



Guide for NRAs on International Mobile Roaming Cost analysis - Technical Paper 2015

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Summary

This technical paper presents a guide for National Regulatory Authorities on international mobile roaming cost analysis.

Keywords

Roaming, International, Costs, Cost model, Charging, Accounting, Mobile Services, Cellular, Wireless, Regulatory, NRA

Change Log

This document contains Version 1 of the ITU-T Technical Paper “Guide for NRAs on International Mobile Roaming Cost analysis” approved at the ITU-T Study Group 3 meeting held in Geneva, 12-16 March 2015.ⁱ

ⁱ The United States neither supports nor approves this document.

Table of contents

Page

Executive summary	iii
Chapter 1 – Introduction and objectives of the ITU-T Study Group 3 (SG3) cost model project	1
1.1 Introduction – Background and context	1
1.2 The supply side begins to react against roaming.....	2
1.3 The consumer is becoming more and more conscious of the penalties of roaming, raising a key question.....	4
1.4 What deliverables are required?	4
Chapter 2 – Principles of telecommunications costing and the basis of the cost model	5
2.1 Principles of telecommunications costing.....	5
2.2 The key principles for the roaming model.....	6
Chapter 3 – Benefits and limits of the cost model.....	11
3.1 Benefits.....	11
3.2 Limits of the model.....	12
3.3 Further cost items that may be included to extend the model, when significant	13
Chapter 4 – Methodology: The cost model, with its mechanisms and assumptions	16
4.1 Methodology	16
4.2 Mechanisms for calculation – Business process analysis	20
4.3 Going from use cases to analysis of assets used in roaming to their costs	25
Chapter 5 – Using the cost model: Guidelines for NRAs, with data collection.....	33
5.1 How to use the cost model.....	34
5.2 Effective data gathering – Data collection process and interaction with MNOs	35
5.3 Sample questionnaire for NRAs, for use with the cost model.....	38
Annex 1 – The regulatory situation in the EU.....	39
Annex 2 – User startup – A one-page summary	46
Annex 3 – A model questionnaire for gathering roaming data.....	47
Annex 4 – Example of spreadsheet used to gather data	51
Annex 5 – Example of parameters used to calculate MNO costs of roaming	52
Abbreviations	55
List of references, background, and further reading.....	59

Executive summary

At the International Mobile Roaming Workshop held at ITU on 23-24 September 2013, participants called for the ITU Telecommunication Standardization Sector (ITU-T) to take the lead in developing a coherent and transparent cost model for roaming for use by regulators. The background to this request to the ITU-T is the growing need for consumer protection in the context of the increasingly global nature of mobile communications across borders¹.

Thus, today's consumer and industry context requires a cost model of mobile roaming to drive a general change in the industry's approach to the roaming question as a whole.

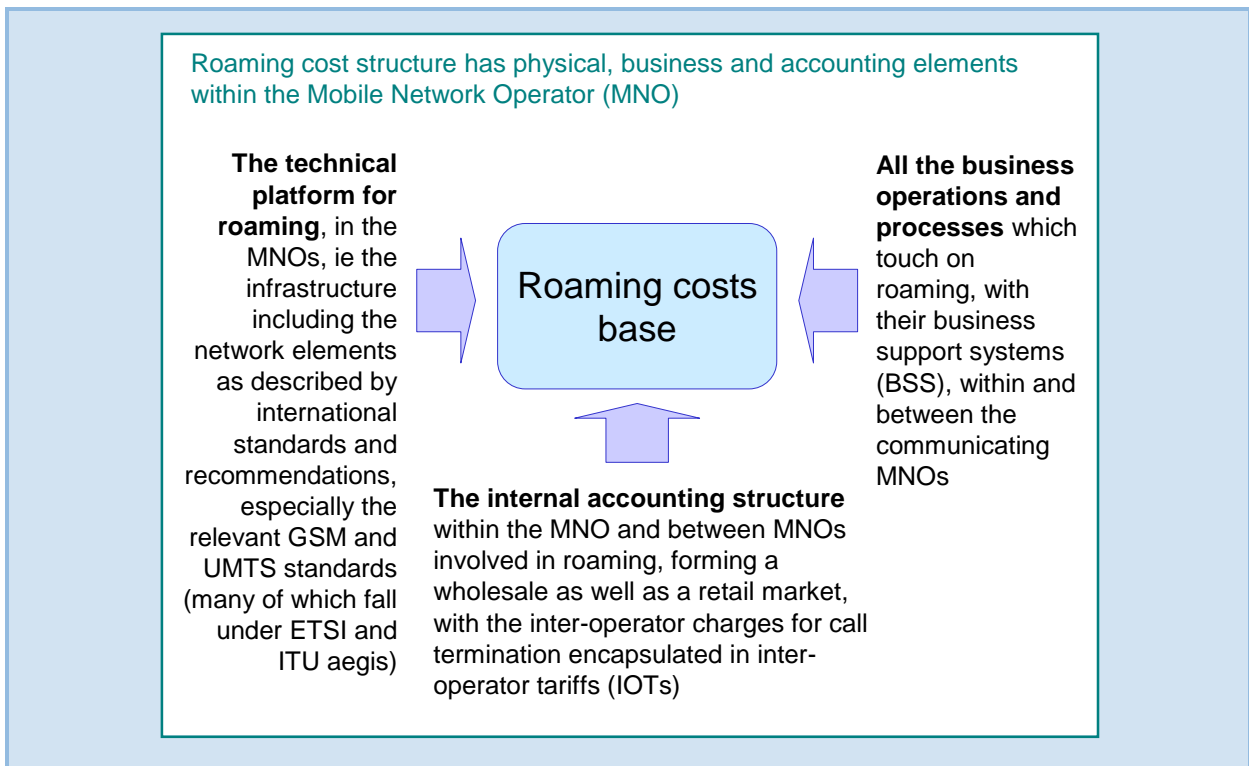
The model attempts to answer the following question:

Do the requirements for technical infrastructure necessarily cause roaming costs to be higher – and if so, by how much?

Mobile network operators (MNOs) may argue that high international roaming prices mainly result from increased costs of technical infrastructure and its operation. To assess this claim, we must answer several questions:

- 1) Is the handling and billing of an international call more expensive than a national call and, if so, by how much?
- 2) What technical infrastructure elements are required for international roaming?
- 3) What are the actual levels of extra costs for roaming and likely future costs of developments?
- 4) What does a comparison of international prices with their corresponding level of national pricing show?

Answering these questions is complex as it involves an analysis of three areas:



¹ Recommendation ITU-T D.98 (2012), Charging in international mobile roaming service.

The question is how much do these three factors – of the technical platform for roaming (signalling and voice/data carriage), the internal accounting structure and business operations and processes with their business support systems (BSS) – really add to the costs of call handling? And critically, by how much do they drive the tariff above the retail price for the same or similar processes performed for handling domestic calls with MNOs and fixed line carriers within the same country. Is there really such a level of extra cost that a roaming call in 2002 was up to four times as much as a domestic call in some parts of the European Union (EU)?

The premise put forward by the mobile industry is that calls across borders cost more, due to longer distances, and reflect different cost bases in the various countries, as well as extra network and business support elements. But how reflective of actual costs are the retail tariffs based on these extra factors? The roaming model we put forward here to answer this question is based on the collection of empirical cost data.

Here we must emphasise that the retail roaming price to the customer is set by two markets:

- First is the wholesale market in international mobile voice calls, as well as for data sessions and short message service (SMS) texts, set by negotiated individual agreements on inter-operator tariffs (IOTs)? The basis of wholesale rates are the prices that the visited operator charges the home operator for allowing the home operator's subscriber to roam on the visited operator's network,
- Second, there is the retail market for final costing to the subscriber which will be at a level above the wholesale price for carrying the call. The dilemma is that the wholesale price internationally is usually higher than an inter-operator agreement domestically.

The EU regulatory group, the Body of European Regulators of Electronic Communications (BEREC), found that in the EU in 2012 (after five years of price caps) retail roaming prices were on average 118% higher than the estimated underlying costs (by what they termed their 'conservative estimations') and that the real costs assessed by BEREC for EU MNOs from its NRA members² should be far lower than retail costs:

	Wholesale costs, EUR cents	Wholesale + retail costs
Calls made (outgoing)	< EUR 5 c/min	< EUR 8 c/min
SMS	< EUR 1 c	< EUR 1.6 c
Data	< EUR 5 c/MB	< EUR 9 c/MB

The Organization for Economic Co-Operation and Development (OECD) has also considered the question of roaming in its 2009 paper from the Working Party on Communication Infrastructures and Services Policy³, whose main points were the following:

- While the wireless industry was considered competitive in domestic markets, there was a widespread perception among many stakeholders, including some within the industry itself, that international mobile roaming (IMR) prices are unreasonably and inefficiently high from comparative information on IMR retail and, where available, wholesale prices.
- In reviewing examples on pricing, it noted that in February 2009, a three-minute call made by a roamer back to their home country, while roaming across the OECD area, costs, on average, USD 7.79. Remarkably, the averages of prices for such a call ranged from USD 3.75 to USD 13.20.

² European Commission, Peter Stuckmann, *EU Roaming Regulation – Towards structural solutions*, presentation, Geneva, March 2012, EC/DG Information Society and Media.

³ International Mobile Roaming Charging In The OECD Area:
<http://www.oecd.org/internet/broadband/44381810.pdf>

- The difference between the cost of sending an SMS, while roaming, in the least expensive and most expensive countries, varied by a factor of five.
- Roaming pricing on bilateral routes (i.e. the cost of the same service for users visiting each other's country and calling home) can vary by a multiple of more than eight.
- It can be up to 20 times more expensive for an international roamer to make a call home than for a local mobile user, in that country, to make an international call to the roamer's home country.

We present here a model of roaming costs to address this issue

To address this issue, we present a model of roaming costs aimed at the assessment of the itemized costs added by roaming. It is based on a breakdown of the roaming activities as business processes, including the assets involved in each case. This represents a bottom-up modelling approach. A technique with the power to distinguish costs across all types and sizes of MNOs is then used, which is based on the subscribers' requirements – *use cases*.

Use cases: To understand what the cost elements are that roaming may involve inside MNO, *use case analysis* can be employed. By employing a breakdown of the scenarios of usage of roaming by the subscriber, it is possible to identify the network and business components within the MNO that engender the costs. The use case approach is thus based on examining user behaviour and the interaction with the MNO's network and business systems, to establish what cost elements are involved. Consequently, it works for any size or type of MNO.

The key business processes involved are firstly those to do with operating the network elements involved, from both the visited and home MNOs, secondly, for the business support services involved, such as the cost of billing, which includes IOT accounts, and finally the back office processes involved, including reaching the multiple inter-operator agreements.

It is important to note that such a model is only as good as the data that feeds into it. Moreover, the data to answer the questions above are not often publicly available, being considered commercially confidential by operators. National regulatory authorities (NRAs) must therefore collect the relevant data. We thus include a procedure for this in chapter 5 which aims at the core problem of roaming – its lack of transparency. Thus a data gathering exercise, perhaps under non-disclosure agreement (NDA) is necessary. If NRAs are to gather such information, while they may not disclose it without permission, they may use it internally perhaps. This cost model is designed for such an approach, to assess the justification for retail roaming charges.

Looking more closely at the four questions above, our findings in summary are as follows:

Question 1: Handling and billing of an international call

For Question 1 – The handling and billing of an international call may be more expensive using current second generation (2G) and third generation (3G) technology; nevertheless, this is a relative cost compared to the domestic tariff. Our own and previous analysis in 2007 for the European Parliament⁴ put this at an additional maximum cost of between 10% and 30% extra over a domestic call, for the base technical costs of additional network elements and business processes involved, trending towards the 10% figure. However, these are maximum estimates. As roaming volume increases with reduced roaming retail tariffs, the processes become less costly and the marginal prices of further calls sink towards the

⁴ For European Parliament's ITRE Committee, January 2007, *Technical Issues on Roaming - Transparency, Technical Aspects and Data* Report IP/A/ITRE/NT/2006-17/Lot2/SC1, PE 382.177, published as an EP policy document for the European Parliament; SCF Associates Ltd contributed the Technical Issues chapter, with cost analysis. Plenary near-unanimous vote on roaming in European Parliament, May 2007.

domestic price floor level. This effect is due to the additional roaming cost elements being amortized over more calls or data sessions so that incremental costs sink with volume, while the additional elements become a lower portion of the cost price.

In the absence of cost-based tariffs, roaming prices have varied greatly, e.g. in the EU, from EUR 1/minute for a voice call (Ireland to the UK in 2007) to EUR 7/minute (Italy to the Czech Republic in 2007) before EU regulation took hold.

The overall conclusion is that pricing regulation in the EU will progressively converge roaming prices with domestic prices - and thus more likely to align with real costs in a competitive market. The EU's glide path for reduction is shown below⁵:

Table 1 – Impact of regulatory price caps in the EU

EC retail caps in Euro cents	1 July 2012	1 July 2013 EUR cents	1 July 2014 EUR cents	1 July 2016 EUR cents
Voice call made/minute	32	28	24	Domestic rate, target
Voice call received/minute	11	11	10	0 (Domestic rate target)
Data (per MegaByte)	90	70	50	Domestic rate, target

Such convergence of roaming and domestic retail tariffs has only been achieved in the EU by constant regulatory pressure on MNOs over the last decade. The glide path caps are still to be maintained over the years to 2016 and beyond.

Note that the emphasis in the EU for roaming pricing is now on data, not just voice, so that price caps for data are now being considered just as important, if not more so as voice over Internet protocol (VoIP) and voice over long term evolution (VoLTE) spread. Here, the underlying aim is to stimulate the business use of broadband mobile and consumer internet access. Both are a part of EU industrial policy for the next decade, with pressures towards a single EU market. Thus the emphasis of regulation in Europe (see Annex 3) is to target a future roaming platform at domestic rates within the EU single market by 2015, if possible. This initiative by the European Commission (EC) has set corresponding caps on wholesale (see Annex 3).

Question 2: Technical infrastructure elements required for mobile roaming

For Question 2, the basic technical infrastructure elements are analysed in more detail in chapter 4 but essentially comprise:

- Extra software for billing and customer care, with the information technology (IT) infrastructure such as extensions to data centres.
- Staff costs of handling extra call volumes and of roaming business processes.
- Network elements, both hardware and software, including additional capacity for greater calling volume.

⁵ EC, DG CONNECT, Commissioner Neelie Kroes, Presentation speech, 12 September 2013.

Question 3: Levels of net additional costs for roaming

The levels of net extra costs, Question 3, are considered in terms of uplift over the retail tariffs of domestic calls, and data sessions, which vary by country. Thus the additional cost fraction given above (maximum cost increase 10%-30% and descending) can be applied. However, there are two forces which impact the levels of cost in a dynamic manner, so actual costs begin to fall faster as they take effect:

- Regulation – The European case, with prices falling from a 300% mark-up over domestic rates in 2002 to an anticipated zero target for 2015.
- Competition – Acting today in limited form, in some regions only (e.g. not in the EU) with examples from the USA (T-Mobile USA) with a USD 20 cent/minute flat retail voice tariff in over 100 countries, under certain conditions, and Africa (Airtel/Zain) with domestic voice pricing over 16 countries.

Note that as retail roaming prices fall, this affects the wholesale market between operators, as downward pressure is put on IOT agreements to try to maintain margins against high wholesale levels.

Question 4: International pricing vs national pricing

Turning to Question 4 – *What does a comparison of international prices with their corresponding level of national pricing show?* It is becoming evident that the descent in roaming prices with regulatory caps, as in Table 1 above, or with competition indicates that the mark-up for roaming both at wholesale and retail levels is increasingly difficult to justify as:

- The extra operational and technical infrastructure elements become merged with the domestic operations and the incremental cost of carrying an extra call sinks as call volumes increase.
- Additional traffic due to roaming will become an extra (and welcome) market that in the long term will be the only source of new revenue and income as domestic markets saturate. Saturation is occurring at rates which are highly variable by region (the USA and the EU are in this state, as are some Asian countries such as Japan and Korea) as developing countries still have unmet demand. However, this may well change over the next decade. For these developing markets, extra revenue streams from (new) roaming customers are most welcome. This will often be the case where market penetration of mobile is restricted by the level of disposable income. In this situation, roaming entrants can drive new mobile growth, if pricing is little different to domestic rates so visitors are not deterred from calling home and local numbers. 'Bill shock' will only kill off this new emergent market.

There is also the question here of whether domestic and international roaming prices could merge – that is, can roaming prices sink to zero? For adjacent countries, as in a region such as the EU, that could be sooner rather than later because, in the final analysis for converged billing procedures, the only real extra cost that remains is the transport of the mobile call long distance. Long distance rates have been coming down over the last 80 years at an increasing pace while the move to Internet protocol (IP)/Internet-carried voice can only accelerate this (and not just for voice calls but also in the future for broadband video calls). This implies that roaming charges could move towards *near-zero* levels.

Recommendations ITU-T D.98, D.99 and D.140 underpin the MNO cost-model position

What is most notable is the absence of a suitable cost model by the MNOs to justify the additional roaming charges. Instead, the main responses from various MNOs and their organizations have been claims that a significant roaming surplus is necessary, to fund investments for LTE rollout of mobile broadband, with 100 Mbit/s download speeds.

Hopefully, the cost model presented here should help to go further in the direction of roaming accountability and transparency, following the path set by ITU-T in [Recommendation D.98](#). The use of the model might build on that Recommendation for roaming transparency.

It is also possible to build on other relevant ITU-T Recommendations. Specifically, Recommendation ITU-T D.99 discusses the question of an indicative rate for international mobile termination and provides some suggestions for consideration by national regulatory authorities, based on using the fixed termination rate as an initial basis for negotiations. It is also possible to move forward on such indicative rates if we take into consideration another Recommendation in the domain of international call termination accounting, Recommendation ITU-T D.140. It proposes the useful principle for setting prices that cost-based accounting is the key tenet, stating in clause E.3.1:

"Administrations which have already attained these indicative target rates should continue to take positive steps to reduce their accounting rates to cost-orientated levels".

Naturally, the question must be asked – should not the same cost-oriented principle be applied to mobile roaming?

A combination of Recommendation ITU-T D.98, extending from transparency for subscribers and employing its suggestions on the use of price caps, would follow the principles from Recommendations ITU-T D.99 and D.140 into cost-based mobile pricing. This could form the basis for further ITU-T Recommendations which are strongly market-related. A cost-based analysis of roaming tariffs would provide the platform for pragmatic and realistic inputs to national regulators considering the impacts of roaming.

The European experience

An important and related aspect to consider is the experience from Europe of its roaming measures. This is examined briefly in Annex 1. The key question is whether the European model developed since 2007 following the European Parliament vote is working – and if so – can it be applied elsewhere?

A first conclusion is that certainly the EU model of constant vigilance and pressure is working and doing so fairly well, although at least six years of legislated price caps have been necessary. Roaming rates, for example, for data are claimed to have been reduced by 90% and might be eliminated between 2016 and 2018.

What is this due to? And can it be applied elsewhere?

Thus a second conclusion for the European experience is that the path to success is conditional, as briefly examined in Annex 1. But if any of the three conditions mentioned are absent, the European experience may not be repeatable.

Perhaps the primary condition for success is the first one – the use of a community of countries with NRAs working in concert, over a set of geographic roaming areas, so that reciprocal roaming data gathering can be set up. Thus a regional approach is probably required. However, it must be backed eventually by common regulation, probably set in legislation – and therefore by a group of governments in the region with the communal will to act together in order to stimulate the economy and protect the citizen.

Chapter 1 – Introduction and objectives of the ITU-T Study Group 3 (SG3) cost model project

1.1 Introduction – Background and context

Retail charges for international mobile roaming have come under increased scrutiny.

This is understandable, as in today's mobile markets, international mobile roaming (IMR) charges have been confusingly different and unpredictable. In addition, for the consumer they often seem to be arbitrarily high, especially for data roaming. Hence the background to this Technical Paper is a request to ITU-T to meet a growing need for consumer protection in the context of an increasingly global nature of mobile communications, which crosses borders for more of its users as international travel and business explode.

As the European Commission's 2006 Impact Assessment (European Commission (2006)) that analysed the European roaming situation put it:

- The core problem is that prices for EU-wide roaming at both wholesale and retail levels stand in no meaningful relationship to the underlying costs of providing the service.
- This problem is compounded by a lack of transparency of prices at retail level, meaning that it is extremely difficult for consumers to understand what they will actually pay. The Commission and some national regulatory authorities have attempted to address the transparency problem by creating websites for roaming prices but these initiatives have not led to sufficient improvements.
- Having studied this market carefully, national regulatory authorities have alerted the Commission services to the fact that they believe the problem is 'non-trivial' and requires action.
- A key issue is the cross-border nature of this service whereby no one national regulatory authority can solve the problem.

Thus a cost model of mobile roaming is needed to highlight the financial reality as far as possible – and so to drive a general change in the industry's approach to the whole roaming question. This specific need was voiced at the [High-level Workshop on Regulatory and Economic Aspects of Roaming](#), held at ITU on 23-24 September 2013, when participants called for ITU-T to take the lead in developing a coherent and transparent cost model for roaming for use by regulators.

A move to greater consumer protection in the current conditions for roaming charges is also echoed by various recent developments around the world.

Following on from the analysis above, in the EU, mobile roaming issues are at the fore of new regulation, especially in the light of the economic plans for a single market. Thus the European Commission is taking strong action backed by the European Parliament. Roaming is viewed as one of the barriers to a single market, whose eventual formation could add at least 1% to the growth domestic product (GDP), according to an EC study cited by the Directorate-General, of the European Commission, for Information Society and Media (DG INFSO) Commissioner Neelie Kroes in her speech of 8 October 2013. Roaming should be seen in the context of mobile communications being a major accelerator of business activities. For example, a Finnish study by Maliranta and Rouvinen⁶, in 2006, found that for small and medium enterprises (SMEs) (some 98% of the EU's companies) the use of mobile without limits increased productivity by 6%. However, use of mobile data and voice is often inhibited when travelling across the

⁶ Maliranta, Mika and Rouvinen, Petri (2006), *Informational mobility and productivity: Finnish evidence*, Economics of Innovation and New Technology, Vol. 15, No. 6, September, pp. 605-616.

