Body of European Regulators for Electronic Communications

BEREC

BoR (15) 196

Case Studies on IP-based Interconnection for Voice Services in the European Union

November 2015

Table of Contents

List of Figures

List of Tables

Executive Summary

In recent years several operators (fixed and mobile) in EU Member States started to migrate their networks to Next Generation Networks or all-IP networks. When networks are migrated to NGN or all-IP networks, it is “natural” and efficient that also the interconnection for voice services is based on IP (and no longer on TDM). In order to get a deeper insight into the IP-based interconnection for voice services (IPvIC) already in place and to foster the exchange of experiences, as well as to contribute to the harmonisation of regulatory instruments and technical solutions used in the European Union, this document has the following two objectives. Firstly, it aims to give an overview of the status of IPvIC in Europe on a general level based on information of 32 European countries. Secondly, it aims to give an overview of the IPvIC currently in place based on the experiences of ten countries (Bulgaria, Croatia, Denmark, Finland, France, Germany, Italy, Slovenia, Spain and Sweden). The latter covers IPvIC offered by fixed network incumbents (FNI, 8 countries), other fixed network operators (OFNO, 3 countries) and mobile network operators (MNO, 2 countries), i.e. in total thirteen cases. The analysis is descriptive and does not aim at being normative or recommend a best practice.

The high level analysis of the status of the IPvIC in Europe shows that the type of operator which most often offers IPvIC is the OFNO followed by the FNI and the MNO. NRAs imposed the obligation to offer IPvIC most frequently on FNI (13 countries) followed by OFNO (11) and MNO (5).

In the countries analysed the IPvIC have the following general characteristics:

- Obligation to offer IPvIC: All operators considered offer IPvIC based on an obligation except for the MNO in Finland.
- National specification(s): In order to support a common solution for several or all operators at the national level most countries analysed (7 of 10) have developed one (or more) national specification(s) defining the characteristics of the IPvIC in detail.
- Transitional period: The countries (9) which have imposed that the operators analysed have to offer IPvIC support the migration from TDM-based interconnection for voice services (TDMvIC) to IPvIC with the obligation that both types of voice IC have to be offered. In most of these countries (6 of 9) a transitional period is not (yet) defined, and therefore the operators are free to migrate to IPvIC when it is best for them. The other three countries have already defined the transitional period.
- Period of notice of phasing out TDMvIC: This period has already been defined in three countries. In the other countries this is not the case and in most of them the operators analysed have not made formal announcements to phase out TDMvIC so far.

In the cases analysed important technical characteristics of the IPvIC are as follows:

- Number of PoIs of the IPvIC: The minimum number of PoIs of the IPvIC which enable operators to handover voice traffic for national destinations based on the regulated termination rates (without additional charges) has been reduced to one or two (8 of 13 cases). This reflects the trend that the number of PoIs is usually reduced with the migration to NGN and all-IP networks.
- Signalling protocol: The signalling protocol to be used at the PoI is SIP (11 of 13). In most of these cases (7 of 11) the use of SIP is further defined with 3GPP specifications (related to IMS). In the two cases with MNO SIP-I (and not SIP) is used at the PoI which is also used within mobile networks.
- Number ranges, codecs and supplementary services supported by IPvIC: The IPvIC supports the same number ranges as the TDMvIC (10 of 13), the audio codec G.711 (all cases) which is typically used in fixed networks and also further audio codecs (9 of 13) as well as fax services (all cases) which all together facilitate the migration from TDMvIC to IPvIC. However, the same supplementary services as TDMvIC are only supported in about the half of the cases analysed.
- QoS: The IPvIC has a defined QoS with regard to certain QoS parameters (at least 11 of 13), whereby different QoS parameters are used in different cases.
- Redundancy and network security of the IPvIC: The networks are interconnected with the networks of the IC partners with direct physical IC links (12 of 13) or via (domestic) exchange points (1 case) and not over the public Internet which provides a significant protection against threats from the Internet. In order to increase the availability, redundancy is used at the level of the physical IC link (12 of 13) and at the level of the border gateway (8 of 13). The operators also apply further security measures (at least 12 of 13).

It can be concluded that from an overall perspective the IPvIC are rather similar. However in detail the characteristics may differ reflecting national circumstances.

1 Introduction and objective

In recent years several operators (fixed and mobile) in EU Member States started to migrate their networks to Next Generation Networks (NGN) or all-IP networks. A main driver for this is the fundamental change of the traffic from previously being dominated by voice traffic to meanwhile being dominated by data traffic. Previously the voice telephony networks were optimised for voice (i.e circuit switching and the use of TDM[1]) and to some extent also data was carried over these networks. Now the networks are optimised for data traffic (i.e. packet switching and IP) and voice is increasingly also transported over these networks. When networks are migrated to NGN or all-IP networks, it is "natural" and efficient that also the interconnection for voice services is based on IP (and no longer on TDM). Then no longer a conversion from IP to TDM is necessary and all voice traffic can stay completely on IP. Several operators therefore demand IP-based interconnection for voice services (IPvIC) instead of TDM-based interconnection for voice services (TDMvIC). If there is a mutual commercial interest, operators will migrate from TDMvIC to IPvIC on a voluntary basis. However, in other cases regulatory intervention may be necessary.

From a regulatory perspective, during the migration phase at least two crucial aspects have to be considered. Firstly, there are several different solutions which can be used for IPvIC. Therefore, all involved operators not only have to agree on which solution should be used but also on all details of the solution in order to guarantee full interoperability between their voice telephony networks. In the ideal case, all operators agree on the technical solution to be used for IPvIC. If, however, operators cannot agree to a common solution or if some operators refuse to offer IPvIC at all, there might be a need for regulatory intervention.

