concluded or foresee roaming agreements with roaming providers that provide new satellite 5G technologies (roaming on non-terrestrial network).

☐ Yes   ☐ No

2.4.2. Please indicate if you offer M2M/IoT communications services over technologies using unlicensed frequencies (e.g. LoRaWan, Sigfox, Wize, etc) in your country.
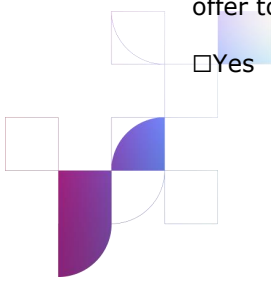
☐ Yes   ☐ No

2.4.2.1. What are the main use cases?

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2.4.2.2. To what extent can these technologies substitute mobile technologies in licenced spectrum to provide M2M/IoT services?

<div style="border:1px solid #000; height:60px;"></div>

2.4.3. Have you implemented the FUP according to CIR (EU) 2016/2286 for M2M services that you offer to retail customers (such as the 4-month observation period)?

☐ Yes   ☐ No

2.4.4. Are there any challenges identified when M2M devices are moving from their home country to another country permanently (e.g. in the case of cars) as regards continuity in the service provided or changing from domestic use to a permanent roaming usage?

☐Yes   ☐ No

2.4.4.1. If **Yes**, please describe.

2.4.5. Are there any challenges identified when numbers are sub-assigned to certain platforms that supply services for certain M2M devices like for example connected cars or emergency communications such as eCall (e.g. the domestic operator does not have any direct relation with the users of the numbers/SIM cards)?

☐Yes   ☐ No

2.4.6. Are there any issues (e.g. delays) in the handover between mobile communications networks at border crossings?

☐Yes   ☐ No

2.4.7. Is there a difference between crossing internal Union borders or crossing borders between EU/EEA and non-EU/EEA countries?

☐Yes   ☐ No

2.4.8. Does the current regulation provide relevant tools to obtain the wholesale services you need to support your customers' use cases for M2M/IoT-devices?

☐Yes   ☐ No

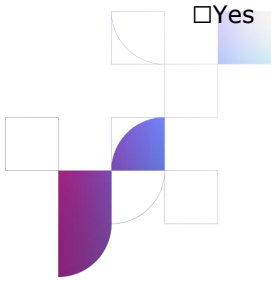2.4.8.1. Is there a need for extended regulatory intervention?

☐Yes   ☐ No

3. Questions for ACCESS PROVIDERS[(8)]

3.1. General questions

3.1.1. Do you provide wholesale M2M communications services in your home country?

☐Yes   ☐ No

3.1.2. Do you provide wholesale M2M communications services outside your home country?

☐Yes   ☐ No

3.2. Questions about wholesale agreements

3.2.1. Have you concluded wholesale agreements for M2M communications services within the framework of the Roaming Regulation?

☐Yes   ☐ No

3.2.1.1. Have you signed wholesale roaming agreements for M2M communications with operators from EU

/EEA countries?

☐Yes   ☐ No

3.2.1.2. Have you signed wholesale roaming agreements for M2M communications with operators outside the EU/EEA?

☐Yes   ☐ No

3.2.1.3. Please indicate the number of agreements **in EU/EEA** countries over the total amount of roaming agreements for the years:

3.2.1.3.1. Year of 2021

3.2.1.3.2. Year of 2022

3.2.1.3.3. Year of 2023

3.2.1.4. Please indicate the number of agreements **outside EU/EEA** countries over the total amount of roaming agreements for the years:
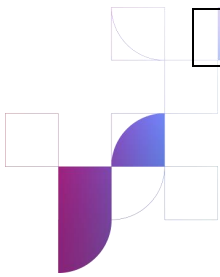
3.2.1.4.1. Year of 2021

3.2.1.4.2. Year of 2022

```
[                                                          ]
```

3.2.1.4.3. Year of 2023

```
[                                                          ]
```

3.2.1.5. In relation to wholesale roaming services for M2M communications, please indicate which technologies you have agreed to offer and with how many operators (e.g. LTE-M, NB-IoT, Standard cellular mobile technologies (e.g. 2G, 3G, 4G, 5G standards for M2M/IoT, etc) for years 2021, 2022 and 2023.

```
[                                                          ]
```

3.2.1.6. Which charging mechanisms for M2M have you agreed (e.g. volume based charges, QoS-based charging schemes, different charges in case of network slices, based on the number of devices, per signalling, combinations of the above etc.)? If others, please describe them. Please elaborate on the answer.