EU, due to the fear of much higher bills with inflated tariffs as consumers cross into other Member States (popularly dubbed 'bill-shock'). This in turn inhibits economic growth. Thus the abolition of EU roaming tariffs promises high returns for the EU economy. It is now leading into a further regulatory phase – European Roaming 3 – with a Directive for NRAs to enforce complete elimination of roaming charges under a calendar of progressive actions. Commissioner Kroes has emphasized that roaming charges within the EU are ending, with the EC plans to abolish roaming by 2016 and so build a single European telecoms market⁷.

To this end, the European Commission has strongly pursued curtailing such charges, which still amount to some EUR 7 billion/year across the EU, even though data roaming, for instance, is some 91% cheaper than in 2007. A vote in the European Parliament in April 2007 was near unanimous in endorsing a lowering of roaming rates by the EU mandate, with one Member of the European Parliament (MEP) abstention against the bill to limit and regularize roaming charges across the EU progressively. Such strong voting by MEPs highlights the popular feeling among their constituents on roaming charges.

Roaming charges are now being squeezed even further at the national level in some countries, as the cost of living is felt to be too high for many, encouraging political pressure against them. For example, the UK's MNOs were summoned to a meeting with the Department for Media and Culture on the instruction of the Prime Minister on 14 November 2013, to be presented with criticism of their pricing tactics especially for roaming prices⁸. The questions that MNOs are now asking themselves is whether they might be attacked publicly, just as the UK's energy companies currently are, accused of exploiting an oligopolistic market position. This is driven by the widely perceived lack of transparency over the justification for any roaming charges, which may even appear as arbitrary, or exorbitant, especially for data. UK government ministers now want roaming abolished *before* the calendar set out by the European Commission.

Many other regions are reviewing the EU successes under the European Parliament and wish to reduce and then remove roaming charges faster than the European Union community, such as the Southern African Development Region (SADC).

1.2 The supply side begins to react against roaming

A further example comes from the USA. It could be even more significant in some ways, as the mobile industry itself may in the future view roaming as a competitive weapon due to its excesses.

This development signals a fundamental change, indicating that for the first time the industry itself is now shifting its operating principles, seeing reduction or abolition of roaming charges as a form of competitive edge. Thus the supply side is just beginning to react against the high tariffs that have been imposed for roaming.

This is the essence of T-mobile's new competitive weapon in a market that is saturated, with high competition and two larger strong competitors:

⁷ Speech, Commissioner Neelie Kroes, 12 September 2013, *We must act now – time for a Connected Continent*.

⁸ D. Thomas, *Cameron calls for mobile bill cuts*, Financial Times, 14 Nov. 2013.

T-Mobile's anti-roaming-charge strategy is a competitive weapon

In the USA, on 10 October 2013, the president of T-Mobile, USA, John Legere, announced that T-Mobile USA would abolish additional roaming charges for texting and mobile data in over 100 countries, with a flat global rate of 20 cents per minute for users who make voice calls while they are abroad on their "Simple Choice" tariff. He stated⁹:

"The cost of staying connected across borders is completely crazy. Today's phones are designed to work around the world, but we're forced to pay insanely inflated international connectivity fees to actually use them."

T-Mobile estimated that if the average user operates their phone abroad in the same way they do at home, charges of up to USD 1'000 a day are possible, causing 40% of customers to turn off data roaming completely. Legere noted:

"It doesn't have to be this way. The truth is that the industry's been charging huge fees for data roaming. But what's most surprising is that no one's called them out – until now."

In the USA, T-Mobile is using retail price differentiation as a key competitive weapon. It has added some 650'000 new subscribers just in Q3 2013 in the USA¹⁰ with roaming playing a major part in this strategy.

Two further examples come from Africa:

Airtel has progressively eliminated roaming charges

In Africa, Airtel (ex-Zain) with its One Network offering launched in 2006 began to eliminate IMR charges for its customers, by covering 16 African countries on its own network. With this offer, customers pay domestic rates for outbound roaming calls and are not charged for incoming calls. It is also possible to use visited network recharge cards, whereby Airtel makes incoming calls free, for up to 100 minutes of use, for 20 countries. Outgoing calls are charged at local rates with a 30% mark-up using current exchange rates.

MTN score on SMS and data while Vodafone has 'One Africa Family'

Also in Africa, MTN operates its "MTN One World" offering for send/receive SMS and browse/use data at a unified call rate while visiting countries where MTN operates.

In a similar vein, Vodacom has its "One Africa Family", offering free incoming calls in 10 African countries and a default rate when roaming on Vodacom network outgoing calls.

One question is – how would such offers work when the consumer has unlimited calls on a flat domestic subscription? For instance, the operator 'Free' in France offers for EUR 19.90/month unlimited domestic calls, fixed and mobile, including fixed line calls to 100 countries. Overall, call volume can be expected to increase – and so revenues and incomes to the operator may climb rather than be throttled when visiting another country. Certainly 'Free' is pursuing this strategy successfully.

Technology advances are also making free and low cost roaming possible – especially IP-based voice using data connectivity (VoIP). For instance, IP voice for a Wi-Fi connected handset is offered at low prices (down to free) from anywhere in the world to its home country by the Norwegian MNO, Network Norway, which is part of the Tele2 Group. Its Mobile IP service for both mobile and fixed line terminations in Norway uses a downloaded IP app. IP voice over LTE (VoLTE) can only expand this trend.

⁹ <http://www.techweekeurope.co.uk/news/t-mobile-usa-roaming-129287>

¹⁰ Financial Times, Lex Column, *The wages of SIM*, 8 November 2013.

1.3 *The consumer is becoming more and more conscious of the penalties of roaming, raising a key question*

Consumer reactions to unintentional roaming are becoming ever more hostile, especially with the rise of accidental roaming across frontiers due to overlapping mobile signal areas. In one common example, Icelandic mobile services can be used by error in the British Channel or the Irish Sea¹¹. These erroneous overlapping coverage areas are being enlarged by services that can give unexpected coverage, such as mobile satellite systems, as in the Icelandic example. This means consumers risk enormous charges, especially for data.

Thus, there is a key question for NRAs and governments:

How can we understand the real cost of roaming, to ensure that any charges are cost-based?

The deliverables and methodology given below outline the overall approach to this project.

1.4 *What deliverables are required?*

The principal deliverable needed to reply to the above situation is a cost-based overview analysis of roaming charges, in order that regulators may understand the real costs involved, in terms of their nature and levels. We examine this through the following elements:

- *A cost model* to show the real cost to the MNOs of roaming, against which a cost-based analysis of roaming tariffs can be established. This will be explained in language and format that is easy to understand. The benefits of the model are that it should make the costs involved to the mobile, and if involved fixed, operators, as transparent as possible by breaking down the operational processes for call handling in terms of the business processes involved. It depends for its actual data on a data gathering exercise by the regulators wishing to understand the roaming situation.
- *Definition and description of the data* that needs to be gathered for the cost model by NRAs that will measure the levels of the major cost elements.
- *A briefing for NRAs*, to guide them firstly through the data gathering process, by use of a questionnaire and secondly on the use of the cost model with its calculations.
- *An outline of the situation on regulatory moves in the European Union*, with an analysis of whether the new directives since 2007 and those continuing to 2016 and beyond have so far brought the roaming charges in line with costs and whether they will do this in the future. This is given in Annex 1.

Presentations of the cost model and use of questionnaire are planned for various future working sessions, at the ITU-T Study Group 3 meetings, showing the spreadsheet and its operation.

¹¹ BBC Radio 4, 23 November 2013, Paul Lewis, Moneybox investigation.

Chapter 2 – Principles of telecommunications costing and the basis of the cost model

2.1 Principles of telecommunications costing

Although well understood, for completeness, some of the key principles in this area are given below as background to the model.

The basic principles of telecommunications costing can be broken down in a simplified view as the two principle levels of:

- a) The retail tariff to the subscriber;
- b) All the underlying operational costs, including necessary capital expenditure for infrastructure, etc., for all of the operators involved in the call.

These are connected by the mark-up or profit on the costs. Note that profit margins are added by each of the operators contributing to the roaming costs by carrying the call. The subscriber's MNO then adds its own profit, to eventually produce the retail tariff for the subscriber.

2.1.1 Retail tariffs

Retail tariffs in the mobile industry are characterized by:

- Metered charging – by time (second or minute) or initial minimum time and then metered.
- Location – national locality and termination.
- Carrier charges end-to-end – whether the call is on the subscribed to MNO only or to a different MNO in the same country, or to a termination or origination of the call from a fixed line subscriber, i.e. whether it is 'on-net' or 'off-net', and also, whether there is an intermediate transit via a long distance fixed, or satellite, carrier.
- Bundling of services volumes as packages for voice, data and SMS. These are often complex as they consist of bundles of fixed numbers of on-net calls, calls to or from fixed lines and reduced tariffs for some outgoing international calls.
- Multiple services with different tariffs and charging principles for each of the media carried – voice, data, SMS and also multimedia messaging services (MMS).

2.1.2 MNO operational costs

The operational costs for MNOs are characterized by being of two main categories:

- Capital expenditure (capex) – Payments either one-time or periodically repeated for significant capital sums, e.g. for amortized equipment, or for spectrum rights at auction.
- Operational expenditure (opex) – Continual recurring payments – e.g. for power supplies and other utilities, staff salaries, maintenance, rents, interconnect charges for use of other carriers, wayleaves, rights of access, rights of way, consumables, annual additional spectrum licence fees, software licences and maintenance, leases for data processing facilities, service level agreements (SLAs), etc.

Note that one of the expenditures for any MNO, be it as capex or opex, is for a real estate portfolio. This is largely for the base stations that provide the radio area network (RAN) coverage whether owned, rented or leased from a large site holder, such as Crown Castle. The network's cable-laying and civil works for backhaul and its own fixed network may also be a basic infrastructure cost. Alternatively, MNO may lease fixed network capacity from others and so avoid network build where possible, both short-haul and long distance.

2.2 The key principles for the roaming model

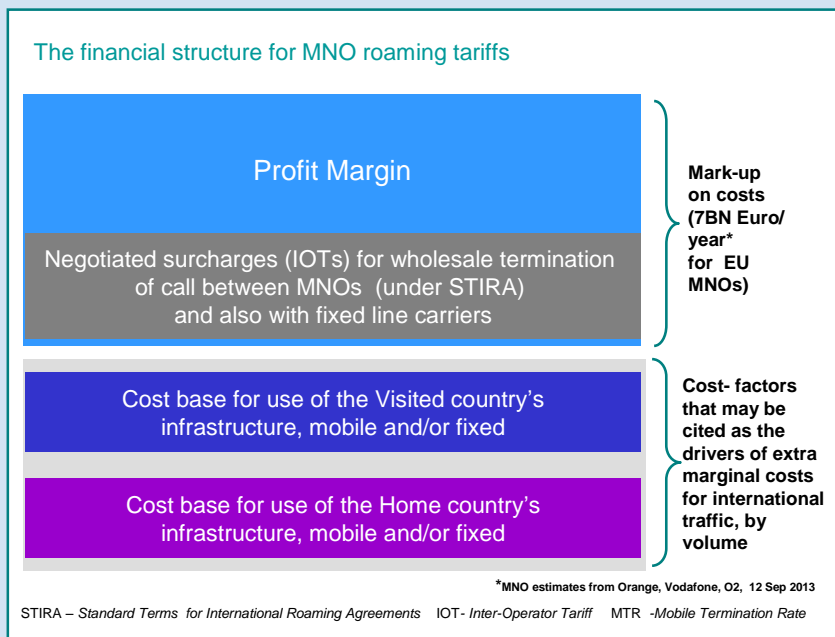
For the roaming model, we are most interested in the incremental cost of carrying additional calls for roaming in and out of the home and visited country, in terms of impacts on the MNO cost base in two areas, as these are the basic cost items:

- a) Additional load on facilities and support infrastructure due to roaming traffic; this includes the infrastructure of at least two MNOs, and perhaps a third and/or a fixed (line) network operator (FNO), especially for long distance (LD) carriage.
- b) Additional load on the business processes to handle roaming – from reception of visiting subscribers to their exit, for both MNOs and for any other operators.

In addition, the roaming subscriber will be charged supplementary fees due to the wholesale agreements between MNOs for roaming, the inter-operator tariffs (IOTs), which increase the MNO mark-up and the subscriber charge for the call. These are agreed under the Standard Terms for International Roaming Agreements (STIRA) framework from the GSM Association (GSMA) and may include agreements through roaming exchanges with many MNOs in a single deal. Agreements are effectively embedded in the subscriber identity module (SIM) card in a mobile phone by a list of the networks with which a roaming agreement exists. This effectively 'locks in' the subscriber to a preferred MNO for each country as the phone will automatically search for this network when it enters a new country.

The key point is that this structure produces two 'markets' in roaming charges, i.e. the wholesale inter-operator tariffs (IOTs) as well as the retail market. The retail market reflects the results of inter-operator commercial negotiations on wholesale international tariffs for call termination, being the floor for retail pricing due the mark-up on the IOTs agreed. The overall cost structure for the roaming business model is illustrated below with the infrastructure's (incremental) costs over domestic operations plus the wholesale agreement charges as shown below in Figure 1.

Figure 1 – Overview of the cost structure with wholesale IOT agreement and margins



2.2.1 Business process modelling and MNO

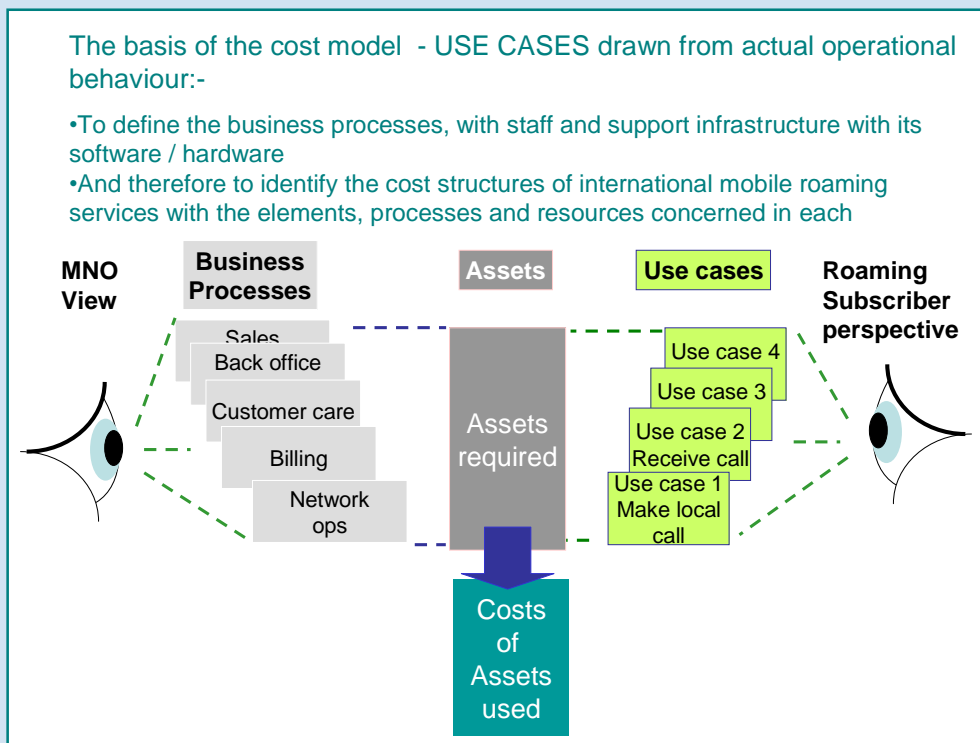
How do we cost the elements in the diagram above? The operational world of MNO is organized as a series of business processes – and platforms designed to support each operational process, everyone with its staff and support assets. Business processes describe and govern all operations – from the signing on by a roaming subscriber to the billing process and inter-operator charging, including the various negotiations for IOT agreements between MNOs to set up roaming agreements and then monitor them. Business process analysis (BPA) is used here, involving a dissection of business activities into a chain of activities.

2.2.2 Use cases enable MNO-independent analysis

The flaw in this approach is that each MNO is different and its implementation of business processes may be subtly dissimilar.

To overcome this, the concept of use cases is introduced to the analytic model. They may be seen as a sort of mini-scenario of typical basic use from the subscriber's viewpoint, not the MNO's. Hence use cases provide an approach with the power to distinguish costs across all types and sizes of MNOs, as it is based on the subscribers' requirements, which are largely unchanging when roaming.

Figure 2 – Two views of the same assets and their costs – MNO and subscriber views



Each activity may then be examined as to its needs, with attribution of the resources necessary, be they human resources, network elements and/or IT support systems, including the main MNO infrastructure elements such as data centres, call centres or network operations centres (NOCs).

This may yield the costs, if attributed by element. So breaking down each step of the business process and then costing that step produces a detailed cost attribution, bottom up. This may be viewed as a simplified form of traditional activity based costing (ABC). An example is shown below:

Table 2 – Business process with activities and the elements for the activity

Business process	Activities	Elements involved
Handling set up of a new visiting subscriber	Receive request from visitor to register and be activated.	Radio area network (RAN) and backhaul network to data centres.
	Check international mobile subscriber identifier (IMSI) and inform home location register (HLR) network and verify allowed to roam. Check if prepaid or postpaid. Check if prepaid has roaming capacity.	RAN, mobile numbers database, interconnect, transferred account procedure (TAP) file update, all in data centre.
	If above all verified, register visitor on visited network, in visiting location register (VLR), and activate; update customer care and billing databases (DBs).	VLR, over-the-air (OTA) activation, billing file, customer care DB.

2.2.3 Incremental cost modelling

A further principle, as we are focused on the differences in costs due to roaming over domestic tariffs, is to understand the *incremental* cost for each part of the business process due to the fact that it is employed for roaming. There are various forms that such incremental costs can take. Incremental cost due to roaming (for equipment for instance) is either an extension of capacity, or of functionality, or spend on specialized quite new equipment by function. Long term, such costs may be absorbed in some way. However, this is a moving target as more extensions of features become absorbed into the standard processes and support platforms over the long term. Various types of increments in costs are shown in Table 3 for the MNO operations related to roaming with their long term trends:

Table 3 – Types of cost increment in MNO assets for roaming

Categories of possible cost increments (opex and capex) for roaming over domestic costs	Long-term cost trend
Increased capacity for international roaming for existing assets.	May become considered part of customary business growth – i.e. normal business expansion cost.
More expensive systems for international calls (e.g. CAMEL for prepaid roaming subscribers).	Prices reduce rapidly, even in medium term, as become mainstream, i.e. just a dormant software feature to be optionally activated, rather than an extra module to be licensed.
Specialized and different operational processes (e.g. customer care) and call handling with specific equipment.	Prices reduce with time as the specialized operations become mainstream with roaming traffic growth.

The roaming cost increment can be measured as an additional percentage of domestic-cost only costs for the model's results.

2.2.4 Long-term trends in roaming costs

Note that the long-term trend is that the incremental costs of a roaming call or session will move towards zero as equipment, software and processes for roaming activities become part of normal business practice, as for domestic calls. Additional effects such as expansion of the volume of calls, both domestic and roaming, if lowered pricing stimulates the market, will also tend to drive down incremental costs of roaming over domestic costs. Attractive roaming tariffs may also act to stimulate domestic business, as customers are drawn to the lower roaming tariffs when travelling

Moreover, technology will also begin to become a factor in the reduction of roaming costs as 2G global system for mobile communications (GSM) and 3G universal mobile telecommunications system (UMTS) are gradually upgraded. A move to an all IP world, as planned for LTE, would herald the entry of a new

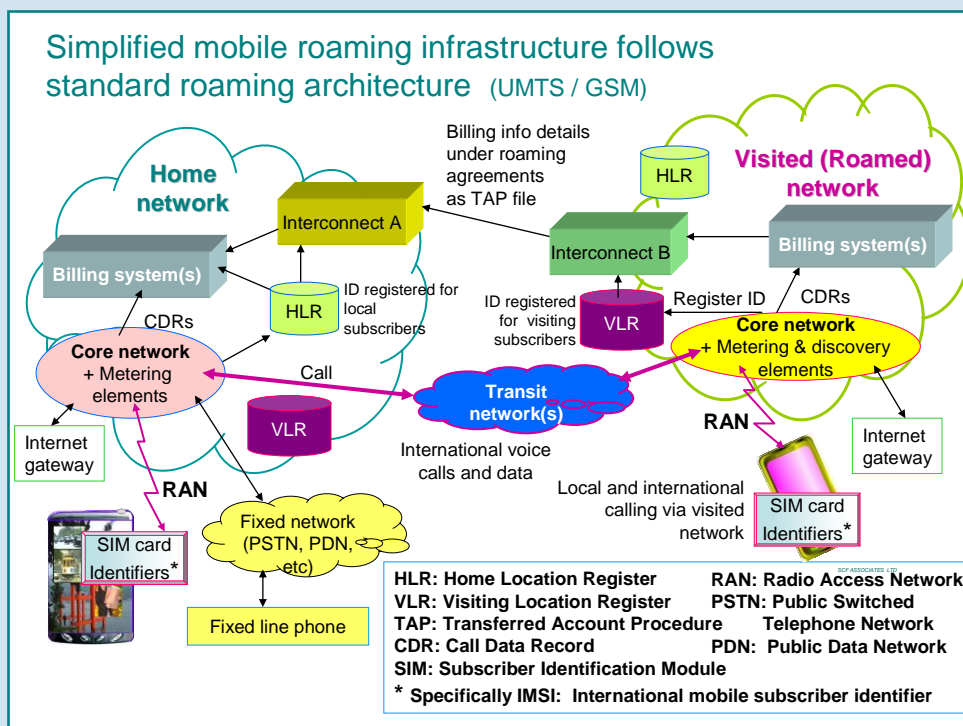
mobile architecture in which the radio area network (RAN) may be directly connected to an IP 'cloud' so voice over IP (VoIP) becomes common. Voice traffic in a decade will move towards an IP stream that requires isochronous working, its only differentiator with other broadband streams. It also is reasonable to expect that wholesale IOTs for international calls will tend towards the levels of domestic IOTs between national operators, in a competitive market for roaming, although this is outside the scope of a cost-based analysis, as they are a negotiated addition. Extra charges for overheads due to international roaming will also reduce with new technology – e.g. with exchange of accounting information via the Internet rather than over the MNO core network.