The second aspect of relevance is the time frame for the migration to IPvIC. Operators may migrate their voice telephony networks at a different time and with a different pace. This would mean that both IPvIC and TDMvIC need to be available in parallel for some time. If operators do not agree on a migration path, there might be a need for regulatory intervention to avoid that both technical solutions are offered over a long time while at the same time taking into account the migration plans of the operators involved.

Over the last years, several NRAs already imposed on operators, in most cases on the fixed network incumbent, the obligation to offer IPvIC, and some operators also started to offer IPvIC on a voluntary basis. In order to get a deeper insight into the IPvIC and foster the exchange of

[1] Time Division Multiplexing (TDM) divides a continues bitstream into equal time periods (called time slots) and assigns a communication channel (e.g. voice channel) to these time slots. The traditional voice switches (e.g. local exchange) connect dynamically such channels in order to set-up a connection for a call. Therefore TDM and circuit switching differ completely from packet switching and IP where information (e.g. voice) is transported and switched based on packets.

experiences, as well as to contribute to the harmonisation[2] of regulatory instruments and technical solutions used in the EU, this report has the following two objectives. Firstly, it aims to give an overview of the status of IPvIC in Europe on a general level based on information of 32 European countries. Secondly, it aims to give an overview of the IPvIC currently in place based on the experiences of ten countries (Bulgaria, Croatia, Denmark, Finalnd, France, Germany, Italy, Slovenia, Spain and Sweden). The latter covers IPvIC offered by fixed network incumbents (FNI, 8 countries), other fixed network operators (OFNO, 3 countries) and mobile network operators (MNO, 2 countries), i.e. in total thirteen cases. The analysis is descriptive and does not aim at being normative or recommend a best practice.

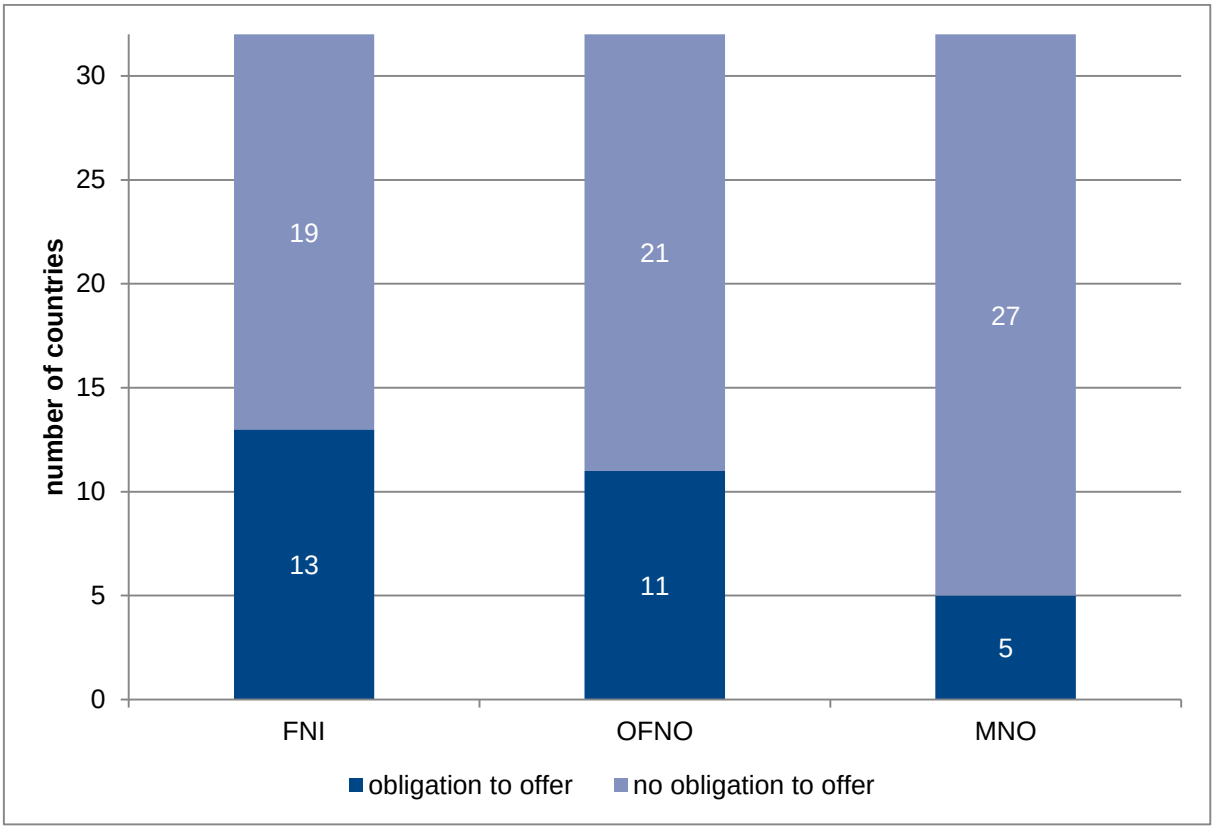
This document starts with an overview of the status of IPvIC in Europe on a general level (section 2). In the next step the IPvIC of the cases considered are analysed. This starts with an overview of the operators analysed (section 3.1) followed by the analysis of general characteristics (section 3.2) and important technical characteristics of the IPvIC (section 3.3). Finally, conclusions are drawn (section 4).

2 Status of IP-based in interconnection for voice services in Europe

This section gives an overview of the status of IPvIC in Europe as of April 2015. The information is based on the responses of 32 NRAs (of totally 37 BEREC members and BEREC observers).