☐   Volume based charges

☐   QoS-based charging schemes

☐   Different charges in case of network slices

☐ Based on the number of devices

☐   Per signalling

☐ Others

3.2.1.6.1. If **Others**, please describe them.

```
[                                                          ]
```

3.2.1.6.2. Please elaborate on the answer 3.2.1.6.

```
[                                                          ]
```

3.2.1.7. Do your M2M wholesale roaming offers allow permanent roaming?

☐Yes   ☐ No

3.2.2. Have you signed wholesale agreements allowing permanent roaming on your network for M2M devices?

☐Yes   ☐ No

3.2.2.1. Please state whether permanent roaming is for any service (voice, SMS or data) or whether it is only for M2M/IoT communications.

```
```

3.2.2.2. Please indicate the number of agreements for M2M/IoT communications with permanent roaming over the total amount of roaming M2M/IoT agreements for the years:

3.2.2.2.1. Year of 2021

```
```

3.2.2.2.2. Year of 2022

```
```

3.2.2.2.3. Year of 2023

```
```

3.2.2.3. Please indicate whether the tariff schemes for M2M/IoT communications services in permanent roaming are the same as those for periodic roaming.

☐Yes   ☐ No

3.2.2.3.1. If **No**, please explain how they differ.

```
```

3.2.2.4. Are there specific methodologies to measure/monitor permanent roaming of M2M devices?
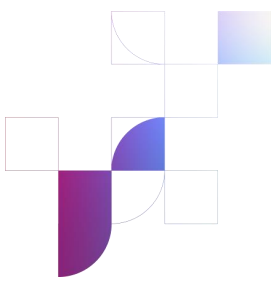
☐Yes   ☐ No

3.2.2.5. Have you implemented such monitoring systems?

☐Yes   ☐ No

3.2.2.5.1. If **No**, are you planning to monitor permanent roaming?

☐Yes   ☐ No

3.2.2.6. What type of provisions does your wholesale roaming offer contain in order to prevent permanent roaming (i.e. consumption limits, different prices for permanent roaming scenarios vs non-permanent roaming)?

> [ ]

3.2.2.7. Have you ever seen the need to take legal or technical measures against access seekers in the M2M/IoT roaming ecosystems, to deal with issues caused by permanent roaming of such devices?

☐Yes   ☐ No

3.2.2.7.1. If **Yes**, what measures did you take?

> [ ]

3.3. QoS-related terms incorporated in roaming agreements

3.3.1. How are QoS-related terms incorporated in roaming agreements?

> [ ]

3.3.2. Do you have separate agreements for specific classes of M2M services? (E.g. for specific use cases such as low data intensity IoT applications with high volume of devices like smart meters, mission-critical M2M/IoT applications as in the case of robotics where network reliability and low latency are critical, etc.).

> [ ]

3.3.3. Which kinds of terms do you offer for M2M roaming in relation to QoS?

> [ ]

3.3.4. Which differences exist between the service level agreements (SLAs) required for specific types of M2M services?

> [ ]

3.3.5. Which processes are usually defined in SLAs for M2M roaming? Are these different from SLAs for end-user roaming?

> [ ]

3.3.6. How are responsibilities for SLAs defined in border regions?

> [ ]

3.3.7. Which issues have you encountered with SLAs in practice?

[ ]

3.3.8. Do you encounter differences when negotiating QoS-related terms in roaming agreements for M2M services depending on whether roaming would be on a permanent or periodic basis?

[ ]

3.3.9. Are you providing or planning to offer wholesale roaming M2M communications services using network slicing technology?

☐Yes   ☐ No

3.3.9.1. If **Yes**, how do you expect to organise the different slices for these purposes?

[ ]

3.3.9.2. If **No**, when do you plan to deploy it and how do you expect to configure the network slicing capability to offer wholesale roaming services?

[ ]

3.4. Other questions

3.4.1.Given technological developments(7), indicate whether you, as access provider, have reached or foresee roaming agreements with access seekers to provide new satellite 5G technologies (roaming on non-terrestrial network).
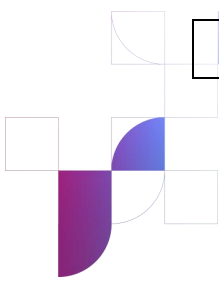
☐Yes   ☐ No

3.4.2. Please indicate if you offer M2M/IoT communications services over technologies using unlicensed frequencies (e.g. LoRaWan, Sigfox, Wize, etc) in your country.

☐Yes   ☐ No

3.4.3. The expected growth in M2M traffic volumes and devices, where many might only have a single IMSI- profile and at the same time need pan-EU/EEA coverage, could lead to high numbers of permanent roaming M2M devices in the networks. From the perspective of a visited network operator, is this development seen as a challenge or as an opportunity?