2.2.5 The physical basis for the model

Cost modelling is based on the layout of operator networks and the business support systems (BSS) that implement the roaming process.

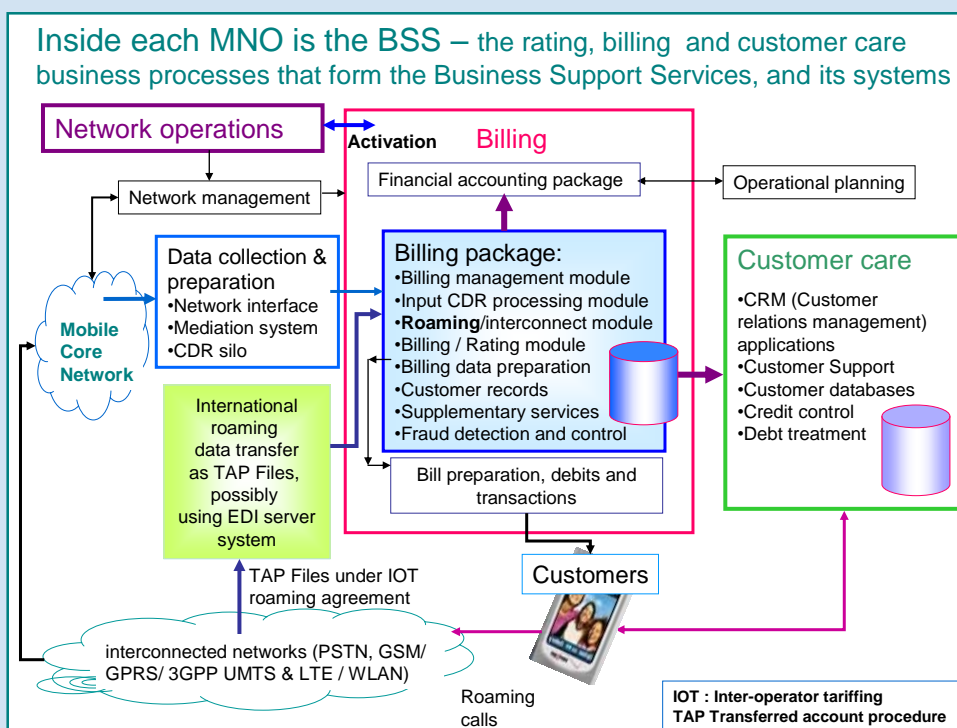
The detailed technical implementation of the MNO infrastructure can have some variations but these are usually minor as international standards must be followed for universal interworking to operate. The generic, simplified mobile view of the roaming infrastructure above follows standard roaming architecture for UMTS (3G) and 2G GSM norms. LTE will tend to follow an evolution of this model, from its switched circuit origins, towards IP packets. Figure 3 below shows the interaction between the networks of two interacting MNOs for handling a roaming call – with not just the call path but also the billing data handover. In this diagram, the MNO fixed (core) network for backhaul, beyond the RAN is shown, in this case being interconnected via a transit network to the home MNO's core network. This connection may also be a direct inter-core network switched link, or via a third party transit operator, which will then also charge for carrying the call. The simplified generic model is:

Figure 3 – Physical infrastructure for roaming, in a simplified generic view



Going further into the costing basis of the infrastructure, our model is based on an analysis of the main business processes for call-data capture, mediation, rating and billing with customer care, and the key elements of the business support systems (BSS), see Figure 4:

Figure 4 – The key BSS systems involved in handling a call



Note that the above is a generalized model with infrastructure oriented more towards voice. However, it is largely valid for data carried over 2G with general packet radio service (GPRS)/enhanced data rates for GSM evolution (EDGE) and current 3G networks with high speed packet access (HSPA). It would be simplified for SMS by the minimal rating and billing mechanisms required by flat rate billing. Actual implementations within MNOs may have specific features and differences with additional systems, (e.g. customized applications for mobile enhanced logic (CAMEL) for prepaid charging for roaming) and/or use of a roaming exchange. Importantly for costing, data networks in the future with LTE may break out of IP packets directly from the RAN via an Internet gateway (IP data records (IPDRs) replace call data records (CDRs)). This may be a less complex and cheaper infrastructure as IP packets enter the Internet broadband infrastructure for low cost international carriage, perhaps at the nearest base transceiver station (BTS), and in an LTE network with direct Internet gateways. This simpler data carriage architecture is likely to encompass IP voice in the future as well, with VoLTE.

2.2.6 Market reality of retail tariff analysis complicated by tariff bundling

As mentioned, complexity for subscribers increases with the number of different tariff bundles (a certain number of units of one or more services combined, in voice minutes, SMS texts and data in MB) for a fixed fee for a specific period (day, week, month). An overview of *roaming* bundle tariffs shows that many MNOs tend to also offer such packages¹². The easiest tariffs to understand and compare are linear tariffs. In many cases, however, prices are higher for roamers with a linear tariff subscription.

¹² BEREC Report on Transparency and Comparability of International Roaming Tariffs, December 2013, BoR (13) 185. It should also be noted that MNOs may offer a bundled roaming tariff that is for a relatively long period of time (e.g. one month) so that they are not always cheaper than a linear tariff if the user is staying abroad for less than a month and is not a high user.

2.2.7 Further practical cost issues

A home network, when buying roaming services, negotiates commercial wholesale roaming charges for traffic from a visited network. Hence, wholesale roaming pricing is what each MNO sees as its floor pricing. However, as noted above, in most situations the level of wholesale charges has little to do with the underlying costs of providing roaming services, it is dictated instead by certain commercial considerations. Principally these are the volume of traffic and especially the balance of the traffic between the two MNOs, influenced above all by an MNO's size and affiliations – e.g. as a local incumbent that is part of an international group or other alliance. However, overall, roaming may have quite limited effects on investments to handle roaming visitors, as their proportion is usually low (perhaps 5%-10% of all traffic volume at most).

The parameters for traffic given here focus on volumes of roaming and domestic traffic of home/visited MNOs. Such information offers a useful insight as to whether a particular MNO is a net buyer or a net seller of roaming traffic, as well as revealing an approximate cost per unit of each traffic type for a given network. In assessing the various cost centres, international transit and networking costs may be less than perhaps expected due to a significant percentage of roaming calls terminating on fixed-line networks, which usually correspond to lower termination rates.

Chapter 3 – Benefits and limits of the cost model

3.1 Benefits

With a suitable cost model describing expenditure and overheads, it is possible to highlight the sources of costs and compare them with the aggregated increments for roaming being applied by the operators. This has substantial further advantages for the consumer, the public and particularly for NRA's duties to the consumer as it is possible to:

- Discuss the degree of real transparency of MNO with far more confidence from evidence of the accounted costs.
- Confer with MNOs on any plans for future mobile roaming tariffs in the light of real costs.
- Evaluate MNOs on their value to the public with comparisons of roaming performance and operational profile from the business processes.

Essentially, the model provides NRA with a tool to assess an operators' claims by going back to the first principles, examining the process and its components, estimating any additional capital (capex) and operational expenditure (opex).

Moreover, the model is flexible as it consists of a set of itemized costs. It is capable of being extended to forecast the cost implications of changes in operations and technologies. Its structure provides a basis for an evolving model of roaming over the years. Updating it will form an essential task as the industry advances, if NRAs are to understand the trajectory of future roaming costs.

In summary, such a cost model may go further in the direction of roaming accountability and transparency, following the path set out by ITU-T in Recommendation D.98 (ITU (2012)). The model might build on that Recommendation for roaming transparency. It could perhaps form the basis for further ITU Recommendations for cost-based analysis of roaming tariffs, and so provide pragmatic and realistic inputs to national regulators considering the impacts of roaming.

It is also possible to build on other relevant ITU-T Recommendations. Specifically, Recommendation ITU-T D.99 discusses the question of an indicative rate for international mobile termination and provides some suggestions for consideration by national regulatory authorities, based on using the fixed

termination rate as an initial basis for negotiations. It is also possible to move forward on such indicative rates if we take into consideration another Recommendation in the domain of international call termination accounting, Recommendation ITU-T D.140. It proposes a useful principle for setting prices that cost-based accounting is the key tenet, stating in clause E.3.1:

"Administrations which have already attained these indicative target rates should continue to take positive steps to reduce their accounting rates to cost-orientated levels".

Naturally, the question must be asked – should not the same cost-oriented principle be applied to mobile roaming? A combination of Recommendation ITU-T D.98, extending from transparency for subscribers and employing its suggestions on the use of price caps, could thus follow the principles from Recommendations ITU-T D.99 and ITU-T D.140 into cost-based mobile pricing. This could form the basis for further ITU-T Recommendations which are strongly market-related.

3.2 Limits of the model

The model attempts to answer the question: *Do the additional operations and technical infrastructure required drive higher roaming costs to the levels charged?*

However, the model has practical limits in its scope and accuracy when attempting to answer this question. In principle, the task is to examine the MNOs' arguments, which claim that international roaming prices mainly result from increased costs of technical infrastructure and its operations. To assess this claim, the model must answer several questions:

- What technical infrastructure elements and operational processes are required for international roaming? This must be performed across the two operators involved in the call or session.
- What are the actual levels of extra costs for roaming that the above impose?
- Thus what does a comparison of international roaming prices with their corresponding level of domestic pricing show in terms of levels of retail tariffs?

The model does not specifically look at the gross level of negotiated wholesale agreements, IOTs, but at their underlying costs. This is because the wholesale agreements, set in IOTs, are fixed in commercial consultations between operators and may be subject to various pressures – e.g. the balance of the volume of traffic of each type, inbound and outbound. Thus IOTs have little to do with costs and are more related to the market power of operators, eventually playing a role in distorting prices. For instance, an operator may agree to a high IOT price on its roaming subscribers in order to assure a larger volume of visiting traffic from that foreign country MNO, which can be recharged for higher income. For such (arbitrary) conditions, basic cost modelling is less applicable, except to show a comparison of the underlying costs. Thus the model can only highlight where the IOTs are the major sources of additional cost for a call, taking it well above domestic charges.

However, it must also be noted that the data to answer these operational and technical questions is usually not publicly available, often considered commercially confidential. This may set a limit on accuracy. If national regulatory authorities possess such information, they may not be permitted to disclose it without explicit permission from MNO. Furthermore, the veracity, completeness and accuracy of the data gathered from MNOs and relevant fixed line operators define the dependability of the results. The model can be expanded, to add extra sources of costs and to revise costs. Nonetheless, it will always be dependent on the quality and completeness of the data input from the various operators. Much of the cost detail of the business processes for IMR may be somewhat obscure and not all captured by MNOs – or there may be a lack of co-operation. Moreover, the data gathering process will only provide information on a case by case basis – i.e. by operator and by countries roamed. On the other hand, if NRAs can gain access to the data, perhaps on conditions not to divulge the data publicly, they should ensure they are permitted to use it for internal purposes of assessment of fairness and accuracy of

roaming tariffs and transparency of offerings to the consumer. With access to sufficient relevant data, it is possible to understand the mark-up and degree of justification of higher charges.

Note that the cost model gives an *overview for guidance* on roaming costs for regulators. Thus it depends on regulators efficiently and painstakingly gathering the relevant input data, for their cases. The first time this is done may be the hardest as both sides have to go through a learning curve on understanding and performing the accounting and the business process cost attribution. A final limit is the NRA's jurisdiction – usually national. However, international roaming knowledge of the costs of MNOs in foreign countries may well be needed to understand if the IOTs being paid out are really cost based. There are at least two approaches here:

- The first approach is to act in concert with fellow NRAs as a community across the neighbouring roamed countries, with the aim of reciprocal analyses of costs, i.e. as a group of NRAs. Various community associations of NRAs exist through which such action can be taken (e.g. the European Regulators Group (ERG) and BEREC in the EU and the Communications Regulators' Association Southern Africa (CRASA) in SADC).
- The second approach is to request that communicating foreign MNOs voluntarily co-operate with the local NRA. Here again the regional community's regulatory framework may be important. In this case, however, it is to use what exists as a common set of rules, directives and guidelines covering the mobile sector as a regulated industry (as exists in the EU) which may also fall under competition and consumer protection. These statutes may be cross-border and require the correspondent MNO to reply in cases of telecommunications pricing, preferred partners and also of consumer protection.

A possible alternative approach is to obtain data from several MNOs of different sizes, using different technologies, to estimate the average of the underlying cost elements. Although an approximation, which may have regional variations, it could avoid the need to share detailed individual MNO information among all NRAs. A generalized average of costs may provide a first indicator to determine termination rates, without gathering detailed data from every MNO.

3.3 Further cost items that may be included to extend the model, when significant

There are a number of further cost issues with their parameters that could be added to a basic set (see Annex 5) when noteworthy, although some in the industry may dispute their costing significance, and whether they are appropriate in some cases:

- *Spectrum access* – Costs vary by the auction prices paid by MNOs. Thus there may be dispute over what to include in cost estimates, as the cost of spectrum when roaming may be cheaper for the radio access network (RAN) for the roaming MNO compared to that of the home MNO, indicating a possible lowering of roaming costs against the domestic call. Spectrum access cost for the subscriber may be measured in terms of licence value, estimated in price at auction per MHz, or cost per MHz per subscriber in coverage (sometime termed 'cost per pop'). Licence costs may be treated as a time depreciated asset to be written off over the life of the licence, with a decreasing value as the licence progresses. For a 3G UMTS licence written off over 15 years and costing originally EUR 6 billion (i.e. among the highest of licence fees, as paid in 2000 in the UK and Germany) and serving a peak user population of 3 million simultaneous subscribers, from a total subscriber population of perhaps 15 or 20 million subscribers, the cost per minute is a small fraction of a Euro (under a thousandth) on average, and could vary by time of day and user population. Adding additional recurring annual charges for use of spectrum of even 10% per annum (to increase net licence fees by an extra 150% over the licence's operational period) would not alter this charge

to more than the same order of cost per roaming minute¹³. Further additional licence costs may come in the form of agreements to share spectrum with other MNOs in licensed shared access (LSA) or authorized shared access (ASA) types of contract which occur in some countries. Again the order of additional cost per minute of voice is at the same low order of magnitude, but varying by agreement. Moreover these additional spectrum charges may act in both ways, i.e. the roaming MNO may be charging for its spectrum to other MNOs via such a scheme, in which case, its net spectrum cost/subscriber/minute could be lowered, not raised. Moreover, it could also be argued that the spectrum cost is a sunk cost, comparable to the cost of a ticket for entry to the mobile market and so is not an activity-based cost.

- *Fraud* is an additional cost and requires appropriate measures. Fraud when roaming is particularly prevalent in certain countries and conditions – it may amount to between 1% and 5% of MNO revenues, and globally accounts for some USD 6 billion¹⁴. A growing threat is from organized syndicates that may involve their own premium rate numbers, called by their roaming fraudsters with a postpaid SIM card activated for roaming. Individual fraud incidents are often highly organized with costs of single incidents running up to USD 15 million for the largest occurrences. The antidote is detection of excessive call usage to specific high premium rate numbers. By using embedded triggers in the CDR database for close-to-real-time alerts in both the home and visited MNO BSS, and/or in the roaming exchange databases, such behaviour can be detected. The problems lie in delays in relaying roaming data. Incidents are fairly evident due to the scale of calls needed to make such sums and the brief period for accumulating charges. GSMA has recommended a near-real time standard, near real-time roaming data exchange (NRTRDE) to counter this, with a CDR extract to be delivered to all participant MNOs in a call within four hours. This may be applied in an international roaming and clearing exchange, as a special service in parallel with activities inside the fraud departments of MNOs. Taking roaming as some 5% of total mobile traffic currently (this may increase if roaming charges are cost-based) and an estimated 8% of revenues due to roaming's more expensive tariffs, at global mobile revenues of USD 1.2 trillion¹⁵, then total roaming fraud at the top end may add some 6% to roaming costs on top of call costs. If total anti-fraud measures are successful, this proportion might decline. How much this actually adds to the cost of a roaming call over a domestic call is thus debateable, especially as some MNOs are quite successful in countering roaming fraud. However, when considering the additional cost of roaming fraud, comparison to domestic fraud is necessary. Domestic fraud is typically comparable in fraud rates, of the order of 1% to 5% of revenues¹⁶. This would tend to make the additional differential cost of roaming fraud with domestic calls vary between close to zero and a few percentage points of the cost of a domestic call.
- *Termination rates* – When fixed and mobile operators connect their customers to local mobile numbers but on a different national mobile network, they pay the MNO managing that called number a wholesale charge to complete those calls. The rates that domestic operators pay each other for delivering off-net calls on their own network are most commonly called 'mobile termination rates' (MTRs) within the same country, and may also be termed mobile call termination (MCT) charges. Thus a visitor to a foreign country placing a call within the visited country will also

¹³ In fact annual charges are often much less than a 10% level – Ofcom's revised annual charges for 900 MHz licences in the UK are EUR 163 million per year for 900 MHz and EUR 200 million per year for 1800 MHz. Thus Ofcom makes a total charge of EUR 363 million (that is the sum for all the 4 MNOs together).

¹⁴ Communications Fraud Control Association, Revector, 2013, Mistry, D. (2014), *Roaming – The most costly type of fraud*, 14 Oct. 2014.

¹⁵ GSMA (2012) Global and mobile revenue trends gsmaintelligence.com/analysis/2013/01/global-and-regional-mobile-revenue-trends/367/

¹⁶ Juniper Research (2012) puts total losses from billing system errors and fraud together at USD 58 billion, or some 6% of total mobile revenues of USD 967 billion total for 2011. Investments in billing could reduce this to 4% by 2016, from *Mobile industry loses over US\$ 58 Billion* www.business.myjoyonline.com/pages/news/201203/83922.php

pay local MTRs which may be charged per minute. This may apply to both mobile and or fixed network operators terminating that call and will add to the cost of local calls while visiting. Such charges may be equally applied to international calls but MTR then becomes part of the total wholesale (or discounted) inter-operator tariff (IOT) under the GSMA STIRA framework. However, the transparency of the costing is more obscure. The introduction of IOTs in the late 1990s produced a significant increase in wholesale roaming charges, as they were now detached from retail prices and MNOs had no pressures to bring IOTs in line with costs.

The defence of high IOTs has been made that if they are reduced, then domestic tariffs and possibly MTRs will rise¹⁷ – an effect sometimes termed the 'waterbed effect'. In markets and regions where cost-based pricing is not positively regulated for, this effect may be seen. For instance, 'lost' roaming revenues in some regional communities (such as the EU) may be compensated for by higher IOT charges for countries *outside* the regulated community – and possibly even compensated for by higher domestic MTRs. Anecdotal evidence of the impacts was gathered in 2008 for the EU after the first roaming Directive of 2007¹⁸ with a 22% rise in charges for calls originated from outside the EU and 35% for local calls in a visited country while roaming.

Some sources had previously considered that simply adding two MTRs might be used as a proxy for the costs of both origination and termination of roaming voice calls but others have disputed the use of pure MTRs¹⁹ as underestimating complete costs. The theory was that on wholesale level, the visited MNO could recover within the wholesale rate the *complete* roaming cost (i.e. costs of access and call origination – sometimes termed ACO – with costs of termination and any non network-related costs including a share of billing, customer care and common overheads). Thus here we look more closely across all cost parameters (for example, Annex 5).

- *Cost of opening up roaming routes and monitoring their operations* – IMR requires agreements between MNOs and also fixed line operators to deliver calls. This obviously comes at some cost especially if it depends on multiple bilateral agreements. One way to reduce this is to use an international exchange, or roaming hub, with many MNO partners physically connected (via CCITT signalling system 7 (SS7)). A roaming exchange hub is especially useful for the smaller operators as a single bulk agreement can provide enormous simplification of the bureaucracy and thus cost reduction. Roaming operations do still require a small team to set up and then test the roaming dataflow with more complicated configuration such as steering of traffic for maximized discounts. Over the long term, the team must monitor the agreements, especially the financial flows and their accounting, also the technical quality and reliability of the roaming setup for call handover between the various roaming partners. Many MNOs may still prefer to negotiate individual IOT agreements with their correspondent partners and also to decide on traffic steering, in order to obtain the best bulk discounts for volume with preferred international partners. The approach is to aggregate larger traffic volumes with the preferred partner. Most large multinational mobile operators pursue this energetically. It may be treated, for costing purposes, as part of the costs of the business process for roaming activities.

¹⁷ Aaron Schiff (2008), *The waterbed effect and price regulation*, Review of Network Economics, Vol. 7 No.3.

¹⁸ Angela Stainthorpe (2008), *Global mobile roaming: operator strategies and market trends*, Informa Telecoms.

¹⁹ BEREC (2010) *International Mobile Roaming Regulation*, BEREC Report BoR (1058) December 2010.