Figure 1 shows the number of countries which have imposed obligations on the FNI, the OFNO and/or the MNO to offer IPvIC (the countries are listed in Table 1). 13 countries (41% of the 32 countries which responded) have imposed the obligation to offer IPvIC on the FNI. In most of these countries, also the OFNO has the obligation to offer IPvIC. Only two countries (CY, GR) imposed an obligation to offer IPvIC on the FNI but not on OFNO.

[2] By providing information and a reference to NRAs of countries where IPvIC has not yet been implemented, this report contributes to harmonisation. A further need for harmonisation has not been identified by BEREC.



Source: BEREC

Figure 1: Number of countries with an obligation on operators to offer IPvIC (Q1/2015)

Table 1: Obligation to offer IPvIC (Q1/2015)

	FNI	OFNO	MNO
Yes	AT*, BG, CH, CY*, DE, DK, ES, FR*, GR, HR, IT, SE*, SI	AT*, BG, CH, DE**, DK**, ES**, FR*, HR, IT, SE*, SI	AT*, CH, DK**, FR*, SE*
No	BE, CZ, EE, FI, FYROM, IE, LI, LT, LU, ME, NL, NO, PL, PT, RO, RS, TR, SK, UK	BE, CY, CZ, EE, FI, FYROM***, GR, IE, LI, LT, LU, ME, NL, NO, PL, PT, RO, RS, TR, SK, UK	BE, BG, CY, CZ, DE, EE, ES, FI, FYROM, GR, HR, IE, IT, LI, LT, LU, ME, NL, NO, PL, PT, RO, RS, SK, SI, TR, UK

* Only in case of (reasonable) request

** Only OFNO with customers directly connected to an NGN (DE) or with VoIP end users have the obligation to offer IPvIC (DK, ES). In Denmark, MNO have the obligation to offer IPvIC only under specific conditions.

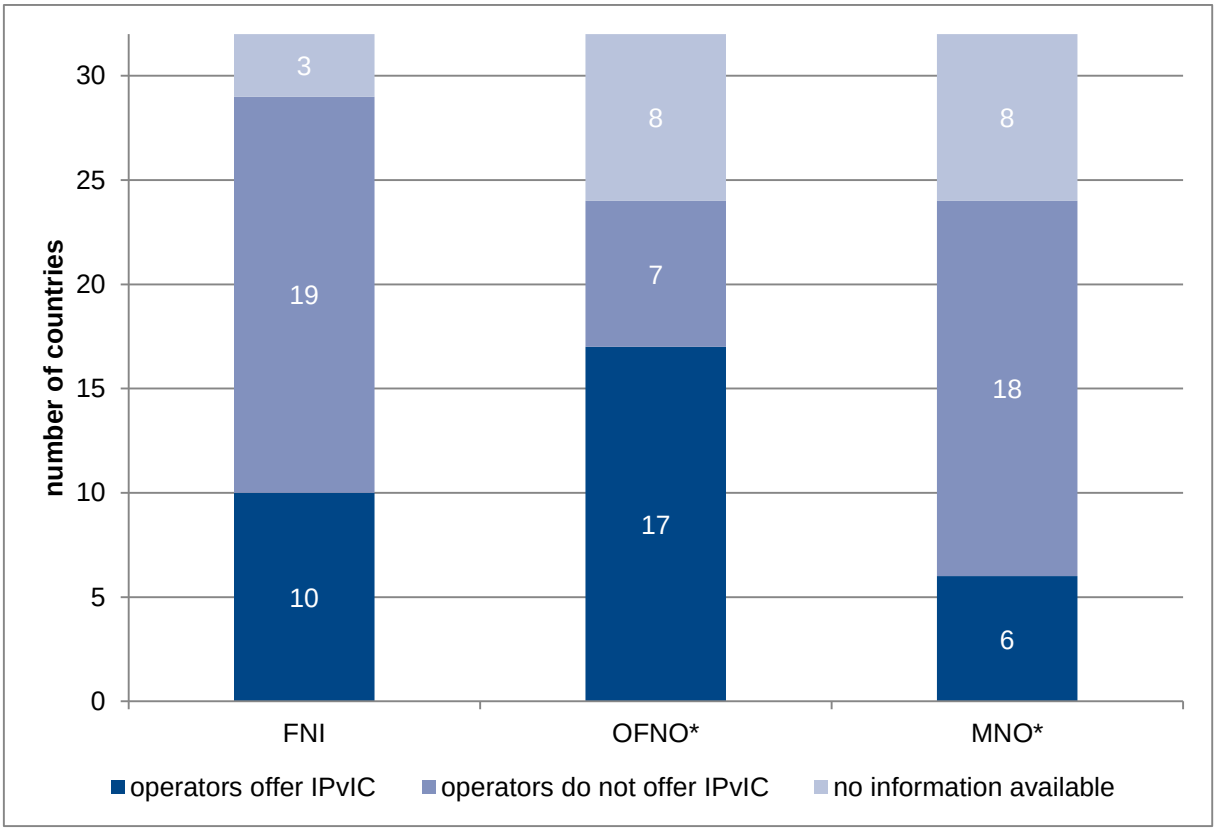
*** In FYROM, OFNO have the obligation to offer IPvIC from 01.01.2017.

Source: BEREC

The share of countries where MNO have the obligation to offer IPvIC is significantly lower (five countries, 16%). An explicit obligation might not be necessary in all cases since, for example, the operator(s) may offer IPvIC on a voluntary basis (and reach an agreement with other

operators with regard to the technical details) or there is (at least currently) no demand for IPvIC.

Figure 2 shows the number of countries where operators are already offering IPvIC (the countries are listed in Table 2).