☐ Challenge   ☐ Opportunity

3.4.3.1. If **Challenge**, please elaborate on the answer.

[ ]

3.4.3.2. If **Opportunity**, please elaborate on the answer.

```



```

3.4.4. Is it difficult to identify M2M devices when they are present in the network?

☐Yes   ☐ No

3.4.4.1. If **Yes**, where do the (technical) challenges lie?

```



```

3.4.5. Is it the case that such devices primarily strain signalling resources instead of data (user plane) resources?

☐Yes   ☐ No

3.4.5. Is it the case that such devices primarily strain signalling resources instead of data (user plane) resources?

If **Yes**, do you take any specific technical measures to deal with this? Which impact will the 5G technology have on this?

```



```

3.4.6. Do you apply the same approach about permanent roaming for M2M devices coming from outside the EU/EEA vs. devices coming from inside the EU/EEA?

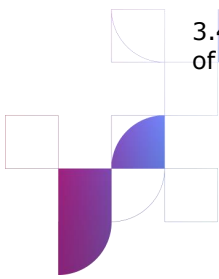☐Yes   ☐ No

3.4.6.1. If **No**, please explain the difference.

```



```

3.4.7. Do you impose any requirements as a precondition for M2M/IoT-devices to be connected to your network for roaming purposes?

☐Yes   ☐ No

3.4.7.1. If **Yes**, please describe the main topics in any such policy briefly.

```



```

3.4.8. Does the current regulation provide relevant tools to control the level of permanent roaming of M2M /IoT-devices?

☐Yes   ☐ No

3.4.8.1. If **No**, is there a need for extended regulatory intervention?

☐Yes   ☐ No

4. General questions for all respondents

4.1. In your opinion, what are the challenges that hinder permanent roaming for M2M? What are the opportunities for M2M permanent roaming?

```



```

4.2. What are the main use cases of M2M permanent roaming from the perspective of your organisation?

```



```

4.3. Are specific M2M (permanent) roaming agreements with operators from another EU/EEA Member State used to provide M2M services at national level (e.g. to expand coverage by having the opportunity in a roaming scenario to use all networks available)?

```



```

4.4. If EU/EEA roaming is used to provide M2M communications at national level with a better national coverage than if M2M communications were provided with only one of the national operators, are there risks of a competition distortion in the visited country?

If **Yes**, please describe the risks? If such risks have been identified, how could this distortion be avoided?

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```

4.5.Is there a need for extended EU/EEA regulatory intervention?

If **Yes**, please describe the issues this intervention should address. Should measures be taken at national level? If yes, which measures should be taken?

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4.6.To what extent do numbering rules in your Member State support or hinder access providers and/or access seekers against the backdrop of permanent roaming for M2M devices? Please specify.

```



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4.7.Is there any other comment you would like to raise about the topic of M2M services and permanent roaming?
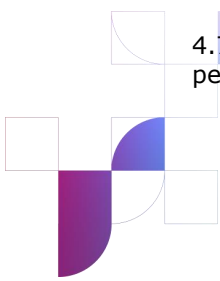
Definitions and references

(1)https://www.berec.europa.eu/en/document-categories/berec/regulatory-best-practices/guidelines/berec- guidelines-on-the-application-of-article-3-of-regulation-eu-2022612-of-6-april-2022-on-roaming-on-public- communications-networks-within-the-union-wholesale-roaming-guidelines

(2)Roaming Regulation (EU) 2022/612 of 6 April 2022 on roaming on public communications networks within the Union.

(3)Definition in Recital 21 Roaming Regulation: M2M communications are services involving an automated transfer of data and information between devices or software-based applications with limited or no human interaction.

(4)Privacy Statement - BEREC Office Policy document

(5)Access seekers are MNOs/ MVNOs requesting wholesale roaming services in order to serve their customers using M2M devices.

(6)Sponsored roaming is a wholesale solution where a MNO or MVNO uses a dual IMSI solution, where one IMSI range belongs to the sponsored network. The effect of this dual IMSI solution is that the MNO or the MVNO's end users have a second identity while roaming and they can make use of all the roaming agreements belonging to the sponsor network.

(7) https://www.spacevoyaging.com/sateliot-and-comfone-join-forces-to-bring-global-5g-satellite-connectivity-to-iot-devices/ or https://totaltele.com/telefonica-germany-partners-with-skylo-for-satellite-supported-iot/

(8)MNOs serving as visited network operators for M2M devices transferred abroad.