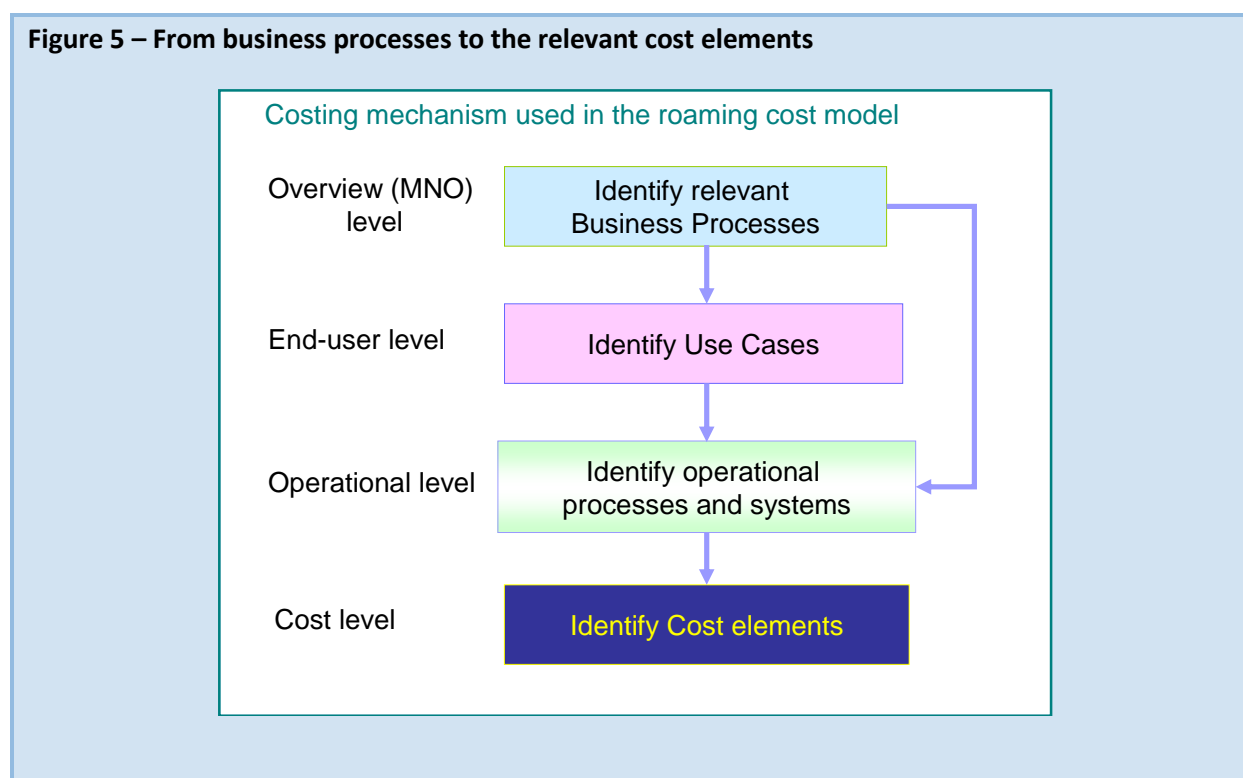
Chapter 4 – Methodology: The cost model, with its mechanisms and assumptions

Here we describe the proposed cost model, the measures and arrangements for ensuring that it has suitable input information.

4.1 Methodology

To construct the cost model, two phases are necessary – firstly design, in outline form, which is described in this chapter, and then secondly the phase of implementation in detail. The latter is based on gathering actual data from MNOs (using standard spreadsheets, shown in Annex 4).

For its design, the model will be based on the operational business processes that identify the major cost elements. A specific approach will be applied for constructing and exercising the cost model employing a construct from business process analysis of *use cases*²⁰. The cost model approach has the following steps:



4.1.1 Identify the business processes

MNO operates through specific major functional business areas, which may be approximately defined as the operating divisions for network operations, including network build, business support systems (BSS) of all kinds such as billing, with their IT systems, and thirdly sales and marketing including a retail arm possibly. Strategy, finance, NRA negotiations, procurement and inter-operator agreements may be carried out through these three functions, usually with specialized units, e.g. for spectrum auction management.

²⁰ Jacobson, I., Booch, G., Rumbaugh, J. (2010), *The Unified Software Development Process*, Addison Wesley, USA.

The key point is that these functional business units operate via set of business processes relevant to a particular activity. For roaming, the business processes may run across network operations and business support (BSS) with possible involvement of marketing sales, if roaming is used as a competitive weapon.

In total, the business processes observed in MNO include the following at least:

The major business processes for MNO

- Acquire and maintain assets – real estate for BTSs, network equipment, IT applications, IT systems, data centres, offices, etc.
- Build network, including site construction, cable laying, NOCs, telecommunications management network (TMN), etc.
- Roll out network services and value added services – e.g. apps store, mapping, etc.
- Operate and extend networks and services – test, commission, run, and maintain.
- For subscribers – acquire, register, activate, provision, retain, for prepaid and postpaid.
- Billing for domestic and roaming services – plan, build, train, operate, maintain.
- Customer care – services and infrastructure – plan, build, train, operate, maintain.
- Handle network management, including repair teams – plan, build, train, operate, maintain.
- Manage logistics for network elements.
- Manage logistics for retail sales channels, including handset inventory, supplier contracts.
- Acquire, equip and manage tied or owned retail outlets, including warehousing space.
- Marketing, with promotions, handset subsidies, etc.
- Sales, with contracts and prepaid.
- Accounts, with accounts payable, payroll and other back office functions.
- International negotiations for roaming agreements.
- Regulatory negotiations and policy with spectrum acquisition.

One assumption made in the model is that a common set of the high level business processes exist in most MNOs. Thus roaming involves these specific business functions and their specific business processes, in particular ways, with the accompanying operational processes and platforms. This assumption is challenged in two areas:

- A) For mobile virtual network operators (MVNOs), where the networking operational processes and network elements are handed to a third party and possibly some BSS services are also outsourced, such as billing (e.g. in the UK, the fixed line virtual operator Onetel outsources its billing to another operator, an MNO in fact, to avoid too much competitive risk for a core business process). However, this may make the cost model somewhat simpler as the outsourced operations involved bundles of services which are clearly identified and priced for the outsourcing service level agreement (SLA) to work. Such agreements may be advantageous when identifying costs, more so than the normal MNOs cost accounting which may not have had the same analysis with itemization and auditing.
- B) For the future – where although the business functions may always be present, and also the business processes to a large extent, the operational implementations will move forward with technology to new business models. This will affect all business support services, especially billing and customer care. One example is the move to all IP networking with LTE and away from the packet technology in UMTS 3G networks.

4.1.2 Construct the cost model

The roaming model described here will cover the fundamental network elements and process costs of roaming, i.e. the cost of business support services such as customer care and billing. Essentially, the cost model in outline form can be summarized as the underlying MNO costs for roaming (on which data has to be gathered) built up from the business processes. Costs can be one of the following:

Cost item	Description
Capital outlays – Capex	Capital expenditures include investments in network infrastructure and which may be largely one-time, on startup, with regular three, five or longer phases of capex outlays for network expansion and renewal.
Operational outlays – Opex	Operational expenditures are required for running the mobile business – recurring costs include everything from salaries to electrical bills to annual software licences to consumable items and maintenance of networks, IT and software. For roaming, the costs include some proportion of the costs for staff for network management and the billing systems with customer care and their software plus the software maintenance costs. It also includes staff for negotiating IOTs although this may not be a continuous process and may reduce in a regulatory regime where IOTs are cost controlled.

Various MNOs have tried to include special marketing and sales costs in their roaming charges. However, this seems questionable in terms of a service that thrives without promotion, through its dependence on its (tied) domestic subscribers who are already signed up.

Note that opex costs are almost always higher than capital investments over a multi-year time window. Even for new mobile technologies at rollout – for instance 3G UMTS annual capex was typically much less than OPEX²¹ over the amortization duration, especially when network element prices fell²².

Billing, call data collection and mediation are fundamental business processes, as the whole revenue stream depends on them. Their total costs are quite variable. They depend on the complexity of charging with the pricing plans, the services offered, as well as the number of subscribers. For instance, a billing system for three to 10 million subscribers may cost EUR four to EUR 10 per subscriber for complex rating systems. For flat rate billing, e.g. for IP data/month like cable television (CATV), the cost may amount to less than EUR 1 to EUR 2 per subscriber²³.

Hence for 10 million subscribers with packaged call bundles, complex time, length of call and volume of call conditions, plus off-net and on-net premiums, would give an initial capex of EUR 40 to EUR 100 million. In contrast, a flat rate billing system may be less than 10% to 20% of this in outlay, similar to an Internet service provider (ISP) or CATV operation.

An MNO handling a wide variety of interconnected networks (e.g. LTE and 2G GSM/GPRS, 3G UMTS plus Wi-Fi WLAN and other Internet services via Internet gateways) will require a complex billing system, or possibly a group of specialist billing packages that interwork. Billing may have to handle a complicated network infrastructure of fixed line circuit switched systems, as well as 2G and 3G mobile, plus IP packets, which all may have different billing modes. In these conditions, roaming becomes a relatively small extra set of conditions that the rating engine (the heart of a billing system) simply adds, creating a new set of tables, perhaps with a specific database schema and some storage. This roaming/interconnect module will be designed to support the individual IOT billing agreements with the roaming partners for their interconnected networks, taking into account all their specific conditions (e.g. minimum charge of 30 seconds per voice call). Note that as roaming charges become regulated and retail charges reduced with cost-based tariffs, so do IOTs which become less of an important negotiating task, and as a result the numbers of staff, and costs will tend to fall.

²¹ Buchanan, Iain (2001), *Pricing and billing for new services, Content and Entertainment Strategies*, Mobile Europe, Cannes, May.

²² UMTS network elements fell nearly 60% in one year in some countries as the technology rollout accelerated between 2003 and 2006.

²³ SCF Associates Ltd, from projects for design of new billing systems.

The call data is connected via interconnect gateways, both international (for roaming) and domestic. Note that for modern mobile operations, real-time mediation and billing are necessary, especially for managing prepaid customers.

However, the opex will always be at least 10% of these figures for a software maintenance licence while staff costs for operating the billing business process may be at least another 10% to 20%. Hence over five years, opex is likely to exceed capex, especially when including all the opex costs of infrastructure – office support, running data centres, or of outsourcing the systems and/or the applications with the data centres. In this way, total opex usually becomes the major portion of costs.

Moreover, total costs of providing, operating and maintaining a billing system with mediation may be a significant portion of all MNO costs, possibly even amounting towards 50% of the MNO infrastructure investment and annual turnover of the network²⁴. Note that a large MNO with a wide geographic spread may have acquired various different billing systems over the years.

In consequence, it is difficult to give exact figures covering all classes and sizes of MNO since the costs depend on all of the above factors, including call volume, network infrastructure with its generation of mobile technology, services offered, number of subscribers, business processes, and the various forms of integration of the business IT systems, the BSS – billing and customer care – and network operational management, the operational support system (OSS).

4.1.3 Identification of data elements is the first step in the design of the cost model

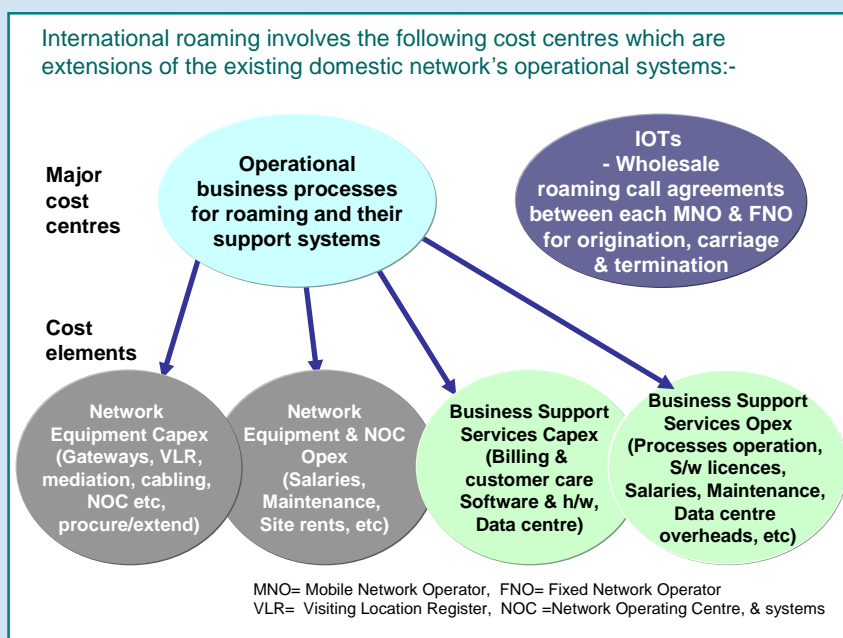
The first step is to define the information required to build an evidence-based cost model – i.e. the basic cost elements. This data must mirror the operating model within and between MNOs. Examples of data elements include:

- Share of costs of network elements due to roaming with their operating costs.
- Costs of BSS infrastructure for mobile and also for any fixed line carriers.

Hence the nature of the cost model will be bottom-up – i.e. the model aggregates total costs from the various elements in the major cost centres with their subsystems and elements:

²⁴ Cushnie, John, Hutchinson, David, *Charging and Billing models for GSM and Future Mobile Internet Services*.

Figure 6 – Main cost centres and underlying cost elements



The wholesale charges are a separate addition, as illustrated figuratively above and although in theory dependent on actual costs, too often have been seen as arbitrary in magnitude.

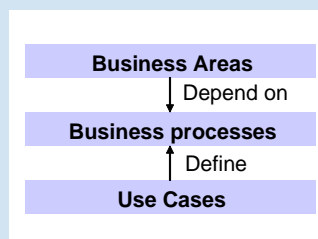
4.1.4 Gathering data required by use of questionnaire

A questionnaire that provides the inputs for the cost model will be provided, to guide NRAs and MNOs in gathering the data required to populate the cost model (model form in Annex 3).

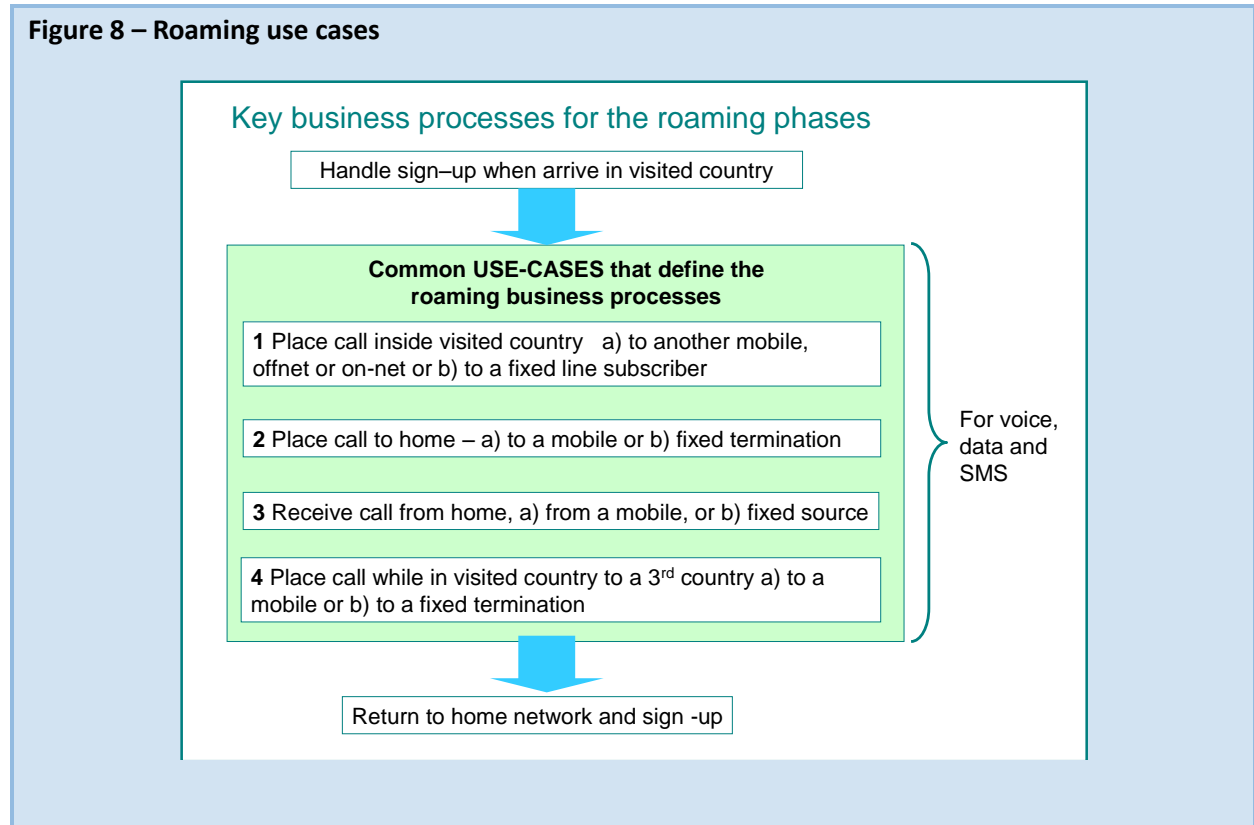
4.2 Mechanisms for calculation – Business process analysis

As mentioned earlier, the mechanism for cost estimation depends on business process analysis (BPA) drawn from the various common situations for roaming. To obtain the functional requirements for roaming, these business processes can in turn be defined and constructed by the common *use cases*, i.e. the everyday ways in which subscribers use their mobile services, which are employed to define the chain of MNO business processes involved in handling a call.

Figure 7 – Business areas (such as networking) depend for their operation on business processes (such as call handling) which can be defined through their use cases



The requirements of the use cases illustrate and define the business processes and their support needs, e.g. for specific network elements, BSS software, hardware and human resources, and therefore the cost structure of an international mobile roaming service. There are four main use cases, or situations, for roaming in a visited country – i.e. examples of how consumers actually exploit their ability to roam:



The four main use cases for roaming may vary in their composition by:

- Prepaid or postpaid billing;
- Media – voice, data, or SMS.

This represents 16 possible use cases in all, varying by billing mode and limiting conditions (for voice: $4 \times 2 = 8$; for SMS: $3 \times 2 = 6$ since receiving SMS is usually free; for Data: $1 \times 2 = 2$ if uploading and downloading data from the Internet are the same price and may be in the same session, so 16 in total).

These are explored below in terms of the activities for each and then the resources required in each use case. We now examine each business process and use case in turn:

Business process 1: Handle sign-up – Visitor enters foreign country and is registered with local MNO (GSM procedure)

1. The visited MNO responds to the request from handset for assignment to network – either through direct sign-up as preferred carrier or by manual selection of MNO.
2. The visited MNO informs the home MNO of the subscriber's presence in the foreign country by the transferred account procedure (TAP) file. It requests service information about the roaming device using the IMSI number (e.g. whether or not the subscriber's mobile handset is allowed to roam). If there is no roaming agreement between the two MNOs, service is denied by the visited MNO.
3. If verified by the home network, then the visited MNO enters in dialogue with the home MNO in country A). For prepaid – check credit available and the appropriate accounting process at roaming rate on visited MNO. To monitor and control calls made by its roaming subscribers, the home network may use a CAMEL²⁵ module.
Or, B) For postpaid – check valid contract details for roaming.
4. The visited MNO makes entry in customer database to set up new visiting subscriber on visited network following handset request. At the same time, the home network updates its HLR subscriber file to indicate that the subscriber is now on the visited network so that any information sent to that device is rerouted.
5. OTA activation of new visiting subscriber.
6. The visited MNO sends an SMS message to the subscriber as welcome, showing roaming charge information for voice, data and SMS or confirming all is the same as at home (option).

Note that in some mobile networks, anti-fraud measures are also taken, to transfer unrated call data records (CDRs) back to the home network much faster than normal, using a hub between MNOs to exchange CDRs and so detect fraud patterns. The hub, termed a "near real-time roaming data exchange (NRTRDE)", follows GSMA guidelines, and is supported via shared costs between MNOs.

Business process 2: Roaming – The network and BSS elements and resources required by the next stage, the roaming business process, can be identified from the four main *use cases* of roaming in the diagram above, for voice, data and SMS.

The use cases for voice roaming cover calling out while in a visited country and receiving calls as both are charged for currently in common roaming tariff plans. The main use cases for roaming are as follows:

²⁵ Customized applications for mobile enhanced logic (CAMEL), an ETSI standard, is a network management application for GSM/GPRS networks that enables a home network to monitor and control calls made by a roaming prepaid subscriber. The "CAMEL application part (CAP)" may also provide other services, such as fraud control and closed user groups.