* Also includes countries where some but not all OFNO or MNO are offering IPvIC

Source: BEREC

Figure 2: Number of countries where operators are offering IPvIC (Q1/2015)

Table 2: Countries where IPvIC is offered (Q1/2015)

	FNI	OFNO	MNO
Yes	DE, DK, FR, FYROM, IT, NL, SE, SK, SI, UK	AT*, BG, DE, ES*, FR, GR*, HR, IT, NL*, NO*, RO*, RS*, TR*, SE*, SI, SK*, UK*	AT*, FI, FR, RS*, TR*, UK*
No	AT, BE, BG, CZ, CY, EE, ES, FI, GR, HR, LI, LT, LU, ME, NO, PT, RO, RS, TR	CY, EE, FI, FYROM, LT, LU, ME	BE, BG, CY, DE, EE, FYROM, GR, HR, IT, LI, LT, LU, ME, NL, NO, PT, RO, SI
NIA**	CH, IE, PL	CH, BE, CZ, DK, IE, LI, PL, PT	CH, CZ, DK, ES, IE, PL, SE, SK

* Some but not all OFNO or MNO are offering IPvIC

** No information available

Grey: Countries where operators have an obligation to offer IPvIC

Source: BEREC

In ten countries, FNI are already offering IPvIC. This is less than the number of countries which have imposed on the FNI the obligation to offer IPvIC. The reason for this is that in some countries the process of defining the details of the reference interconnection offer (RIO) is still ongoing (BG, ES, GR) or has been finished only recently (HR). In other cases (AT, CY), the FNI has to provide IPvIC only if this is demanded by other operators, which has not been the case so far. On the other hand, there are cases where there is no regulatory obligation but the FNI is offering IPvIC on a voluntary basis (FYROM, NL, SK, UK).

The number of countries where OFNO are offering IPvIC is much higher (17 countries). However, this also includes cases where only some (and not all) OFNO are offering IPvIC (eleven countries). Many OFNO, in particular those who rolled-out their networks recently, already built pure IP networks and therefore also implemented IPvIC.

Compared to FNI and OFNO, there are only few countries where MNO are already offering IPvIC (six countries). This already includes four cases where only some MNO offer IPvIC. There is, however, also a significant number of countries where no information is available.

3 Analysis of IP-based interconnection for voice services

This section analyses the IPvIC used by thirteen operators or groups of operators in ten countries (BG, DE, DK, ES, FI, FR, HR, IT, SE, SI). It starts with an overview of the operators analysed (see section 3.1) followed by the analysis of the regulation with regard to IPvIC (see

section 3.2) and the technical characteristics of the IPvIC (see section 3.3). The data collected for the analysis in this section is shown in the tables of the Annex.

In two countries (DE, ES), the IPvIC of the FNI is based on information of the draft RIO of the FNI submitted to the NRA and the approval process is not yet finished. Therefore, the IPvIC of these FNI reflects the view of the FNI but not necessarily of the NRA.

3.1 Overview of the operators analysed

Table 3 gives an overview of the operators analysed in the report. These are the operators for which sufficient information on the IPvIC offer is available and easily accessible (e.g. based on a published reference offer) to make a detailed analysis and comparison of technical characteristics.

Table 3: Overview of the cases analysed

Country	Type of operator	Name of operator
Croatia (HR)	FNI	Hrvatski Telekom
Denmark (DK)	FNI	TDC
France (FR)	FNI	Orange
Germany (DE)	FNI	Deutsche Telekom (draft RIO)
Italy (IT)	FNI	Telecom Italia
Slovenia (SI)	FNI	Telekom Slovenije
Spain (ES)	FNI	Telefónica (draft RIO)
Sweden (SE)	FNI	TeliaSonera
Bulgaria (BG)	OFNO	all operators
Croatia (HR)	OFNO	all operators
France (FR)	OFNO	4 operators (SFR, Bouygues Telecom, Free, Colt)
Finland (FI)	MNO	3 operators (TeliaSonera, Elisa, DNA)
France (FR)	MNO	3 operators (Orange, SFR, Bouygues Telecom)

Source: BEREC

In the analysis, it is usually referred to the country and not to the operator, only for Croatia and France it is also referred to the type of operator if necessary.

The FNI analysed have already migrated their networks at least to some extent to an NGN or all-IP network and this migration process is still ongoing. The OFNO analysed have migrated their networks already completely to an NGN or all-IP network or have started from the beginning with such networks.

3.2 General characteristics of the IPvIC

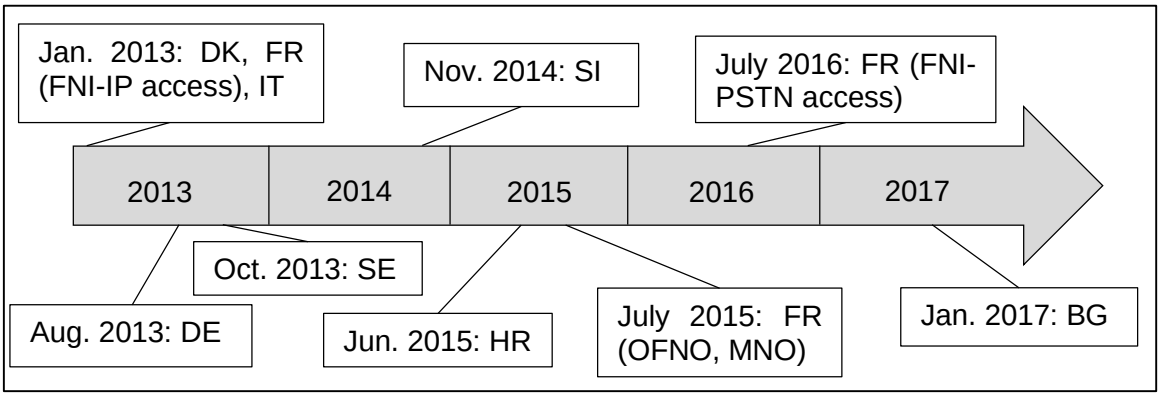
This section discusses general aspects of the obligation to offer IPvIC, the obligation to offer a RIO for IPvIC, whether a national specification for IPvIC exists and how it was developed, and certain aspects with regard to the transition from TDMvIC to IPvIC.

3.2.1 Obligation to offer IPvIC

If there is reasonable demand for IPvIC by some operators and other operators deny access to IPvIC, or the operators cannot reach an agreement on the terms and conditions, there might be a need to impose an obligation to offer IPvIC by the NRA.

As described in section 2, nine of the ten countries analysed have imposed regulatory obligations on operators to offer IPvIC (see also Table 11 to Table 13). These obligations have been imposed on the FNI and OFNO on the market for fixed network termination and on the MNO on the market for mobile network termination. Three countries (DE, HR, IT) have imposed this obligation on the FNI also on the market for fixed network origination.[3] The offers analysed from the MNO in Finland are not based on a regulatory obligation but are voluntary offers.

Figure 3 shows from which date the operators have (or had) to make IPvIC available to other operators. In Spain, no specific date is set, but the FNI has to make IPvIC available on reasonable request at any time. Once available, the operators have to offer IPvIC to all operators, fixed and mobile with the following exception: In Bulgaria, the MNO did not demand an IPvIC from the OFNO so far and hence the OFNO offer IPvIC only to fixed network operators.



Source: BEREC

Figure 3: Date from which operators have to offer IPvIC

[3] In Spain a proposal for such an obligation is currently under public consultation.

3.2.2 Obligation to offer a RIO for IPvIC

A reference interconnection offer (RIO) significantly increases transparency and reduces transaction costs. Therefore, large operators are usually obliged to publish a RIO which might or might not be approved by the NRA. For smaller operators, this obligation might be disproportionate and therefore may not be imposed by NRA.

Six FNI analysed (DK, FR, HR, IT, SE, SI) have already published a RIO for IPvIC (see Table 17 to Table 19). In Italy the RIO is approved by the NRA and in the other five countries the NRA does not formally approve the RIO.[4] Two FNI analysed (DE, ES) have submitted a draft RIO to the NRA and the approval process by the NRA is currently ongoing. The OFNO in Croatia and the MNO of France have also already published a RIO.[5] The OFNO in Bulgaria do not have the obligation to offer a RIO and the MNO in Finland do not have the obligation to offer IPvIC and therefore also do not have the obligation to offer a RIO for IPvIC.

For the analysis of the IPvIC it is important to know for which main categories of voice traffic the IPvIC can be used. The traffic types covered by the RIO are shown in Table 4. Termination in the own network is covered in all RIO due to the fact that the obligation to offer IPvIC is imposed on the markets for fixed or mobile network termination (see section 3.2.1) which regulate the termination in the own network. The RIO of the FNI of Germany, Croatia and Italy also include origination in their own networks since the NRA imposed IPvIC also on the market for fixed network origination (see section 3.2.1). The RIO of the FNI in Sweden also encompasses origination in their own network although this is not demanded by regulation. Transit in the own network is included in the RIO on a voluntary basis since transit is no longer regulated. The access to services in the own network is covered by RIO of five FNI (DE, HR, IT, SE, SI) and the OFNO of Croatia. The RIO of three FNI (DE, HR, SI) and the OFNO of Croatia also includes termination and access to services in the network of the IC partner.

[4] In Croatia, the NRA has the possibility to open a procedure and to investigate whether the RIO is compliant with regulatory obligations after RIO is published.
[5] With the exception of Colt which does not have the obligation to offer a RIO because in France a RIO does not have to be offered by operators with less than 1 million (fixed and mobile) subscribers.

Table 4: Traffic types covered by the RIO for IPvIC

	FNI								OFNO			MNO	
	DE	DK	ES	FR	HR	IT	SE	SI	BG	FR	HR	FI	FR
Traffic types in the network of the operator									No obligation to offer RIO			No obligation to offer RIO	
Termination	X	X	X	X	X	X	X	X		X	X		X
Origination	X				X	X	X						
Transit	X					X	X	X					
Access to services	X				X	X	X	X			X		
Other								X[6]					
Traffic types in the network of the IC partner													
Termination	X[7]				X			X			X		
Access to services	X[7]				X			X			X		
Other								X[6]					

Source: BEREC

3.2.3 National specification of IPvIC

The use of IPvIC is only possible if the operators agree on how to interconnect their networks based on IPvIC. Therefore a solution is necessary which in the ideal case fits for all operators which is especially important in case of the IPvIC offered by FNI which typically is used by most of the operators. Such specifications were elaborated in the following ways:

In three countries (BG, FI, HR), the NRA and in one country (IT) a ministry, defined technical characteristics either in a decision (BG[8], HR, IT) or recommendation (FI) or in a technical specification (IT[9]) which have to be fulfilled by the IPvIC of the operators analysed (see Table 20 to Table 28). In another country (ES), technical characteristics of the IPvIC were defined by an industry forum consisting of network operators hosted by the NRA. In further two countries (DE, FR), an industry body of network operators[10] defined technical characteristics of the IPvIC at a national level. Specifications of these industry bodies are referred to in the RIO (DE, FR (FNI, Orange mobile)), or operators comply with them although not included in the RIO (FR (OFNO, SFR mobile, Bouygues Telecom mobile)).