Figure 9 – Use case 1: Calling inside visited country

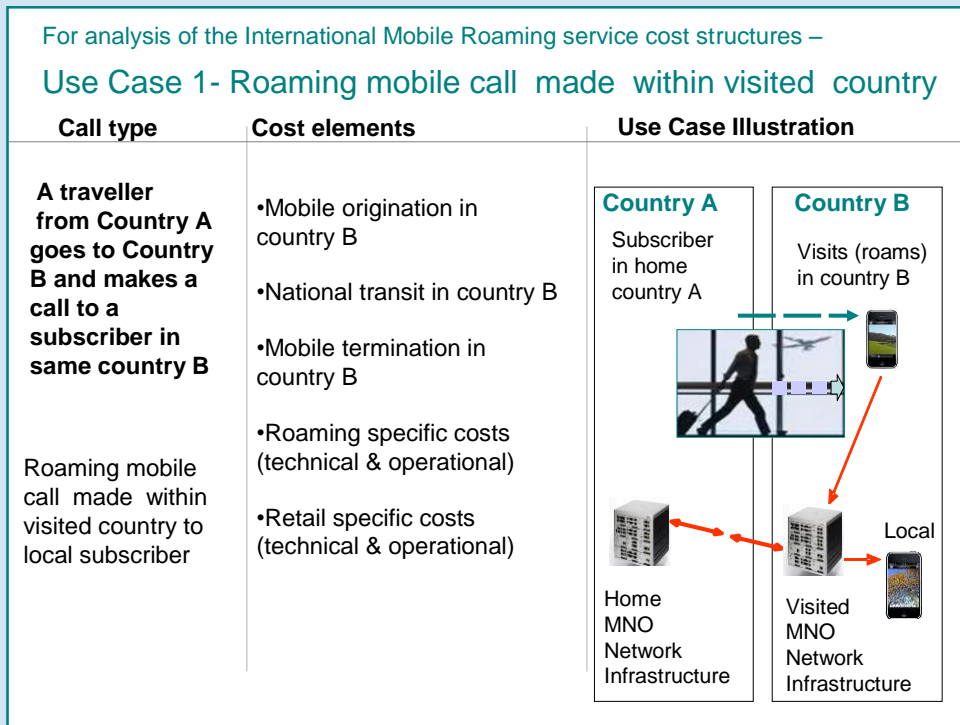


Figure 10 – Use case 2: Calling home

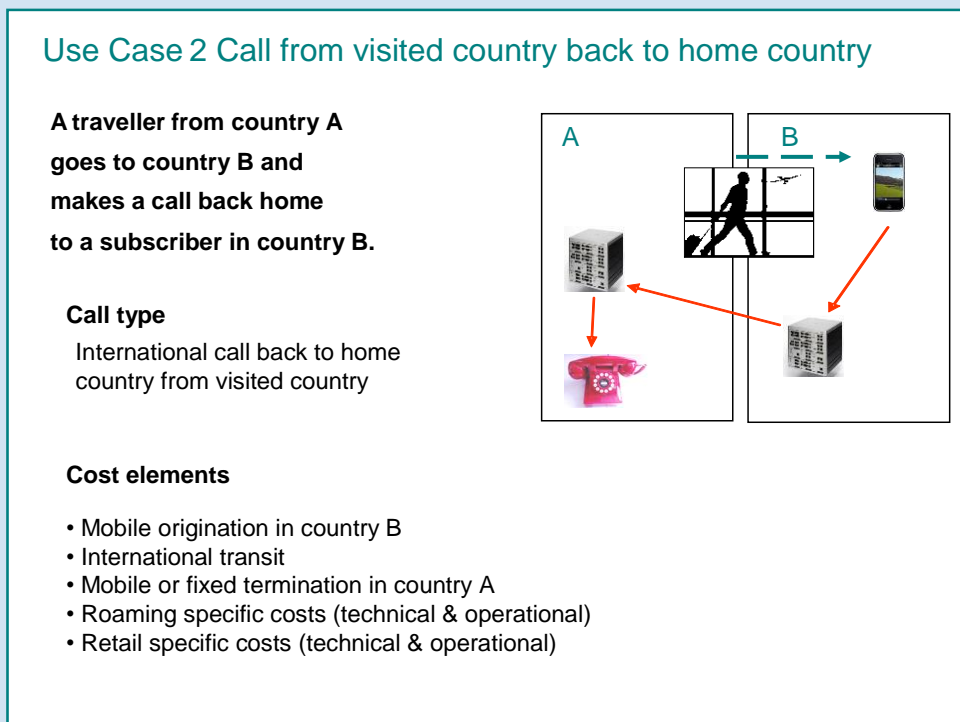


Figure 11 – Use case 3: Receiving a call while roaming

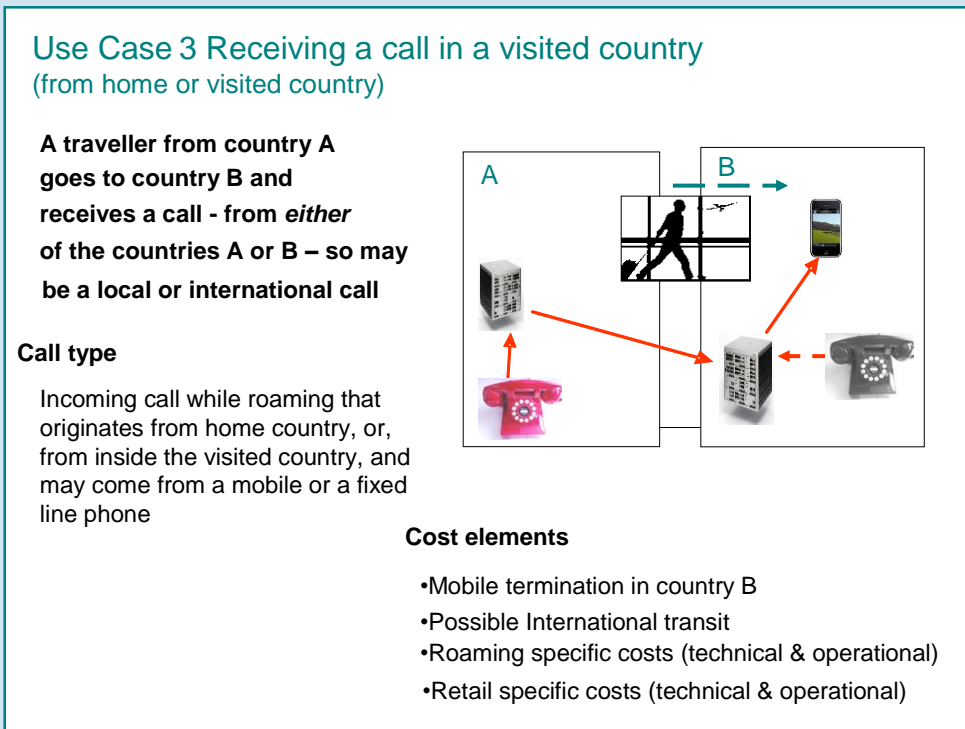
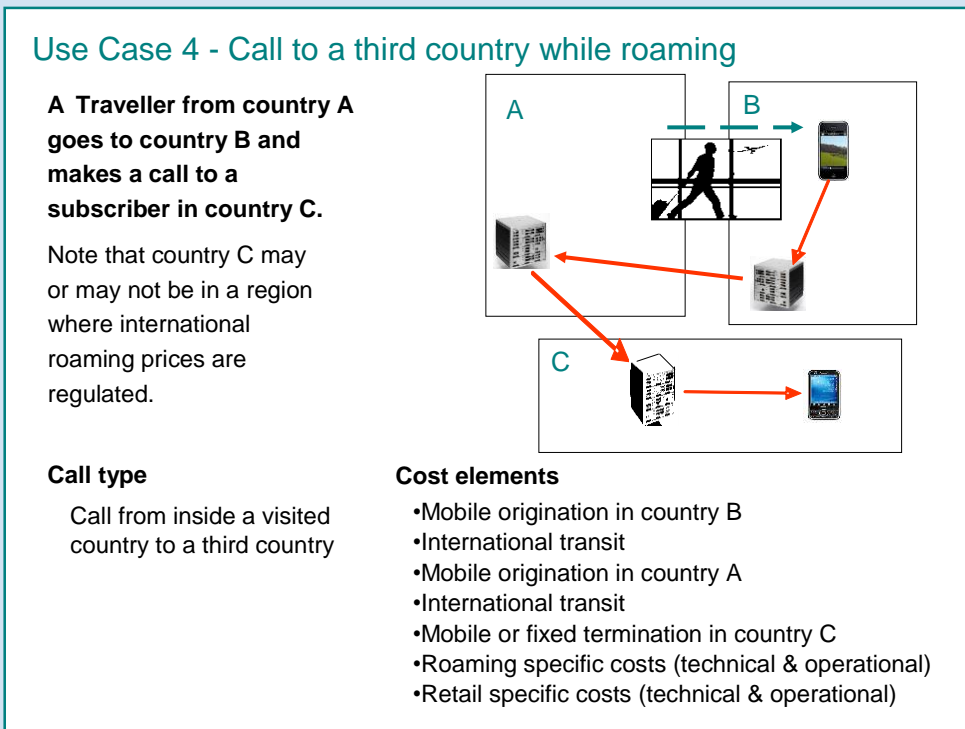


Figure 12 – Use case 4: Calling a third country while roaming



On returning to the home country, the subscriber is registered as being in the home coverage area when the handset polls for network access. The temporary roaming file in the visited country is closed. Note that the above use cases are the most generic possible in order to simplify the cost model and various other detailed operations could be added such as that for customer care. For instance, some MNOs (especially those with multi-country coverage) sell prepaid phone cards in their visited countries so that prepaid subscribers can 'top-up' while roaming abroad. The processes for this are just an extension of the BSS and OSS elements and many of the processes illustrated here.

4.3 Going from use cases to analysis of assets used in roaming to their costs

The model then exploits the use cases to understand the BSS and networking elements involved. From these, the extent of the roaming cost above domestic can be estimated. To do this in detail demands information from MNO. Hence, a survey by the regulator is required to examine roaming costs in detail. A questionnaire for this, with its composition and use is explored in the next chapter. In Table 4, we give an example in overview of what a costed implementation following the use case 1A for voice might yield, following its verification from the MNO survey:

Table 4 – Use case 1A – Calling inside visited country: Example of voice roaming assets and their extra costs

Use case 1A: Activity	Assets – to be verified from NRA questionnaire with MNOs, with actual opex and capex costs; includes staff, IT systems and ops centres	Percentage extra on domestic load, capex and opex pa – (to be MNO verified) for all assets – estimated approximations
1) Visited network – receives request for call.	Visited RAN, interconnect gateway, LD and core network, TAP file generation, operational staff for home and visited network.	~5% extra network elements over domestic; effort varies with roaming numbers:
2) Visited network – checks IMSI against VLR and destination and triggers BSS billing subscriber databases to set up charging, according to whether prepaid or postpaid and any limits and IOT conditions (e.g. one minute minimum, then by second).	Billing system assets and operations VLR and network elements.	~5% extra over domestic in assets and operations; cost/visiting subscriber varies with roaming numbers: reduces with volume.
3) Visited network – routes call to local subscriber and then accumulates CDRs for mediation processes at international wholesale level with fraud and limits checking – real time if pre-paid.	Visited MNO's RAN and core network. Visited MNO's billing system with temporary subscriber file and mediation.	Little or no extra over domestic. Also extra volume reduces cost per call transaction.
4) Visited MNO BSS and billing system – makes wholesale charge to home MNO – via TAP file – under IOT agreement for the call, with conditions applied – e.g. on time and length of call using a pre-set rating involving billing engine and mediation platform.	Generation of TAP file under IOT policy rules. Possible use of EDI system for exchange of IOT data in TAP file.	< 5% extra for billing and other BSS over domestic in assets and operations; cost/visiting subscriber varies with roaming numbers: reduces with volume.
5) Home MNO BSS billing system calculates subscriber charges.	Home MNO billing system using roaming rates and TAP file.	< 5% extra costs for billing system added features.
6) Home MNO BSS billing system: makes retail charge to subscriber for the call – either debits prepaid credit file or adds charge to postpaid contract, in each case with appropriate mark-up.	Home MNO billing system.	No extra cost.

Note that each of the steps above will involve the three elements of:

- Staff costs of handling extra call volumes and of the roaming business processes.
- Network elements, both hardware and software, including additional capacity for greater calling volume, including extra effort and systems in NOCs.
- Extra software for billing and customer care, with the IT infrastructure such as extensions to data centres and/or IT support systems including call centres.

The assets and their costs as shown are only examples that must be verified using MNO accounts collected by an NRA questionnaire survey, with actual opex and capex costs. A further example for the second use case is shown in Table 5:

Table 5 – Use case 2A – Calling home: Example of voice roaming assets and their extra costs

Use case 2A: Activity	Assets – to be verified from NRA questionnaire with MNOs, with actual opex and capex costs; includes staff, IT systems and ops centres	Percentage extra on domestic load, capex and opex pa – (to be MNO verified) for all assets – estimated approximations
1) Visited network – receives request for call.	RAN, core network.	No extra cost.
2) Visited network – checks IMSI against VLR and destination and signals to BSS to set up charging, according to whether prepaid or postpaid and any limits and IOT conditions (e.g. one minute minimum, then by second).	VLR. Visited MNO mediation and billing systems.	< 5% extra costs.
3) Visited network – routes call and then accumulates CDRs for subsequent mediation processes at international wholesale level with fraud and limits checking.	Visited core and RAN network. Inter domestic call handover if off-net to fixed line or other local MNO. Visited MNO mediation and billing.	< 5% extra costs.
4) Home network receives call via international gateway – either direct from the visited MNO, or via an intermediate fixed line LD carrier, traced via CAMEL application.	Visited core network. International gateways for home and visited network; LD international carrier.	< 10% with LD carrier, else < 5% depending on volume tariffs agreed for international calls.
5) Visited MNO BSS billing system – makes wholesale charge to home MNO – via TAP file – under IOT agreement for the call, with conditions applied – e.g. on time and length of call using a pre-set rating and any LD charges.	Visited MNO mediation and billing. Generation of TAP file under IOT policy rules. Possible use of EDI system for exchange of IOT data in TAP file.	< 5% extra costs.
6) Home MNO billing system calculates roaming subscriber charges.	Home MNO billing system.	No or small extra cost, normal billing process.
7) Home MNO billing system: makes retail charge to subscriber for the call – either debits prepaid credit file or adds charge to postpaid contract, plus appropriate mark-up.	Home MNO billing system.	No extra cost, normal billing.

Setup costs are included in the above table for network and billing with facilities for set up of business processes, as well as with testing of everything and final rollout.

As noted in chapter 2, Table 2, the added costs for the network elements, systems and processes are for:

- Extension (for volume) of inter-operator gateways for data traffic in both the home and visited network.²⁶
- Extension (for volume) of the home network and of the visited network.
- New components in the home network and in the visited network.

These added costs also affect the IOT level. For all use cases, there are also the costs of making commercial agreements for roaming at wholesale level. These form additional costs on top of the national domestic business processes, as they require negotiations to determine the IOT levels in roaming performed with each of the correspondent foreign MNOs. Use cases 3A and 4A for voice can be analysed in the same manner.

4.3.1 Use cases for data roaming

Here we consider data roaming for applications such as e-mail, web browsing and file transfer by mobile subscribers – i.e. a focus on mobile access to the Internet. In the future, as pointed out above, this may embrace IP voice with VoIP and VoLTE. The cost situation is to some extent more complex than for voice with so many different technology options for data that can affect underlying costs. However, it should also be remembered that these differences usually affect domestic data sessions equally. In addition, devices used by subscribers may vary from mobile phone handsets to tablet computers to laptop personal computers (PCs) with UMTS modems ('dongles).

However, there may be a greater complexity in data roaming tariffs against domestic rates than those for voice. Roaming data tariffs have changed rapidly over the last decade at both retail and wholesale levels – and the EC claims its price caps have reduced data roaming pricing by up to 91% inside the EU community.

Roaming data tariffs are also highly variable in the wholesale agreements between MNOs, for their preferred partner MNOs and for large end-customers. For instance, in 2007, the EU average standard data IOT charges were EUR 5 to EUR 10/MB. However, for *preferred partners* among MNOs, IOT rates may be much lower i.e. < 0.5 to EUR 1/MB, with wholesale charges becoming as low as EUR 0.25/MB (2007). Vodafone offered EUR 0.5/MB for any reciprocal offer in the EU in 2007²⁷. Overall in the EU in 2007, retail prices per MByte varied from EUR 10/MByte down to EUR 0.02/MByte for favoured large retail customers at high volume, a ratio of 500:1. Data tariffs may be set as part of a subscriber's bundle of services that also includes voice with SMS texts, and have limits with different charging thresholds and time-related limits.

Moreover, data traffic may need to be steered to a network suitable for data (not a voice network probably). Furthermore, not all operators have high speed data technology in the network (e.g. HSPA/UMTS); and as a result, a subscriber benefits if it is possible to change from the home MNO's preferred voice operator when the home MNO negotiates a wholesale data IOT.

Data sessions carried over mobile networks may require additional costs on top of voice carriage. For instance, special extra base station equipment, e.g. for higher downlink speeds with new protocols or new frequencies (e.g. 1452-1492 MHz for supplementary downlink (SDL)) may be used. This is however equally required for serving domestic subscribers. Consequently, data roaming sessions may be largely similar or the same in resources needed and processes as domestic. Thus carrying data internationally

²⁶ For instance, the added components may include a global/GPRS roaming exchange (GRX) for data, cost varying with MNO size and data volumes (approximate order of EUR 5000-10'000/month).

²⁷ European Commission Europa Digital Agenda for Europe : Roaming update with EU roaming tariffs, ec.europa.eu/information_society/activities/roaming/data/index_en.htm

between two MNOs may be the same as for a domestic off-net data session between two MNOs in the same country (as for voice) apart from certain extensions explored below.

These extensions relate to differences between prepaid and postpaid roaming, which, as for voice, are different for data. However, they may be more important in costing terms than for voice. Roaming for prepaid data customers may involve some additional investment by operators for signalling and billing systems, to operate in real time or near real time, in order to keep up with roaming subscribers' credit levels. This requires rapid signalling for subscriber authentication and authorization of roaming.

Such measures are less of a requirement for postpaid services when roaming, because as soon as the subscriber first switches on the handset abroad, the visited network checks in real time whether the home MNO authenticates the subscriber and then authorizes roaming. For prepaid subscribers, all the call data records (CDRs), are sent to the home MNO²⁸. For postpaid, the details on each data session and SMS may be sent to the home MNO with some delay – possibly of several days.

For prepaid roaming, in addition to the initial authentication step, the call-related data must be exchanged between the visited and home MNOs and processed in real time. A specific mediation and billing system enhancement, CAMEL²⁹ (customized applications for mobile enhanced logic), is added to monitor and halt the roaming subscriber prepaid account before it is overdrawn.

The data carriage architecture, and its costs, depends on the data packet transport technology used. Data advances have spread from 2G GSM into 3G UMTS with backward compatibility for newer advances such as LTE. The 2G advances include GPRS and EDGE³⁰, and for 3G, extensions such as high speed uplink packet access (HSUPA) and high speed downlink packet access (HSDPA).

Radio access networks (RANs) have evolved from 2G networks with GSM handsets to 3G, which introduces IP. However, 3G networks internally do not usually offer end-to-end IP-based service. Rather, the data portion of the traffic is carried³¹ to gateways into IP-based networks. Whatever generation of mobile network subscribers are attached by (3G UMTS or 2G GSM) there are two major transport routes for data, which impact the networking elements employed and so the cost structure:

- Via the packet switching structure for data in 2G and 3G³².

²⁸ Note that for some MNOs a data equivalent to a CDR voice record may be used, termed IP data record (IPDR), for use of IP packet streams.

²⁹ ETSI TS 29.078, *The 3GPP specification for CAP, the CAMEL Application Part*, designed by a committee, ETSI 3GPP.

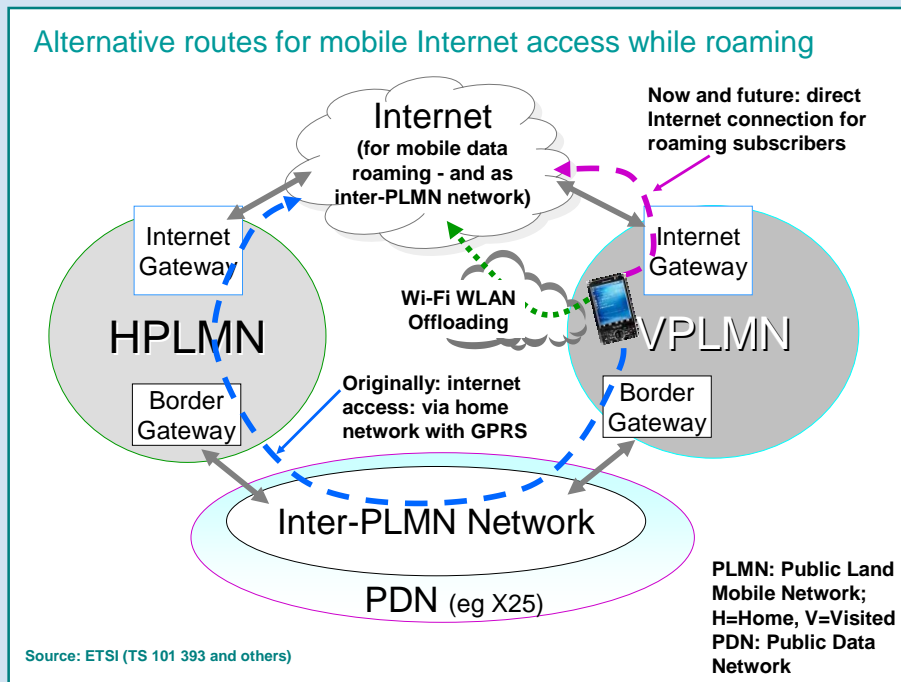
³⁰ For instance, enhanced data rates for GSM evolution (EDGE) is a 2G mobile data transport technology for higher data transmission rates. EDGE can be used for any packet switched application, such as an Internet connection. It offers a backward-compatible extension for data for 2G GSM, tripling capacity and performance per radio channel over a GSM/GPRS connection through improved coding and transmission. EDGE was first deployed on GSM networks in 2003 and is now a standardized part of the GSM norms (from 3GPP, ETSI).

³¹ Packets are carried over serving GPRS support node (SGSN) 'tunnels', i.e. as pseudo packet protocol, to GPRS routers which act as gateways to IP-based networks. The next advance in mobile networks, commonly called long term evolution (LTE), introduces more IP into mobile backhaul networks, transforming RAN networks into IP RAN networks. In LTE networks, voice packets are encapsulated into IP packets and are transmitted over IP RAN, not over the legacy PSTN network as is the case with 3G.

³² In this case, data is sent via the sending MNO's RAN (home or visited) and its core network backhaul, into a gateway to be then routed via a fixed line data carrier, perhaps a packet network, into the receiving MNO, or direct into a second MNO, i.e. via a point-to-point MNO/FNO network. In this scheme, IP packets may also be carried in public data network packets (e.g. Recommendation ITU-T X.25) which may add overhead costs and performance penalties – and so be generally a more expensive routing.

- As soon as possible into an Internet gateway as an IP packet stream³³ for carriage between MNOs or to FNOs.

Figure 13 – Mobile Internet access paths vary with technology



LTE networks, largely following the second model for data transport, may use the Diameter signalling service standard for IMR across the 2G and 3G generations of mobile technology as well as Wi-Fi, via a dedicated IP packet switch³⁴.

Offloading mobile data carriage, by alternative routing with Wi-Fi, is also being increasingly invested in by MNOs, by connecting to the Wi-Fi interface in the handset over a wireless local area network (WLAN). The overall aim is not only to reduce mobile traffic in the RAN mainly but also in the core fixed network. If the MNO enters fully into the Wi-Fi offload market, it may invest in a high density of Wi-Fi hubs, plus their backhaul, and perhaps add Wi-Fi to its most appropriately sited mobile BTS. Then, connection via Wi-Fi may require expansion of the sending and receiving Internet gateways, if used for Wi-Fi also.

For billing, data sessions may be somewhat different to voice, as the download and upload data streams may be charged at different rates³⁵. It is also possible to differentiate tariffs on speed only. Actual bit rates may vary with the radio signal quality and network speeds to particular websites, so that, depending on the MNO, uplinks might be slower (and in theory cheaper). Often the MNO's "guaranteed" advertised data rates are elusive in practice.

³³ Here, access is via the RAN and core network backhaul of the visited MNO, then to an Internet gateway for standard IP traffic, to be carried internationally (perhaps long distance) via a wholesale Internet carrier for delivery to a browsing destination, e.g. shopping website, or e-mail server, etc., or to a second Internet gateway into the (home) MNO's RAN, for mobile-to-mobile IP, often a cheaper route.

³⁴ Deutsche Telekom offers wholesale LTE Diameter signaling service for roaming, 18 Nov. 2013, Cellular-News; at <http://www.cellular-news.com/story/63036.php>

³⁵ Download may possibly be lower cost per byte and delivered at a higher data rate, while upload is slower and may be more expensive per byte, if differentiation is made that way.

For the wholesale rates of IOTs for inter-MNO charging for data, there are various models, often reflected in retail tariffing. For instance two common ones are:

- A flat rate per MByte charged with billing increments – e.g. every 100 kBytes or every kByte for any total number of bytes.
- Steps in a data session by volume: The steps in data volumes are rated differently, e.g. first MByte at X currency units, then the following 10 MBytes at Y, with the following 100 MBytes at Z – i.e. high volume sessions have lower rates.

Costs depend on the generation of data architecture in use but all architectures indicate high entry, or one-time costs, followed by lower expansion costs for major surges in data volumes. Real costs per MByte depend on volume of data. Thus as traffic builds, the justification for a mark-up over domestic data charges may become less justified. The wholesale charges sought by MNOs reflect the roaming data volume and their revenues from roaming: generally the higher the volume, the lower the wholesale price sought for IOTs. Thus IOTs also reflect the volume of traffic expected – and the revenues for the MNO from that, just as for voice – for both the visited and home MNO. However, recent cases indicate that for data roaming, the MNOs may still not be very logical in charges as the so-called "bill-shock" cases illustrate³⁶. Thus scrutiny of IOTs for data roaming may provide some surprising levels of tariffs (as the case of roaming between Sweden and Norway by overlap error at the frontier, for instance, has shown).

Turning to the use cases for data, as shown in Figure 13 above, the single most important case when abroad perhaps is mobile Internet access. As illustrated, this can be via mobile broadband services which some MNOs may refer to as packet switched data (PSD), with a connection established by the visited MNO back to the home MNO network. Conventionally for this, the visited MNO passes the roaming subscriber's Internet traffic via an international gateway into a data transit network for two-way data communication with the home network. The home network then connects the roaming subscriber to the Internet, to access all the personalized services such as e-mail, social networking and other data services, e.g. for the cloud. The future is to move to direct local IP connection via the visited MNO's RAN into an Internet gateway for lower cost infrastructure, with potentially higher performance.

The MNOs and any carriers involved then communicate billing information on data roaming customers for all data services on the visited network. This may be in a mode as near to real time as possible, in cases of tariff limits on data volumes, e.g. for prepaid and possibly for postpaid, if warnings on volume-based charging thresholds must be given.

In principle, the billing process is as follows. The visited MNO captures the details of each data session as a call data record (CDR or IPDR). CDRs or IPDRs register all key data for billing, including data rate, data volume exchanged in each direction for asymmetrical billing upload/download (measured in Mbytes or kBytes), session duration, locations, identity of sending and receiving parties, with time of connection. From this record, the visited MNO calculates the wholesale roaming charge under IOT for data, payable by the home MNO. All of the data, with the CDR records, plus the wholesale charges due, are encoded in a transferred account procedure (TAP) file transmitted by the visited MNO to the home MNO perhaps via an intermediary³⁷.

³⁶ *Mobile workers report average monthly data roaming bill shock of US\$1089*, Cellular-news, 22 Aug. 2012, for mobile workers, monthly bill, 1.4 times per year on average, at: <http://www.cellular-news.com/story/55980.php>

³⁷ The file transfer may be performed via a data clearing house, which provides a hub service for the distribution of TAP files between MNOs, with auditable records and accounting history for roaming subscribers.

To simplify the use cases for data roaming (designated by 'B' for data), we focus on a generic interactive data session – i.e. the condition that data roaming is switched on by the mobile subscriber on the handset. Note that the Internet once reached is 'locationless', i.e. we can send data and e-mails anywhere in the world but may be charged for delivery, if the final part of the route is over a mobile connection. This implies that the use case for sending data to a third country only applies for reception by a mobile subscriber over a mobile connection. The final delivery via a local ISP should not be part of the tariff. Thus the interactive roaming session use case may be considered for billing purposes as of in two modes in terms of the costings of the network elements used, due to the asymmetric charging used by some MNOs for upload and download. Mobile Internet roaming consists of gaining mobile internet access, and interactively browsing the web as follows:

- Use case 1B: Send e-mail or transaction responses in an interactive session with upload of data files.
- Use case 2B: Receive e-mails and transaction responses and download data.

This encompasses all other potential roaming use cases:

- Browse web and upload/download data files.
- Send e-mail or data files to destination in the visited country, including a local mobile subscriber.
- Send data to home country: a) to another mobile, either off-net or on-net, or b) to an Internet fixed location.
- Send data/e-mail or browse while in visited country to a 3rd country: a) to a mobile, or b) to other off-net termination.
- Receive data from home country, such as an e-mail or file download, a) from a mobile, or b) fixed line source.
- Receive e-mail or data sent from inside visited country.
- Receive data/e-mail while in visited country from a third country.

These transfers may use GSM/GPRS procedures and/or 3G/IP procedures, with differentiation of tariffs for data download and upload. Any such differences should appear in the cost analysis calculations for the use cases. However, a single tariff for both directions for a data session would merge the two use case cost calculations.

There may also be a situation of distance-based charging being absent if the Internet 'cloud' means that geographic differentiation is less meaningful and so is not applied. However, MNOs may opt to charge for roaming access to the 'cloud' on their own terms. In contrast, use of immediate Internet access for data roaming should enable MNOs to offer retail packages for roaming at a flat fee across many countries, especially as flat rate IOTs may be negotiated. Although the elements and their costs will vary by generation of mobile technology actually in use within each MNO, the *use cases are technology neutral*. They can thus be used to identify the cost elements that the subscriber's activity will involve across the MNOs' technologies.

Examples in outline of the technical network elements involved across the various technologies, for the use cases, are shown in Table 6 below. It should be noted that this is just an example – the actual situation within each MNO may vary in terms of the network infrastructure and mixing of generations of technology. Moreover, the cost items for BSS systems and processes must be added to these costs – and any other back office systems and processes involved in data roaming. Such a network element table should be further analysed by the proportion of those elements involved during the roaming process, in order to attribute roaming costs, as well as for distinctions in uplink and downlink tariffs, if they differ:

Table 6 – Examples of network elements involved in data roaming within the cellular system vary by technology and costing should take account of the differences

Use case	2G GPRS/EDGE example	3G UMTS example	2G GPRS example of interconnect with 3G IP streaming
1B: Send while roaming: log on to Internet, access e-mail server and send e-mail or data to local subscriber in visited country or elsewhere, or browse web (GSM procedure) or if 3G+, download video or audio or stream video.	VLR check; home network advised, authenticates and authorizes; send data to home MNO for Internet access. 2G RAN and GGSN/SGSN network interconnect. CAMEL for prepaid data over GPRS networks and for connecting to visited Internet gateway.	Data transfer either with or without Internet gateway. VLR check; home MNO advised, authenticates and authorizes. For connection to 2G network: RAN and GGSN/SGSN (and CAMEL signalling for prepaid) for network interconnect. Send data to home MNO for Internet access (or 3G + perhaps data transfer via visited MNO Internet gateway).	GPRS tunnelling protocol between MNOs with CAMEL system for 2G prepaid checking. Possible direct connection to visited MNO's Internet gateway.
2B: Receive e-mail and data from home: a) from a mobile, or b) any Internet connected source: log on to Internet and connect to e-mail server or other data sources.	VLR check; home network advised, authenticates and authorizes 2G RAN and GGSN/SGSN network interconnect: CAMEL for prepaid for browsing for GPRS data networks.	Data transfer either with or without Internet gateway, with VLR check; home network advised, authenticates and authorizes. For 2G, RAN and GGSN/SGSN network interconnect, CAMEL for prepaid for browsing for GPRS data.	GPRS tunnelling protocol between MNOs with CAMEL system for 2G prepaid checking. Possible direct connection to visited MNO's Internet gateway.

As noted above, tariff bundles complicate the retail pricing side, especially for data. The easiest tariffs to understand are the linear tariffs, as their pricing, such as per MB or used minute for voice or SMS for texting, is easy to compare with other linear tariffs. However in many cases, prices are not linear but volume related with limits, and excess charges per MByte, per voice minute and per SMS or (especially for infrequent travellers). The charges for exceeding the limit are at a higher rate. Generally, prices are higher for customers with a linear tariff subscription than for others. Alternative linear roaming tariffs are offered by many MNOs. Most of these tariffs are not restricted to a specific time period, but are applied as long as the customer does not switch to another roaming tariff. Bundles with more than one service included are offered by a significant number of MNOs. For instance BEREC in 2013 found³⁸ that in the EU, 19% of providers offered tariffs that include all three services (data, voice, SMS), 18% offered bundles with minutes and SMS, 12% offered bundles with minutes and MB, and just six providers offered bundles with SMS and data services only.

4.3.2 Use cases for SMS roaming

Here the focus is on texting short message services (SMS) rather than the multimedia messaging services (MMS) which are generally at a far higher tariff but less commonly used, although the use cases generally apply to them. Naturally, as for data, SMS roaming tariffs may be part of a tariff bundle.

As for data or voice, when the subscriber is abroad and sends an SMS home to a domestic mobile subscriber, conventionally the SMS is routed and managed by the visited MNO network into the home MNO. The visited network passes the SMS via a dedicated signalling link, and possibly via an

³⁸ BEREC Report on Transparency and Comparability of International Roaming Tariffs, December 2013, BoR (13) 185.

international transit data network that may include an IP network, perhaps the Internet. The home MNO network routes SMS to MNO for the domestic mobile subscriber, whose network delivers it to the recipient mobile handset. The uses cases for SMS (denoted by 'C') are as follows:

- Use case 1C: Send SMS text message within the visited country while roaming, to a subscriber in the visited country.
- Use case 2C: Receive SMS from home, from a mobile subscriber.
- Use case 3C: Send SMS to home country to another mobile, either off-net or on-net for home MNO.
- Use case 4B: Send SMS while in visited country to a mobile in a 3rd country.

If a subscriber of Country A roams into country B and sends a text message to a local subscriber in Country B, the visited MNO will send the text message directly to the subscriber's MNO in Country B.

Examining the second use case of receiving an SMS while the subscriber is abroad, the activities are that the sender transmits the text via their local MNO network, addressed to the receiving mobile handset, currently roaming. The sending subscriber's MNO first contacts the roaming subscriber's home network to find out where the roaming handset is. The sender's MNO then routes the SMS to the visited network connected to the roaming subscriber. The visited network forwards the SMS to the roaming mobile handset. For an MMS, an additional step may be introduced, of a notification and verification of accepting to receive the more expensive MMS, performed via SMS, before delivering the MMS abroad.

Note that for the fourth use case, visited MNOs treat SMS roamers differently to their own subscribers. For a roaming visitor in Country B, who comes from Country A, and who sends an SMS text message to a subscriber in a third country, C, then Country B's visited MNO will send the text message back to the roaming subscriber's MNO in Country A. It will then be the home MNO in Country A that will forward the SMS to the recipient MNO in Country C. For all use cases, the actual network elements employed for sending or receiving SMS will vary according to the generation of mobile network employed in each communicating MNO, with similar features to those shown in Table 6 above for data roaming technologies.

Chapter 5 – Using the cost model: Guidelines for NRAs, with data collection

Here we set out the use of the cost model by an NRA with some instructions on how to approach data gathering. Gaining the core information that the model needs is the main priority for its effective use. So the powers of NRA to achieve this objective become a key factor in its successful use.

The range of interventions available to obtain such information can be extensive for telecommunications NRAs, or for governments, or for central government bodies for consumer affairs and competition (such as the UK Competition Commission which investigated the domestic MNO accounts for roaming in 2002 in the UK) as an ex-post competition regulator.

As each country will have its own relevant statutes and laws, regulatory powers reach from soft power recommendations, to powers of search and legal requisition of accounts and audits, with fines to ensure compliance. They may also extend to powers to propose and perhaps mandate directives under legislation, both for wholesale and retail tariffs.

However, to even understand whether prices bear a relation to costs requires some investigative powers. Only then, if information on excessive pricing and a lack of competitive pressures becomes evident can any actions be considered as appropriate (e.g. to introduce price caps or some form of structural intervention such as separation of markets for domestic and roaming services by forcing unbundling).

If NRA has decided to partner with a regional group of NRAs, then some additional considerations for obtaining data from MNOs can apply. Perhaps the first is whether the data given under NDA in one country to NRA can be shared with other NRAs under NDA. It may be necessary to form a multi-country view if market failure internationally is being investigated.

5.1 How to use the cost model

Cost accounting is the basis of the data required. It is a normal part of the MNO budgeting exercise but may not be seen from the perspective of roaming for the cost accounts. Also note that the model is neutral on the form of accounting used (e.g. long run incremental cost (LRIC), and long run average incremental cost (LRAIC), etc.) as it simply uses the resulting costs estimated by MNO.

If we wish to understand roaming costs, the cost model above highlights that quite detailed accounting will be necessary to locate costs, which, as emphasized will be both capex and opex. Often, opex may be the most important factor especially as the capital investments may be amortized over three, five or perhaps 10 years – e.g. a major 'traditional' voice switch may last five to 10 years but the common 2G and 3G network equipment (BTS units and the SGSN/GGSN network controlling elements with packet switches) may be written off far faster for technology upgrade reasons.

Acquiring cost data is difficult but necessary, and we look at this further in subsequent sections of this chapter.

The cost model requires that NRA identify and classify those elements used for each of the use cases for each media and type of subscriber (prepaid and postpaid) in collaboration with the MNO for:

- Equipment and operating costs for the BSS IT infrastructure including staff.
- Network elements and operating costs of the infrastructure including staff.
- Financial details of IOT agreements by country and operator.

Ideally, data should be gathered with the home country MNOs but also where possible with the correspondent visited MNOs, perhaps in a regional community. The latter accounting inputs are required to understand the costs on which the wholesale pricing is based.

In general, the data gathering process will require interaction with:

- Those responsible for the main business processes involved in roaming within the MNO, i.e. – network operations, billing, also customer care, as well as the IOT negotiations internationally, with the setup of roaming agreements and any back office extra costs (e.g. accounting for roaming).
- Those in charge of business operations at a more detailed level, who should know the chain of command and so who is responsible for the relevant cost accounting. This requires locating who has responsibility for budgetary costs for staff by business process activity with equipment and amortization for processes that touch on roaming.

The process of collection may be accelerated and possibly made more thorough with *a single point of contact within MNO*, if one can be identified who is able to take care of all the roaming accounting data collection. While that should be the optimal approach, direct contact with budget holders may still be required in some cases.

Information needed will include not just the knowledge of costs but attribution of the percentage of costs of processes to roaming with the staff, recurrent costs, consumables and equipment.

To help MNO with roaming cost accounting, it is likely to be necessary to:

- Examine the use cases – which define both processes and the technical platform with its component equipment and software – in a joint session with the MNO.
- Then identify cost elements via the use cases with the appropriate MNO staff with the portion attributable to roaming.

5.2 Effective data gathering – Data collection process and interaction with MNOs

5.2.1 Context

Here we outline some guidelines for NRAs on effective data gathering for the cost model. Much is devoted to negotiated approaches for NRA to obtain the data required.

However initially it should be noted that the mobile industry's business model is already changing, especially with two trends reshaping the cost/revenue model with possible impacts on roaming tariffs. First is the high cost of smartphones, which is forcing the abandoning of handset subsidies as freezing too much capital.

Second is the gradual saturation of many markets in terms of numbers of subscribers, (even in some developing countries, where those with the appropriate levels of disposable income are already being served). The net result is the move to inciting subscribers to use the mobile services far more – i.e. to generate more traffic – although to do this the retail prices may have to be reduced³⁹. This is especially true for data tariffs. A "perception of freeness" is sought to drive demand, by breaking out from the Dupuit curves for public service markets⁴⁰. Thus roaming may become viewed more as an attractive extra market for new volume revenue growth. In consequence, it may be that MNOs are sometimes far less reluctant to share detailed data on roaming as they see advantages in a positive public perception of their roaming tariffs. This may well be further driven by structural market changes (e.g. regulatory intervention for separation of roaming and domestic service, i.e. a transfer to roaming service providers who are not automatically the home MNOs, and who may be chosen by the subscriber⁴¹). Discussions with MNOs with this in mind emphasize the positive sides of roaming tariff reform.

5.2.2 Negotiations with MNOs – Dealing with roaming issues

Whatever the regulatory powers are of NRA vis-à-vis the collection of roaming data at a detailed cost level from an MNO's accounts, when interacting with MNOs the following points should be considered:

- Much of the information required is likely to be labelled commercially sensitive. However, it may be that agreement can be reached for release under a non-disclosure agreement (NDA). If released to NRA, this may be under conditions that it cannot be shared with any third party. The key point here is whether information under NDA can be shared with other NRAs as often a community of roaming countries may need to formulate a roaming policy in concert. Here the mediating role of ITU as the internationally responsible body may be important for achieving progress on sharing restricted to a closed group of NRAs.

³⁹ For instance AT&T and T-Mobile are pursuing this in their developed country markets but this is spreading to developing markets via flat rate roaming plans, e.g. see Taylor, P. (2013), *T-Mobile shakes up US market*, Financial Times, 18 December.

⁴⁰ Forge, S. (2013), *Approaching roaming charges pragmatically*, Presentation, ITU Geneva, 23 Sept.

⁴¹ See ITU (2012). ITU-T D-Series Recommendations, General Tariff principles – Charging and Accounting in the Mobile Services, Recommendation ITU-T D.98 (2012), available at <https://www.itu.int/rec/T-REC-D.98>

- However contrary to expectations for the reasons given above, it may be that certain MNOs actually wish to permit sharing of the data with other NRAs – but obviously it will be necessary to seek explicit written permission for this.
- NRAs should always be aware that internally MNOs may work on quite different accounting systems and principles. Moreover, much detailed information useful for analysis of costs of roaming may be missing in the accounts. In this case, various methods for interpolating the existing data may be necessary which will be individual to each MNO case. For instance, roaming traffic as a percentage of total traffic handled will give a first very approximate estimate of costs when applied to the total costs for capex and opex. But obviously this may tend to exaggerate roaming costs, especially if the cost of roaming is in fact covered by small increments on domestic costs which are not linearly sensitive to traffic volumes.
- Information on IOT agreements with other operators is likely to be sensitive as it shows mark-ups on wholesale levels for retail prices and possibly wholesale mark-up over costs if corresponding visited MNO data is available.

In addition, there may be existing regulatory rules and requirements in vigour for the MNO's accounting that are pertinent. Note that they may originate in legislative areas other than direct mobile telecommunications, including competition, anti-trust or consumer protection regulation that apply to the roaming situation. Naturally, these protective measures vary enormously by country but may refer to specific conditions such as cross-subsidization and market distortion as well as any statutory requirements for transparency and support for subscriber roaming information.

NRA would be well to consider the following questions on jurisdiction, either alone or in concert with NRAs from other countries, on a regional basis:

Questions for the regulatory body to consider on jurisdiction

- 1) Does the regulatory body have the authority to obtain wholesale roaming charges that domestic mobile network operators are charged in other countries, and if so, on what basis?
- 2) Does the regulatory body have the power or authority to obtain the wholesale roaming charges that domestic mobile network operators charge operators from other countries, and if so, on what basis?
- 3) If so, would the regulatory body have the authority to provide this information to other regulatory authorities in other countries (e.g. in the context of bilateral/regional agreements)?
- 4) Does the regulatory body have the authority to regulate the retail roaming prices charged by domestic MNOs to their customers roaming in other countries?
- 5) Does the regulatory body have the authority to regulate the wholesale roaming prices charged by domestic MNOs to the MNOs from visited countries, and if so, on what basis?

5.2.3 Interviews – Data collection process

When carrying out interviews, a selection process for candidates may be useful. The first candidate MNOs to be chosen will be important both to train NRA personnel on the process and to provide key data that may be indicative during interactions with subsequent MNOs. Choices for interview are at two levels: at the level of the organization (i.e. which MNO) to approach first, and at the level of those within the organization.

Who to choose as first among several MNOs, if there is a choice, turns on:

- The presence of a consistent and coherent internal organization, with accounting for all business processes.
- Good NRA relationship with MNO.
- Strong customer-oriented values.

- Stable growth with anticipation of future markets.
- Many international partners.

The data collection process *within* MNO must first consider who to choose on the MNO staff for actual data collection – if no single point of contact is offered after the initial approach on data gathering. Preferences for interviewees may be among certain major functions:

- Business process 'owners', such as billing or network operations – and especially a roaming process manager, if there is one.
- IT staff, particularly those responsible for delivering BSS, such as the billing systems.
- Accounts and budgets staff who provide cost based analyses.
- Strategic, legal and external relations staff who deal with IOTs and with outside bodies such as other correspondent MNOs and roaming exchanges.

In setting up the interview, use of a questionnaire to explain the areas to be discussed for data collection should be a first step, together with a focus on explaining the use cases.