In all cases the relevant operators and stakeholders were involved in the process by which the national specifications were established. Consensus was achieved through discussions in the

[6] International services e.g. voice traffic from an OFNO over the FNI (Telekom Slovenije) to a foreign operator.
[7] optional
[8] A draft decision is already notified to the European Commission (BG/2015/1752), however, the final decision is not yet taken.
[9] The decision no. 128/11/CIR of the NRA (Agcom) provides the rules for the implementation of IPvIC and the technical specification ST 769 v.1 of the Ministry for Economic Development which builds upon the decision no. 128/11/CIR and defines the technical characteristics of the IPvIC which has to be fulfilled in detail.
[10] In Germany, the Working Group for Technical and Operational Numbering and Network Interconnection Issues (AKNN) and in France, the French Federation of Telecommunications (FFT)

specification process (BG, DE, ES, FR, HR), or because the national specification is based on implementations already used (FI) or by intervention of the NRA (IT). In Bulgaria, it was not possible to achieve consensus with regard to all aspects of IPvIC and the NRA had to decide on the other aspects of the national specification.

The technical topics covered by the national specifications are shown in Table 5.

Table 5: Technical topics covered by the national specification(s)

	FNI								OFNO			MNO	
	DE	DK	ES	FR	HR	IT	SE	SI	BG	FR	HR	FI	FR
Interconnection architecture	X	No national specification	X	X	X	X	No national specification	No national specification		X			X
Signalling protocol (at PoI)	X		X	X	X	X			X	X	X	X	X
Number ranges supported			X		X	X					X	X	X
Supplementary services supported	X		X	X	X	X			X	X	X	X	X
Codecs supported	X		X	X	X	X			X	X	X	X	X
Quality of service	X		X			X			X				
Physical interface				X	X	X			X	X	X		X
Redundancy				X	X	X			X	X	X	X	X
Security			X	X	X	X			X	X	X		X
Other major technical aspects	X[11]		X[12]		X[13]	X[11]					X[13]		

Source: BEREC

3.2.4 Migration to IPvIC

This section analyses the migration to IPvIC with regard to

- the transitional period for the migration to IPvIC,
- the periods of notice regarding the phasing out of TDMvIC,
- the delay of the migration to IPvIC compared with the migration plan and
- the current state of the migration to IPvIC.

Transitional period for the migration to IPvIC

Operators may have a different view on when the TDMvIC should be migrated to IPvIC. Operators which already have migrated their networks to an NGN or all-IP network may want to migrate the voice interconnection as soon as possible to IPvIC. Other operators which have not or only recently started to migrate their networks to an NGN or all-IP network may want to migrate to IPvIC at a later point in time which means that they will need the TDMvIC currently in place still for a certain time period. But operators may not want to offer both “old” TDMvIC

[11] Emergency calls
[12] Number portability information
[13] Emergency calls and number portability information

and “new” IPvIC in parallel over a long time in order to keep their costs low. Therefore, there may be a demand to regulate the migration to IPvIC in order to ensure a smooth transition.

All operators analysed currently have the obligation to offer both IPvIC and TDMvIC with the exception of the MNO in Finland which offer IPvIC on a voluntary basis (i.e., without any obligation to do so, see section 3.2.1 and Table 14 to Table 16). The FNI in five countries (DE, DK, ES, IT, SE) and the OFNO in Bulgaria have to offer IPvIC and TDMvIC over a time period which is currently not (yet) defined by the NRAs. Therefore the interconnection (IC) partners of these operators have the possibility to migrate to IPvIC when it best fits for them. On the other hand, this may cause costs for the operators who are offering both possibilities and will no longer be necessary after all or at least most of the operators migrated to IPvIC. Therefore, NRAs may define in the next round of market analysis the end of the transitional period.

In Croatia, the FNI and the OFNO have to offer TDMvIC at least until end 2017. In France, for FNI, OFNO and MNO the length of the transitional period is defined by the NRA with at least 18 months and in Slovenia, the FNI has the obligation to offer both TDMvIC and IPvIC at least for one year. Such solutions foster the migration to IPvIC but on the other hand leave operators less choice regarding when they migrate to IPvIC.

Periods of notice regarding the phasing out of TDMvIC

Operators need to know an appropriate time period in advance when the TDMvIC will no longer be available. Therefore, especially in countries where operators already announced to phase out TDMvIC there may be a demand to regulate periods of notice regarding the phasing out of TDMvIC in order to ensure that other operators will have sufficient time to prepare for the migration to IPvIC.

In France, three MNO and at least one OFNO already announced to phase out TDMvIC and the NRA (ARCEP) defined the minimum periods of notice for major steps of phasing out TDMvIC (see Figure 4). The minimum periods of notice are

- 12 months before commercial closure of TDMvIC (no new interconnections or capacity extension),
- 12 months before any increase in TDMvIC tariffs and
- 24 months before technical shutdown of TDMvIC

Source: ARCEP

Figure 4: Minimum period of notice for FNI, OFNO and MNO in France

In Denmark and Germany, it is envisaged that the FNI will phase out TDMvIC end of 2016 (DE) or over the years up to 2020 (DK). In other six countries (BG, ES, HR, IT, SE, SI), the operators analysed have not made any formal announcements to phase out TDMvIC. In these countries, there was no need for the NRA to regulate periods of notice regarding the phasing out of TDMvIC so far with the following two exceptions: The period of notice for no longer offering TDMvIC is already defined in Croatia with one year and in Slovenia with six months.

In Finland, the MNO analysed offer IPvIC on a voluntary basis (see section 3.2.1) and have already migrated the voice interconnections between them (not to fixed network operators) completely to IPvIC.

Delay of the actual migration to IPvIC compared with the migration plan

The delay of the actual migration to IPvIC compared with the migration plan may have a negative impact on operators. In Italy, the NRA uses an economic disincentive for the FNI in order to avoid such drawbacks for the IC partners of the FNI. According to rules defined by the NRA an IC partner has to pay the use of the TDM ports of the TDMvIC and the use of the IP ports of the IPvIC according to the migration plan agreed between him and the FNI and not according to the actual migration process, if the migration process is delayed for reasons objectively attributable to the FNI.

In the other countries analysed, no regulation with regard to the delay of the migration to IPvIC was necessary so far.

Current state of the migration to IPvIC

In nine countries (BG, DE, DK, FI, FR, HR, IT, SI, SE) the operators analysed (in HR the OFNO but not the FNI) already have implemented the IPvIC and the IPvIC is also already used by the IC partners. In Spain, the FNI only recently submitted the RIO to the NRA and in Croatia, the decision from the NRA (see section 3.2.3) only recently was made and therefore the FNI in both countries do not have implemented IPvIC yet.

In Finland, the IPvIC of the MNO analysed is already used for 80% of the voice IC traffic and the TDMvIC only for the remaining 20%.[14] As already mentioned the MNO have already migrated the voice interconnection between them completely to IPvIC and only IC traffic to fixed network operators is still based on TDMvIC. In Denmark, France and Italy, the IPvIC of the FNI is used for 30% (FR), 16% (IT), and less than 10% (DK) and the remaining IC traffic is still based on TDMvIC (data from end 2014 / begin of 2015). No information with regard to the use of IPvIC is available for the other operators analysed.

3.3 Technical characteristics of the IPvIC

This section covers several important technical characteristics of IPvIC and compares them across the cases analysed.

In two countries (DE, ES), the IPvIC of the FNI is based on information of the draft RIO of the FNI submitted to the NRA and the approval process is not yet finished. Therefore, the IPvIC of these FNI reflects the view of the FNI but not necessarily of the NRA.

3.3.1 Number of PoIs of the IPvIC

The number of points of interconnection (PoI) is an important characteristic of interconnections between networks. Interconnections for voice services based on traditional technology (TDMvIC) typically use different PoIs for subscribers in different areas. Since voice traffic only accounts for a small share of total traffic in all-IP networks, the migration to such networks usually also leads to a reduction of the number of PoIs.

In four countries (DK-TDM end user[15], ES[16], IT, SE), the IPvIC of the FNI is based on different PoIs for subscribers in different areas and the IC partner have either to connect to (at least) one PoI in each area or they have to pay unregulated transit rates in addition to the regulated termination rate (see Table 6, and Table 29 to Table 31).

[14] This is a rough estimate.
[15] The IPvIC for customers of the FNI which are still connected to the PSTN network of the FNI.
[16] According to the draft RIO

Table 6: Number of PoIs for IPvIC

	FNI								OFNO			MNO	
	DE	DK	ES	FR	HR	IT	SE	SI	BG	FR	HR	FI	FR
Minimum number for redundancy and local rates	2	2/6[17]	19	2	2	32[18]	4[18]	2	ND[19]	2	ND[19]	2	2
Total number	22[20]	6	19	10	4	32	4	2	1[21]	NIA	ND[19]	3	4/3[22]

Source: BEREC

In five countries (DE, DK-VoIP end user[23], FR, HR, SI), the FNI has reduced the minimum number of PoIs for the IPvIC to 1 or 2 in case of redundancy. The IC partner have the possibility to handover the traffic for the whole national territory on only one (or two in case of redundancy) PoI and have to pay only the regulated termination rate. In two countries (DE, DK), this has been imposed by the NRA. Reasons for that are to provide ANOs with more flexibility (DK) and that the FNI was not able to provide sufficient reasons for the use of more PoIs (DE). The IPvIC is offered by the FNI with more than 2 PoIs (4/6/10/22) in four countries (HR/DK/FR/DE) and the ANOs can choose one or two PoIs out of these PoIs.

In Bulgaria, the IPvIC of the OFNO is generally based on one PoI on a voluntary basis. In Croatia, the minimum and total number of PoIs of the IPvIC of the OFNO is not yet defined by the NRA. In France, the minimum number of PoIs of the IPvIC of the OFNO and the MNO is two. In Finland, the minimum number of PoIs of the IPvIC offered by the MNOs is two according to a recommendation of the NRA (FI[24]) and the total number of PoIs is three.

3.3.2 Signalling protocols at the PoI of the IPvIC

Signalling protocols are used e.g. for the set-up and ending of calls. With the move to NGN and IPvIC the traditional signalling protocol for voice (ISUP)[25] which is based on TDM has to be replaced by a signalling protocol based on IP.[26] Several different IP-based signalling protocols have been standardized and are available. In order to connect their networks operators have to agree on the signalling protocols used at the PoI.

[17] 2 PoIs for voice traffic to VoIP end users of the FNI and 6 PoIs for voice traffic to TDM end users of the FNI.
[18] In Italy and Sweden, the whole territory is divided in 16 (IT) or 2 (SE) (gateway) areas each with two PoIs. In order to avoid unregulated transit rates, it is sufficient to connect to one PoI of each area. However, if redundancy is required, it is necessary to connect to both PoIs of an area
[19] For OFNO the NRA has not yet defined the minimum or total number of PoIs.
[20] 22 PoIs on 12 locations
[21] Currently OFNO use generally 1 PoI
[22] Orange 4 PoIs, Bouygues Telecom 3 PoIs.
[23] The IPvIC for customers of the FNI which are already connected to the network of the FNI based on IP (VoIP).
[24] Ficoras`s regulation on redundancy (not Ficora`s recommendation regarding IPvIC described in section 3.2.3)
[25] ISDN User Part, which is part of the Signalling System No. 7 (SS7).
[26] Technically possible is also to keep the traditional signalling protocol for voice (ISUP) and transport it over IP (e.g. with SIGTRAN). However, the cases analysed in this report do not use such a solution.