5.2.4 Organization of data from MNOs

Classifying and processing the complex data, possibly large volumes, requires:

- Organizing the roaming data by MNO for base costs, retail and wholesale (IOT) tariffs, plus the tariffs for domestic calls for comparison.
- Laying out data as tariffs for calls between countries, using spreadsheets for voice, data and SMS for retail and wholesale (IOT), as in Annex 4.
- Assimilating and checking the data, noting any anomalies, gaps and issues that may require further investigation with MNOs.
- Classifying the results, in order to write conclusions for the roaming costs report (as a final section).

5.2.5 Standard format for final report

The final report contents should examine each MNO in turn, with a section for each MNO having the following tables of the data collected, for voice, data and SMS in the following steps 1 to 6:

- 1) Cost analysis of underlying costs for the home MNO for handling roaming calls to and from each country with both the home country as an itemized list of costs, and also for the visited country MNO costs, where available.
- 2) Cost analysis of the MNO's domestic costs for handling on-net and off-net calls, inbound and outbound as an itemized list of costs.
- 3) Retail roaming tariffs charged by country by MNO.
- 4) Wholesale roaming tariffs by country, as a table of the data collected on IOTs. This will require the study of the underlying costs (step 1) to understand their profit margins.
- 5) Comparison of retail and wholesale tariffs against cost.
- 6) Domestic tariffs for off-net calls, for mobile and fixed terminations, for calls made and calls received.
- 7) Conclusion on roaming costs, both retail and wholesale for MNO, with a comparison against the MNOs domestic costs and domestic retail tariffs and also the differences across countries and correspondent MNOs in the same country.

5.3 Sample questionnaire for NRAs, for use with the cost model

A structure for a questionnaire on roaming tariffs is shown in Annex 3 as a model that can be used with MNOs. The aim of these questions is to cover the main areas of concern for voice, data and SMS in terms of wholesale and retail tariffs.

Thus questions cover the costs between different countries that MNO has IOTs with across the various classes of media. There are four main categories where questions for operators have been assembled:

- PART A: Pricing of wholesale services – for voice, data and SMS.
- PART B: Pricing of retail services – for voice, data and SMS.
- PART C: Accounting analysis.
- PART D: MNO costs base – Elements of capex and opex

While the first three are important to understand the costing basis, the main area for probing is Part D which looks at cost elements explicitly and in detail – this is where more detail may be required to obtain a complete picture. For questions where accounting separation for roaming or detailed costing information is requested, some operators may not initially have the level of information required if it has not been analysed for roaming already. As this is a complex exercise which will require careful consideration, the timelines to respond are likely to be from one to three months, or perhaps even a month longer. These suggested timelines are only indicative as each operator will have different internal systems, accounting approaches and resources so times for response will vary between MNOs; some may be more rapid than others.

To ensure successful co-operation, it would probably be necessary to work with MNOs in two phases:

- PHASE 1: Firstly in a pilot test phase with a questionnaire with a selected small number of operators (perhaps three to five)
- PHASE 2: Secondly a final version of the questionnaire should be sent to minimize any issues experienced by MNOs, so that they may respond accurately to the questions.

Annex 1 – The regulatory situation in the EU

The IMR situation in the EU has been a regulatory and government concern for over a decade due to the assessment by DG INFSO and others that roaming tariffs bear little or no relation to costs. A key summary of the problem and the steps to its resolution is the 2006 internal impact assessment, the Commission Staff Working paper⁴².

Since then EU regulations, often termed Roaming I and II for those in 2007 and in 2012, and now Roaming III in 2013, have administered a series of wholesale and retail pricing caps to reduce tariffs.

It was firstly in 2002 that Roaming charges in the EU came under direct scrutiny, when the EC asked MNOs to lower roaming charges, which at that time were on average four times more expensive than domestic mobile phone calls.

With little response, the EC then launched a consumer website on roaming tariffs in October 2005. It exposed roaming prices of up to EUR 12 for a four-minute call⁴³. For roaming data, the multiples were more extreme – at the top end being 500 to 1'000 times more expensive than domestic rates. The EC intervention was proposed following the Impact Assessment (*ibid.* COM (2006) 382 Final) leading to proposals for roaming tariff regulation within the EU. This was published by the EC in July 2006, followed by a public consultation on retail roaming tariffs.

After this, the European Parliament Industry, Research and Energy (EP ITRE) Committee had also commissioned a report on the underlying costs of roaming⁴⁴, a roaming regulation was approved by EP in April 2007 by a near unanimous vote. This capped the wholesale IOTs between operators for roaming in the EU and also limited retail tariffs. On 30 June 2007, the new regulation entered into force. MNOs were required to inform customers about the new tariffs (or "Eurotariff") by 31 July 2007 and to provide an offer for switching to the new tariff, which automatically applied at the latest from 30 September 2007, for both prepaid and postpaid (contract) customers (unless a special roaming package had been agreed).

Operators may only compete below the maximum price permitted – the Eurotariff – which has progressively reduced each year since 2007. Thus today in 2013 the Eurotariff is available in all 28 Member States of the European Union and in the three European Economic Area countries. Switching to a Eurotariff is free of charge with no effect on the existing mobile phone contract. Subscribers receive a free SMS when crossing the border to another EU or European Economic Area (EEA) Member State. This gives price information (including all taxes) for both making and receiving calls, plus a free-call phone number for detailed pricing, given via SMS or automated voice messaging. Also, the EC specified that this applied to the EEA Member States (Iceland, Liechtenstein and Norway) as well, from 1 January 2008.

⁴² OM (2006) 382 Final, 12 July 2006, SEC (2006) 925, Impact Assessment of policy options relating to a Commission proposal for a regulation of the European Parliament and of the Council on roaming on public mobile networks with the Community.

⁴³ *Ibid.*, COM (2006) 382 Final, 12 July 2006, SEC (2006) 925.

⁴⁴ European Parliament - DG Internal Policies of The Union, Policy Department Economic and Scientific Policy, *Technical Issues On Roaming Transparency, Technical Aspects and Data, Overview related to the Proposed Regulation on Roaming, Briefing Note* (IP/A/ITRE/FWC/2006-087/Lot2/SC1), IP/A/ITRE/NT/2006-17 PE 382.177, requested by the European Parliament's Committee on Industry, Research and Energy (ITRE), January 2007.

SMS and data roaming

Roaming regulation was again reviewed in June 2008. The EC asked for comments on the review of roaming regulation, with a view to regulation extension to SMS and data roaming. Other specific issues also examined included inadvertent and involuntary roaming by use of handsets on country borders within the coverage of a foreign MNO, billing increments – changes from seconds to minutes, effects on smaller operators, also impacts on domestic prices.

Following letters from the EC on SMS pricing in early 2008 to all CEOs of EU MNOs, an assessment of replies showed high pricing. Regulation on SMS was then studied by EC and the EC Commissioner requested that MNOs lower SMS and also their data roaming charges by 1 July 2008, with a public consultation being launched. The ERG (European NRAs) suggested EUR 11 and EUR 15 cents as the price for an SMS, and the EC then introduced maximum SMS roaming price limits.

Moreover, from 1 July 2009, subscribers had to be offered per-second billing after 30 seconds for outgoing voice calls made but with per-second billing throughout for calls received. The EC expected subscribers to save over 20% on roaming calls with this rule, due to elimination of the hidden roaming costs.

On 1 July 2010, the EC also introduced the capability for the subscriber to set cut-off limits for spend while roaming. This rule made it mandatory for MNOs to offer subscribers the facility to determine their spend in advance, before a service is disabled automatically.

Data roaming was first addressed in 2009 by the EC, with a wholesale price cap on Internet roaming being published on 1 July 2009. However, only on 1 July 2012 was a subscriber retail tariff cap for data introduced, together with a mandatory requirement for a warning message on charges applicable when data roaming.

The EC then launched a public consultation on future roaming regulation, from December 2010 to February 2011. It subsequently suggested further regulation on price caps in a report to the EP, on 6 July 2011⁴⁵ proposing a glide path for retail and wholesale tariffs (in Euros and cents of Euros) of:

Current and proposed retail price caps (excluding VAT)

	Current	1 July 2012	1 July 2013	1 July 2014
Data (per MB)	None	90 cents	70 cents	50 cents
Voice-calls made (per minute)	35 cents	32 cents	28 cents	24 cents
Voice-calls received (per minute)	11 cents	11 cents	10 cents	10 cents
SMS (per SMS)	11 cents	10 cents	10 cents	10 cents

Current and proposed wholesale price caps (on prices operators charge each other):

	Current	1 July 2012	1 July 2013	1 July 2014
Data (per MB)	50 cents	30 cents	20 cents	10 cents
Voice (per minute)	18 cents	14 cents	10 cents	6 cents
SMS (per SMS)	4 cents	3 cents	3 cents	2 cents

⁴⁵ *Digital Agenda: Commission proposes more competition, more choice, lower prices for mobile phone users abroad*, EC Press Release, Brussels 06JULY 2011.

Following this over 2011 and 2012, the EC, together with the NRAs, monitored the development of roaming prices. If normal market conditions had been established in the market for roaming calls, the regulation would have expired in three years from 2007, i.e. on 30 June 2010. However, this had not been found to be so, and thus the above capping scheme was proposed. The Commission also reviewed the situation and reported with new proposals on 6 July 2011 on the functioning of the Roaming Regulation to the European Parliament and Council, following a Public consultation, and an Impact Assessment.

Although good compliance with price caps was found, and roaming prices were down, they were clustered around the regulated caps showing competition was not yet effective and structural problems of roaming market remained⁴⁶. The main barriers to competition were found to be:

- Strategic: Bundling of roaming with domestic services leads to low consumer awareness of pricing structure above costs and a lack of transparency.
- Regulatory: In the EU, regulation imposes too many barriers to entry of new players.
- Structural: There is lack of roaming MNOs and mechanisms to introduce choice.
- Real costs: Retail and wholesale prices have no correlation to costs.

BEREC found in the EU in 2012 that retail roaming prices were on average 118% higher than the estimated underlying costs (conservative estimations), and that the costs assessed by BEREC for EU MNOs from its NRA members⁴⁷ were:

	Wholesale costs	Wholesale + retail costs
Calls made (outgoing)	< EUR 5 c/min	< EUR 8 c/min
SMS	< EUR 1 c	< EUR 1.6 c
Data	< EUR 5 c/MB	< EUR 9 c/MB

Moreover, reduction of wholesale prices for mobile data was not reflected at retail level. In consequence, in late 2011 the EC wanted to extend price ceilings for several years for all roaming services – both wholesale and retail limits on pricing – for voice, SMS and mobile Internet because price competition without regulation was not yielding reasonable pricing. New regulation for price caps would mean extensions of capping, for up to 10 years, with the limit on retail prices maintained until July 2016.

Wholesale limits would be continued until 2022, with price stability enforced from 2015 to 2022. Additionally, a capability for pre-selection of different MNOs or MVNOs for roaming would be offered from July 2014. Commissioner Neelie Kroes noted that the aim of this is to reach the *stated 2015 objective of a close to zero difference between domestic and roaming prices*.

However, the European joint regulator for NRAs, BEREC, supported stronger action with structural market reform as well. This was seen as necessary because the relevant market forces were not considered strong enough yet to ensure reasonable pricing over the next five years in the EU. Thus in August 2011, BEREC criticized the Commission's proposal as unable to bring a structural solution, in a report to the EU Parliament⁴⁸. In February 2012, the EP's ITRE Committee voted for lower (and longer) retail ceilings, backing a structural solution, for which the technical details would set by BEREC.

⁴⁶ European Commission, Peter Stuckmann, DG Information Society and Media, 2012, *EU Roaming Regulation - towards structural solutions*, presentation, Geneva, March 2012.

⁴⁷ *Ibid.*, EU Roaming Regulation – towards structural solutions, Geneva, March 2012.

⁴⁸ BEREC BEREC Analysis of the European Commission's Proposal for a regulation on Roaming COM(2011) 402 as of 06July 2011, BEREC report, AUGUST 2011, Riga, available from: http://berec.europa.eu/doc/berec/bor_11_46.pdf

A compromise level was agreed in March 2012, between the EC, EP and the European Council of Ministers, for lower retail ceilings than originally proposed by the EC. A vote in the EP endorsed this on 10 May 2012.

Then BEREC was asked to organize the technical details, e.g. possibly with a multi-international mobile subscriber identity (IMSI) identification, for multiple MNOs for roaming, and analysis for a structural solution, e.g. separation of service providers for domestic and roaming services, all by the end of 2012, in order to be implemented on a compulsory basis in the EU in July 2014 (following Articles 4 and 5 of the Roaming Regulation⁴⁹, also termed Roaming III). BEREC's document⁵⁰ of May 2013 has caused some debate, especially over the implementation timetable for MNOs. The schedule for implementation of structural solutions for MNOs requires that preparations are already under way. Its principles appear in the Roaming III Regulation document while the EC's *Implementing Regulation* of December 2012 sets out two structural solutions to be implemented, firstly a local break out (LBO) solution and secondly a single IMSI. This has been the task of the 'Industry Platform' for roaming implementation created last year under the aegis of the EC and BEREC. However, technical specifications and requirements still needed to be entirely defined.

Under the latest proposals, the EC roaming regulation would be extended to 30 June 2016, and possibly beyond, if normal market conditions are not working. Moreover, the European Commission's target is to drive the difference between roaming and domestic retail tariffs prices towards zero by 2015. These aims follow analysis of the costs of failure to achieve a single market in telecommunications, especially mobile.

Until the announcements of September 2013 take effect in 2014 and onwards, the current regulation in force is "*Regulation (EU) No 531/2012 of the European Parliament and of the Council of 13 June 2012 on roaming on public mobile communications networks within the Union*", which repealed and replaced the original "*Regulation (EC) No 717/2007 of the European Parliament and of the Council of 27 June 2007 on roaming on public mobile telephone networks within the Community and amending Directive 2002/21/EC*" with effect from 1 July 2012. Prices for roaming within this regulation are often referred to as *Eurotariffs*.

The beginning of the end of roaming – September 2013: EC legislative package

Let us look more closely at what has been achieved and what is in store for the EU. As background, it is well to note that in July 2013, the latest stage of the current EU roaming regulation came into force and cut prices for roaming (e.g. by over 30% for using mobile Internet abroad)⁵¹.

Commissioner Kroes outlined in her address of 11 Sept. 2013⁵² that price caps are already making EU roaming far cheaper today, compared to 2007:

- Voice and SMS 80% cheaper in the EU; data roaming 91% cheaper.
- Data roaming has grown 630% since 2007.

She then made new proposals building on the 2012 Roaming Regulation which subjects operators to wholesale price cuts of 67% for data in July 2014. Commissioner Kroes also presented proposals for

⁴⁹ Regulation (EU) No 531/2012.

⁵⁰ BEREC Guidelines on the separate sale of regulated retail roaming services and the implementation of separate sale of regulated retail roaming services under article 4 & 5 of the Roaming Regulation – a consultation, May 2013.

⁵¹ European Commission, Digital Agenda for Europe, website, 12 September 2013.

⁵² <http://ec.europa.eu/digital-agenda/en/node/67489/#roaming>

telecommunications policy in a broader perspective with the move towards a connected continent, i.e. building a telecommunications single market requiring several quite radical actions:

- A European Commission telecommunications package intended as a "reset" with the aim of adding EUR 110 billion per year to EU GDP – note that the proposals are not yet set in legislation.
- Proposals for a "gradual removal of national barriers" to cross-border competition, to create a "real single market". It is worth noting however that this falls short of a single EU-wide telecommunications regulator or pan-European mobile licences.
- A goal for 2016 to merge the 28 national fragments of European telecommunications markets into a single market.

The new EC Legislative Package of Sept. 2013 positions roaming as one part of larger industry reforms. For intra-EU roaming there are various key advances:

- Remove called-party payments (i.e. on incoming calls) from 1 July 2014.
- Outbound, mobile-to-mobile calls intra-EU are capped at EUR 0.19/minute + value added tax (VAT).
- Target – Phase out roaming charges altogether in 2016.
- However, MNOs largely free of European roaming regulation, if they extend their domestic plans/bundles from 2014 so that by 2018 at latest, customers charged at domestic rates⁵³ for voice and data across all EU MS – offer at least a 17 country package.
- Transition from July 2014 ('glide path') allowing operators to adapt either the number of plans they offer, or the number of countries they cover at domestic rates.
- In practice, MNOs have a choice, either to:
 - 1) Offer plans that apply everywhere in the European Union ("roam like at home"), with prices driven by domestic competition, or
 - 2) Permit customers to "decouple", i.e. opt for a separate roaming provider that offers cheaper rates (without buying a new SIM card).
- Cap prices of EU-wide calls at the level of long-distance calls within an MS.
- Mobile licences in one EU Member State valid in 28 MSs – carriers have to charge the same service rates in every EU country, forming alliances in MSs where they do not operate, i.e. mandating the creation of operator alliances for Pan-European service plans.

However, the question has also been asked as to whether these measures are in effect too benign to MNOs, especially the largest ones? Even though they seem draconian, roaming tariff cuts have not been mandated abruptly – they are gradual and do not entirely cover the whole EU, allowing for 17 country packages by 2018 at domestic pricing which still allows higher margins, especially if domestic customers are to some extent 'locked in' without serious alternatives. Moreover, for data, MNOs are even allowed to set limits on what is 'reasonable usage' before additional charges pertain.

Thus, the question has been asked by the EC of whether there should be a stronger measure – namely unbundling of roaming from domestic service? Unbundling would mean structural changes in the retail roaming market as an essential part of the overall solution to high tariffs. This could be set up with either a wholesale roaming offer to other MNOs to resell (but a difficult market entry) or simply as an alternative retail roaming MNO offering. The latter would open the possibility for users to select an alternative MNO for roaming services only, or for roaming MVNOs to enter the market.

⁵³ <http://ec.europa.eu/digital-agenda/en/node/67489/#roaming>

Such a market structure could increase subscriber awareness and transparency. The fears of 'bill shock' have also highlighted the far higher elasticity of demand for data than for voice when roaming – many subscribers switch off all data options when roaming, except for local Wi-Fi. This is a further factor putting pressure on MNOs to bring prices down, in order to retain existing customers – and in an unbundled roaming/domestic market – a business opportunity to gain new ones.

Intervention and ruling on legality on roaming regulation by the European Court of Justice (ECJ)

The EU-wide roaming legislation was proposed by the European Commission in 2006 resulting in the Roaming Regulation (Regulation (EC) No 717/2007) being adopted in 2007 under Article 95 of the EC Treaty (now Article 114 of the Treaty on the Functioning of the EU) that imposed a ceiling on the maximum amount MNO could charge for voice calls made and received when travelling, set out in a Eurotariff that MNOs had to actively offer their customers and also capped wholesale roaming charges, i.e. the fee paid by a customer's home network MNO to the foreign network MNO used by the roaming consumer.

The original Roaming Regulation was time limited and was set to expire in June 2010. However, this was later amended by a new regulation that expanded its scope to cover SMS, as well as data calls and prolonged its validity until June 2012. This led to the call for judicial review by four MNOs, namely Telefónica O2, T-Mobile, Orange and Vodafone, challenging the validity of the Roaming Regulation in the High Court of England and Wales (UK). The High Court referred two questions to the ECJ for a preliminary ruling. Firstly whether Article 95 of the EC Treaty formed an adequate legal basis for the adoption of the Roaming Regulation, and secondly whether, by setting the aforementioned Eurotariff, the EC legislature had transgressed the principles of *proportionality* and/or *subsidiarity*.

According to EC case law, the principle of proportionality mandates that any measures implemented through EC law provisions must be appropriate and must not go beyond what is necessary to attain the objectives of the legislation. Despite what appears to be a rather wide discretionary power, the EC legislature's decisions must be based on objective criteria. For these, ECJ took note of the studies conducted by the Commission at the time of drafting the Roaming Regulation, which showed average retail rates for roaming services to be over five times higher than the actual cost of the provision of the wholesale service. The time limits imposed in the original legislation were also considered as important for proportionality principles. Moreover, the Eurotariff was set at a level that more accurately reflected the costs incurred by MNOs, and the ECJ considered this appropriate to protect customers against unnecessarily high charges. On the issue of subsidiarity, the principle in EU law is that in areas that do not fall within its exclusive competence, the EU institutions are to act only if and in so far as the Member States (MS) themselves cannot sufficiently achieve the objectives of the proposed action. ECJ referred once again to the interdependence of retail and wholesale roaming fees, and the significant disruption that would ensue should each MS choose to only tackle the issue of high retail charges. A joint approach was deemed necessary by the EC, and both the wholesale and retail levels, and this was wholeheartedly backed by ECJ.

In consequence on 8 June 2010, ECJ ruled to reject the challenge to the validity of a cap imposed by the EU on the roaming fees MNOs can charge in the EU, as put before it by various leading European MNOs. ECJ upheld the legal validity of the Roaming Regulation having taken into account the difficulties faced by national regulatory authorities in identifying undertakings that held considerable market power and controlling the behaviour of visiting network operators in other MSs whose services were used by customers when roaming. In its decision, ECJ also noted the Commission's concerns over the extremely high retail charges for international roaming services as well as failed attempts by national regulators under the existing legal framework to tackle the charges. Given the significant interdependence of retail and wholesale roaming charges, it seemed apparent to ECJ that any move by MS to only tackle retail charges, without lowering the wholesale costs for the provision of such EC-wide roaming services, would severely distort competition and disrupt the '*orderly functioning of the EC-wide roaming market*'. ECJ

believed at the time that the Roaming Regulation was adopted, *'the relationship between costs and charges was not such as would prevail in fully competitive markets'*.

In conclusion – Is the European model working and can it be applied elsewhere?

Certainly the EU model of constant vigilance and pressure is working and doing so fairly well, although at least six years of legislated price caps have been necessary. Roaming rates, for example for data, are claimed to have reduced by 90%, and perhaps by 2016 may be eliminated, certainly by 2018 if a gentler glide path is taken within the EU.

What is this due to? And can it be applied elsewhere? The keys to success are threefold:

- Firstly, it has been applied across a community of some 28 countries. Note however that it is only applicable inside the EU – Switzerland, for instance, may exclude itself and so offers much higher roaming charges.
- Secondly, reduction of retail roaming tariffs towards costs has had significant and strong endorsement from the EP, i.e. the elected representatives of the citizen. They gave the only near-unanimous vote ever in its history in May 2007 to begin the rounds of price caps. This has obliged Europe's administrative and legislation drafting body, the Commission, to act energetically and also obliged the MS governments as represented by the Council to accede to the wishes of subscribers.
- Thirdly, the mobile industry has taken note and gradually complied, despite strong protests against this intervention. Its arguments over the need for high roaming charges to finance LTE infrastructure have been examined by the EC over several years and found wanting.

Thus if these three conditions are absent, the European experience may not be repeatable. The key condition is the first – the use of a community of countries with NRAs working in concert, over the most common roaming areas geographically so that reciprocal roaming arrangements can be set up. Thus a regional approach is probably required. Nonetheless, it must be backed by common legislation – and therefore by a group of governments in the region with the communal will to act in order to protect the citizen.

European States covered by European Union roaming regulation

Currently roaming regulation is applied within 31 European countries, that is, all members of the European Economic Area (EEA):

- 28 EU Member States with Croatia,
- Iceland, Liechtenstein and Norway.

The EU countries have applied the Roaming Regulation in its various forms since 30 August 2007, while the non-EU countries have only applied it since 1 January 2008. Although it has relations with the EU in specific telecommunications fields, Switzerland is not included in this jurisdiction. Thus roaming tariffs are significantly higher for EU residents roaming in Switzerland and for Swiss residents roaming in the EU, especially for Internet data, which may vary, but are up to EUR 3/MegaByte (2012).

In general, it should be noted that the issue of roaming is subject to regionally-based regulation and therefore will be individual to each region. What is given above is for the European Union only, and other regions and economic communities may have quite different conditions and rulings. Moreover, the criteria given here are of a pragmatic economic nature that sometimes, in some regions and national jurisdictions, may be balanced by equally significant policy issues.

Annex 2 – User startup – A one-page summary

Here we give a brief summary for regulators of how to use the ITU-T cost model with the accompanying model for a questionnaire (Annex 3):

- 1) Examine the principles behind the cost model as given here, specifically:
 - The major business processes concerned with roaming (for network operations, business support systems (BSS), and back office functions including IOT agreements and recharging).
 - The use cases that identify the relevant cost elements for roaming and their proportion of total use.
 - The technical infrastructure for mobile operations, as it touches on roaming.
- 2) Select MNOs for a cost and tariff survey in terms of organizational attributes and quality of relations with NRA (see chapter 5). Decide on approach to foreign MNOs. Create an NDA in case needed.
- 3) Meet MNOs to agree on points of contact and goals for delivery – timescales, types of information, with a set of milestones for delivery and progress meetings.
- 4) Organize a pilot exercise with a few MNOs before proceeding to a complete survey (from three to six MNOs). Examine how it goes and any difficulties in the data returned, identifying MNOs, etc.
- 5) Use a questionnaire with MNO staff for data collection, as given in the questionnaire example.
- 6) Apply the cost model: Using the breakdown of costs in the major categories of the MNO business processes that are touched by the roaming use cases as shown in chapter 4. Cost elements for roaming are most likely to be largely network operations, roaming-related activities within the business support system operations, any back office and overhead attributable costs such as IOT negotiations, written off across transactions. The empirical cost structure should be built up for each use case.
- 7) Organize the data gathered for the cost elements by use case, as shown in the questionnaire, Annex 3, Part D, and detail the opex and capex costs for each element for networking, BSS and other cost items.
- 8) Assemble the cost information gathered for retail and wholesale roaming tariffs by MNO.
- 9) Gather the domestic tariffs for terminating off-net voice, data and SMS from other domestic MNOs/FNOs and for handing off domestic calls to them.
- 10) Process the roaming information gathered by comparing – compare the domestic and roaming tariffs, identifying any major cost differences and tracing their origin in the roaming wholesale and retail tariffs and where possible down to the empirical cost elements.
- 11) Draw the final conclusions: Examine and detail the differences between roaming and domestic charges, for roaming to all relevant countries for voice, data, SMS, with itemized sources of major cost differences and highlight any anomalies identified by the cost analysis.

Annex 3 – A model questionnaire for gathering roaming data

This is an example of the kinds of questions required to gather the relevant data for the roaming cost model. This may require a non-disclosure agreement (NDA) to be signed between the NRA and each mobile network operator. To share the information gathered with other NRAs, an appropriate clause in the NDA would be required.

Questions for the mobile network operator (MNO) on pricing

The information required here should only cover the relevant countries.

PART A: Pricing of WHOLESALE services – for voice, data and SMS

- 1) Please provide the inter-operator tariffs (IOTs) charged to other mobile network operators. If necessary, please use the attached spreadsheets:
 - a) For voice
 - b) For data
 - c) For SMS

Please also indicate and provide tariff information on any IOTs with first preferred partners:

- a) For voice
 - b) For data
 - c) For SMS
- 2) Conditions in Roaming Agreements:
 - a) What are the Roaming Agreements' definitions of conditions that set wholesale prices for voice services (e.g. duration of call/time of day/distance/weekend and also whether there are volume discounts)?
 - b) What are the Roaming Agreements' definitions of conditions that set wholesale prices for data services (e.g. flat rate, flat rate with billing increments, step-based (i.e. higher volume sessions are priced at lower rates)). Are there differentials in wholesale rates for, e.g. time of day, uploading/downloading data? Please provide details.
 - 3) For comparison, what are:
 - a) The **domestic** mobile call termination rates (MTRs) between the **national MNOs** in the **same** country?
 - b) The call termination rates with the **fixed line** operators?
 - c) Are these rates regulated?
 - 4) Please provide the values of the specific **roaming cost elements** to MNO as listed below for making roaming **voice calls** for various use cases given:

Firstly, for the case of a visitor from country A calling inside the visited country (B) to a mobile phone inside the visited country B:

- a) What is the contracted charge by the visited MNO of the mobile origination in country B (i.e. the IOT charged by the country B MNO)?
- b) What is the cost of the national transit inside country B, and maybe via a fixed line operator, i.e. perhaps a third party (and which is likely to be included in IOT)?
- c) What is the cost of mobile termination in country B (which is likely to be included in IOT)?
- d) What are the other roaming-specific costs (billing, signalling, etc.)?
- e) What are the home and visited MNO retail operation specific costs (billing, customer care services, etc.)?

Secondly, **for the case of making a voice call from a visited country (B) to the home country (A):**

- f) What is the cost of the mobile origination in country B (likely to be included in IOT)?
- g) What is the cost of the international transit?
- h) What is the cost of the mobile or fixed termination in country A?
- i) What are the roaming-specific costs (billing, signalling, etc.)?
- j) What are the retail operation specific costs (billing, customer care services, etc.)?

Thirdly, **for receiving a call from home country A when in a visited country B:**

- k) What is the cost of the mobile termination in country B (IOT)?
- l) International transit
- m) Roaming specific costs
- n) Retail specific costs
- 5) Please give the equivalent or similar cost elements involved in **data** roaming in other countries and their values for the three use cases above.
- 6) Please give the equivalent or similar cost elements involved in **SMS** roaming in other countries and their values for these three use cases.
- 7) How (or to what extent) do the costs for roaming by prepaid customers differ from postpaid customers?

PART B: Pricing of RETAIL services – for voice, data and SMS

- 8) What are the metered tariff rates in local currency for roaming for each country, for **prepaid and post-paid** for voice, data and SMS (for voice, please specify whether charges are per second/per minute and whether there is an initial call setup charge and any equivalent for data or SMS) – please see spreadsheets.
- 9) How is the price calculation performed for roaming tariffs to customers for voice, data and SMS? (i.e. what factors are used in their calculation and what are their levels)?
- 10) How have prepaid and postpaid prices differed over the last two years, for voice, data and SMS? (Please give quarterly rates by country.)

PART C: Accounting analysis (please give the annual figures for the last two financial years by month)

For ROAMING services (voice, data, SMS):

- 11) What are the total **revenues** from roaming services (sum of outgoing and incoming call revenues)?
 - a) Voice (local currency):
 - b) Data (local currency):
 - c) SMS (local currency):
- 12) What are the total summed **costs** of roaming services?
 - a) Voice (local currency):
 - b) Data (local currency):
 - c) SMS (local currency):
- 13) What are the cost items included in the accounts for roaming, for both capex and opex?

For DOMESTIC services (voice, data, SMS):

- 14) What are the total **revenues** from domestic calls?
 - a) Voice (local currency):

- b) Data (local currency):
 - c) SMS (local currency):
- 15) What are the total **costs** of domestic calls?
- a) Voice (local currency):
 - b) Data (local currency):
 - c) SMS (local currency):
- 16) What are the **cost items** included in the accounts, for domestic services, for both capex and opex?
- 17) What are the **roaming traffic volumes** – ingoing and outgoing for:
- a) Voice (minutes):
 - b) Data (Gigabyte):
 - c) SMS (messages):
- 18) What is the traffic volume per quarter over the last two years, to show trends – ingoing and outgoing:
- a) **Roaming** traffic for voice, data, SMS
 - b) **Domestic** traffic for voice, data, SMS

PART D: MNO costs base – Elements of capex and opex

Here we examine overall costs, domestic services costs and roaming services costs. The cost items for roaming may either be separate items, or a portion of existing facilities and operations, or specific extensions of existing systems and processes. These will be repeated for data and SMS as well as for voice.

- 19) What is the billing process for prepaid consumers at network, IT and business support systems (BSS) levels? Please describe all elements and procedures involved in the overall domestic process and in the roaming business process, with an overview of the assets used, for:
- a) Prepaid, at network, IT and BSS levels, for voice, data and SMS?
 - b) Postpaid, at network, IT and BSS levels, for voice, data and SMS?

Annual cost estimation table – for the last two years:

ITEM	Domestic	Roaming
a) Network elements costs?		
Capex		
Opex		
b) Network management and its operational costs (OSS, NOCs, etc.)		
Capex		
Opex		
c) Network attachments for roaming costs (e.g. CDR capture and storage with mediation)		
Capex		
Opex		
d) Network rollout, support and maintenance operational costs		
Capex		
Opex		

ITEM	Domestic	Roaming
e) IT elements		
Total Capex		
Total Opex		
f) Software, e.g. billing and customer care		
Capex		
Opex		
g) IT Hardware		
Capex		
Opex		
h) IT Operations including data centres and their support services (e.g. power)		
Capex		
Opex		
i) Other costs – e.g. special customer service		
Capex		
Opex		
j) Roaming Business process – total cost of operations, including setup		
Capex		
Opex		
k) Cost of accounting for roaming		
Capex		
Opex		

Annex 4 – Example of spreadsheet used to gather data

VOICE – Prepaid

For a PREPAID SUBSCRIBER – Retail rates for voice roaming services: As of {latest previous quarter, please state quarter}. In local currency and per minute including any taxes (please indicate if there is a setup charge, e.g. first minute is more expensive than subsequent minutes).

Please provide peak rate prices and indicate whether there are off-peak prices and their value.

Please indicate if there are taxes additional to the normal domestic tax on mobile calls.

Outgoing calls – roaming charges between countries

Date of tariff:

Country	1	2	3	4	5	6
1	0					
2		0				
3			0			
4				0		
5					0	
6						0

Incoming calls – roaming charges between countries

Date of tariff:

	1	2	3	4	5	6
1	0					
2		0				
3			0			
4				0		
5					0	
6						0

Repeated for voice, data, SMS, incoming and outgoing calls also for postpaid as well as for prepaid.

Annex 5 – Example of parameters used to calculate MNO costs of roaming

The table of parameters below is drawn from the ITU NRA Training Tool for International Mobile Roaming, for which values are entered to estimate costs of roaming for both visited and home networks and for each type of communication as appropriate (voice, data and, SMS):

Home network		
Short code	Parameter description	Unit
NH1	Total Number of voice calls per year, all types	Number of calls
NH2	Number of inbound roaming calls to home country	Number of calls
NH3	Number of outbound calls by a roaming visitor per year	Number of calls
NH4	Number of roaming voice calls per year inside visited countries	Number of calls
NH5	Number of total domestic voice calls per year	Number of calls
HV1	Volume of total voice minutes per year	Voice Call minutes
HV2	Volume of roaming voice minutes per year	Voice Call minutes
ND1	Number of roaming data sessions per year	Number of sessions
ND2	Total number of data sessions per year	Number of sessions
DHV1	Volume of total data per year	MB
DHV2	Volume of roaming data per year	MB
LRV1	Visitor Location Register, VLR, cost of use for roaming per year	currency (USD)
LRH1	Home Location Register, HLR, cost of use per year for domestic and roaming	currency (USD)
CAM1	GSM CAMEL Application Part for Prepaid roaming, fraud control, 3G/2G etc, cost/year	currency (USD)
CN1	Core Network - use for call transport, cost/year	currency (USD)
IVG1	International voice gateway, cost/year	currency (USD)
IDG1	International data gateway, cost/year	currency (USD)
BMR1	Billing system module for roaming (home network) voice/data, cost/year	currency (USD) for voice or data
BS1	Billing system (home network) with mediation, includes servers, databases and data centre slice, cost/year	currency (USD)
TR1	International transit service cost for voice carriage, cost/year	currency (USD)
TRD1	International transit service cost for data files, cost/year	currency (USD)
A1	Operational cost/year of business process element for updating HLR for roaming subscriber	currency (USD)
A2	Operational cost/year of business process element for handling TAP file, billing for roaming subscriber and making international payment	currency (USD)
A3	Maintenance and support for core network, cost/year	currency (USD)
A4	Maintenance and support for RAN, cost/ year	currency (USD)
B1	Operational cost/year of billing transactions to charge a roaming subscriber	currency (USD)
B2	Cost/year of CDR collection, management and rating	currency (USD)
BT1	Operational cost/year of handling received TAP file with billing system	currency (USD)

Home network		
Short code	Parameter description	Unit
ID1	Cost/year to Verify identification of caller for roaming, authorise, prepaid limits or post-paid limit	currency (USD)
BCAM1	Business process cost/year for CAMEL applications	currency (USD)
Neg1	Cost of inter operator negotiations (one-time)	currency (USD)

Visited network		
Short code	Parameter description	Unit
NV1	Total Number of voice calls per year, all types	Number of calls
NV2	Number of outbound roaming calls, per year	Number of calls
NV3	Number of foreign calls inbound to a roaming visitor per year	Number of calls
NV4	Volume of roaming voice calls per year in visited country	Number of calls
NV5	Volume of total domestic voice calls per year	Number of calls
VV1	Volume of total voice minutes per year	Voice Call minutes
VV2	Volume of roaming voice minutes per year	Voice Call minutes
CCM	cost of inter-operator negotiations (one time)	currency (USD)
NDV1	Number of roaming data sessions per year	Number of sessions
NDV2	Total number of data sessions per year	Number of sessions
DVV1	Volume of total data per year	MB
DVV2	Volume of roaming data per year	MB
RAV	RAN use, cost/year (visited network)	currency (USD)
LRV2	VLR use, cost/year	currency (USD)
LRH2	HLR cost of use/ year (for roaming)	currency (USD)
CAM2	GSM CAMEL Application Part, Prepaid 3G/2G roaming, fraud control etc cost/year	currency (USD)
CN2	Core Network - use for call transport cost/year	currency (USD)
IVG2	International voice gateway (visited network) cost/year	currency (USD)
IDG2	International data gateway (visited network) cost/year	currency (USD)
BMR2	Billing system module for roaming (visited network) includes server and data centre slice	currency (USD)
BS2	Billing system (Visited network) with mediation, includes servers, databases and data centre slice, cost/year	currency (USD)
TR2	International transit service cost/year for voice carriage	currency (USD)
TRD2	International transit service cost/year for data files	currency (USD)
A5	Operational cost/year of mobile Voice origination business process element in visited country	currency (USD)
A6	Operational cost/year of mobile termination business process element in visited country ie an on-net call	currency (USD)

Visited network		
Short code	Parameter description	Unit
A7	Operational cost/year of off-net mobile termination business process element in visited country with MTR	currency (USD)
A8	Operational cost/year of business process of creating and sending TAP file from processed CDRs and billing for roaming subscriber then handling payment	currency (USD)
A9	Request to HLR and location of local number with CDR update, cost/year	currency (USD)
A10	Maintenance and support for core network, cost/year	currency (USD)
A11	Maintenance and support for RAN, cost/year	currency (USD)
B3	Operational cost / year of billing transaction for visitor	currency (USD)
B4	CDR collection, management and rating business process, cost/year	currency (USD)
ID2	Verify caller against prepaid/ postpaid limits received, cost/year	currency (USD)
A5D	Operational cost/year of mobile data session origination business process element in visited country	currency (USD)
BCAM2	Business process cost/year for CAMEL applications including fraud control	currency (USD)
CDS	OPEX cost /year of CDR accumulation, storage & rating	currency (USD)

Abbreviations

This Technical Paper uses the following abbreviations and acronyms:

2G GSM	Second Generation mobile services and networks – digital mobile service
3G UMTS	Third Generation mobile services and networks – packet based service
3GPP	Third Generation Partnership Project (ETSI)
ABC	Activity Based Costing
ACO	Access and Call Origination
ASA	Authorized Shared Access
BCAM	Business process cost for CAMEL applications
BDT	<i>Bureau de Développement de Télécommunications</i> (Telecommunication Development Bureau)
BEREC	Body of European Regulators of Electronic Communications (EU NRA group)
BMR	Billing system Module for Roaming
BPA	Business Process Analysis
BS	Billing System
BSS	Business Support System
BTS	Base Transceiver Station (as for base station)
CAMEL	Customized Applications for Mobile Enhanced Logic (for prepaid 2G services)
CAP	CAMEL Application Part
CapEx	Capital Expenditure
CATV	Cable Television
CCITT	The International Telegraph and Telephone Consultative Committee
CCM	Current Call Minutes
CDR	Call Data Record (details of each call for billing) also Call Detail Record
CDS	Current Data Session
CEO	Chief Executive Officer
CN	Core Network
CRASA	Communications Regulators' Association Southern Africa
CRM	Customer Relationship Management
DB	Database
DG CNCT	Directorate-General, of the European Commission, for Communications, Networks, Content and Technology, also DG CONNECT
DG INFSO	Directorate-General, of the European Commission, for Information Society and Media
EC	European Commission
ECJ	European Court of Justice
EDGE	Enhanced Data rates for GSM Evolution (faster data protocol for 2G)

EDI	Electronic Data Interchange
EEA	European Economic Area
EP	European Parliament
ERG	European Regulators Group
ETSI	European Telecommunications Standards Institute
EU	European Union
FNO	Fixed (line) Network Operator
GDP	Gross Domestic Product
GGSN	Gateway GPRS Support Node (routes subscriber GPRS data to IP networks)
GPRS	General Packet Radio Service
GRX	GPRS Roaming eXchange
GSM	Global System for Mobile communications
GSMA	GSM Association
HLR	Home Location Register (Local)
HPLMN	Home Public Land Mobile Network
HPMN	Home Public Mobile Network
HSDPA	High Speed Downlink Packet Access (3G W-CDMA data protocol)
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access (3G W-CDMA data protocol)
IDG	International Date Gateway
IMR	International Mobile Roaming
IMSI	International Mobile Subscriber Identity
INTUG	International Telecommunications Users Group
IOT	Inter-Operator Tariff
IP	Internet Protocol (used with GPRS/3G data transfers)
IPDR	IP Data Record
ISP	Internet Service Provider
IT	Information Technology
ITU-T	The ITU Telecommunication Standardization Sector (formerly CCITT)
ITRE	Industry, Research and Energy
IVG	International Voice Gateway
LBO	Local Break Out
LD	Long Distance
LRAIC	Long Run Average Incremental Cost
LRIC	Long Run Incremental Cost
LSA	Licensed Shared Access
LTE	Long Term Evolution (of 3G UMTS)

MB	MegaByte
Mbit/s	Megabit per second
MCT	Mobile Call Termination
MEP	Member of the European Parliament
MMS	Multimedia Messaging Service
MNO	Mobile Network Operator
MS	Member State (e.g. of the EU or other regional community); or in ETSI and ITU documents: Mobile Station, i.e. the handset used by a subscriber, such as a smartphone
MTR	Mobile Termination Rate: fee charged by MNO to terminate call on network
MVNO	Mobile Virtual Network Operator
NDA MNOs)	Non-Disclosure Agreement (signed contract for confidentiality of data gathering with
NOC	Network Operations Centre
NRA	National Regulatory Authority
NRTRDE	Near Real-Time Roaming Data Exchange
OECD	The Organization for Economic Co-Operation and Development
OpEx	Operating Expenditure
OSS	Operational Support System
OTA	Over-The-Air (e.g. for visitor activation)
pa	per annum
PC	Personal Computer
PDN	Public Data Network
PLMN	Public Land Mobile Network (as opposed to maritime or aeronautical)
PSD	Packet Switched Data – mobile data service combining GPRS/3G and IP
PSTN	Public Switched Telephone Network
RAN	Radio Area Network
SADC	Southern African Development Community
SDL	Supplementary Downlink
SG3	Study Group 3
SGSN	Serving GPRS Support Node (for non-IP packet transfer in core network)
SIM	Subscriber Identification Module, contains the IMSI and roaming network list
SLA	Service Level Agreement
SME	Small and Medium Enterprises
SMS	Short Message Service
SS7	Signalling System 7
STIRA	Standard Terms for International Roaming Agreements
TAP	Transferred Account Procedure (file of roaming charges, usually wholesale)

TMN	Telecommunications Management Network
TSB	Telecommunication Standardization Bureau
UMTS	Universal Mobile Telecommunications System
VAT	Value Added Tax
VLR	Visiting Location Register
VPLMN	Visited Public Land Mobile Network
VoIP	Voice over IP
VoLTE	Voice over LTE
VV	Volume of total Voice
W-CDMA	Wideband Code Division Multiple Access
Wi-Fi	Wireless Fidelity, an IEEE standard for WLANs
WLAN	Wireless Local Area Network

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