Three FNI analysed (IT, SE, SI) offer IPvIC with two different signalling protocols at the PoI and the IC partners can choose between them (see Table 32 to Table 34). All other operators analysed provide IPvIC only with one signalling protocol at the PoI.

The following signalling protocols are used at the PoI in the cases considered:[27]

(i) SIP (IETF): The Session Initiation Protocol (SIP) defined by IETF standards (so-called RFCs) leaves room for network operators on how to use SIP. This provides, on the one hand, flexibility for the network operator but, on the other hand, further specifications may be needed in order to guarantee operability between different networks.

(ii) SIP (IETF+3GPP): SIP which also fulfils specifications of 3GPP[28] is based on the use of the so-called IP Multimedia Subsystem (IMS) defined by 3GPP. Such a solution is especially appropriate if an operator uses an IMS in its own network and defines the use of SIP in more detail.

(iii) SIP-I (ITU-T): SIP-I is a hybrid signalling protocol: It is SIP defined by IETF but used in a rather specific way defined by ITU-T where the traditional (TDM-based) signalling protocol (ISUP) is transported within the “new” signalling protocol SIP. Therefore, it can also be seen as an intermediate step between traditional signalling protocol (ISUP) and the “new” IP-based signalling protocol SIP. The standards of mobile networks already separated the call control from packet based transport for many years and suggest the use of SIP-I (or different signalling protocol[29]) within mobile networks. Therefore, it seems natural if MNOs use IPvIC based on SIP-I.[30]

All FNI and OFNO analysed offer IPvIC either with the Session Initiation Protocol (SIP) as defined by IETF (BG, DK, SE, SI) or with SIP defined by IETF including specifications of 3GPP (related to IMS) (DE, ES, FR (FNI, OFNO), HR (FNI, OFNO), IT). Three FNI (IT, SE, SI) offer in addition also SIP-I.[31] All MNO analysed (FI, FR (MNO)) offer IPvIC based on SIP-I.

[27] Other possible signaling protocols are e.g. SIP-T defined by IETF and BICC defined by ITU-T (primarily used in mobile networks, not fixed networks).
[28] 3GPP (3rd Generation Partnership Project) unites seven telecommunications standard development organizations, see http://www.3gpp.org/about-3gpp.
[29] Bearer Independant Call Control (BICC)
[30] With the introduction of voice over LTE (VoLTE) in mobile networks SIP may gain importance since VoLTE is based on SIP and IMS specified by 3GPP.
[31] In Croatia, the FNI and the OFNO are allowed to use SIP-I instead of SIP in case of IPvIC with mobile networks.

Table 7: Signalling protocols at the PoI of the IPvIC

	FNI								OFNO			MNO	
	DE	DK	ES	FR	HR	IT	SE	SI	BG	FR	HR	FI	FR
SIP (IETF)		X					X	X	X				
SIP (IETF+3GPP)	X		X	X	X	X				X	X		
SIP-I (ITU-T)						X	X	X				X	X[32]

Source: BEREC

The above mentioned IP-based signalling protocols used at the PoI by the operators analysed are not imposed by regulation except the signalling protocols used by the FNI of Croatia and Italy and the OFNO of Bulgaria[33] and Croatia.

The analysis shows that the signalling protocols used at the PoI are based on several international standards. SIP (IETF) is based on the main standard (RFC 3261) and usually also on other standards (RFCs) depending on which further aspects of SIP are used. SIP (IETF+3GPP) is also based on standards of 3GPP and the operators analysed are using four 3GPP specifications.[34] SIP-I (ITU-T) is defined in the ITU-T Rec. Q.1912.5 Profile C.

3.3.3 Number ranges supported by the IPvIC

For operators it is desirable that the "new" IPvIC supports the same number ranges as the TDMvIC. In such a case the voice IC traffic can be migrated completely from TDMvIC to IPvIC without any need of an additional solution for number ranges which are not supported by IPvIC.

In five countries (DE, HR, IT, SI, SE) the IPvIC of the FNI supports all number ranges including (see Table 35 to Table 37):

- geographical numbers,
- service numbers (e.g. free phone numbers, premium rate numbers),
- emergency numbers,
- harmonized European short codes (116xxx),
- public national short codes,
- location independent corporate numbers,
- mobile numbers, and
- international numbers.

[32] The target protocol is SIP but not yet implemented.
[33] In Bulgaria, the regulation demands at the PoI the use of SIP (IETF) or SIP-I (ITU-T). However, OFNO have (at least currently) implemented SIP (IETF).
[34] 3GPP TS 29.165 (ES, IT), 3GPP TS 24.229 (DE, FR (FNI, OFNO)), 3GPP TS 24.528 (ES) and 3GPP TS 24.628 (FR (FNI, OFNO)). In Germany, the IPvIC of the FNI is based on ETSI TS 124.503 which is an ETSI TISPAN endorsement of 3GPP TS 24.229.

In Denmark, the IPvIC of the FNI supports the same number ranges as the TDMvIC. In France, the IPvIC of the FNI is available for all interpersonal numbers (e.g. geographical numbers, mobile numbers, international numbers) but not yet for service numbers and short codes which currently still needs to be handed over based on TDMvIC.[35] In Spain, according to the draft RIO of the FNI the IPvIC will enable other operators to handover traffic to geographical and nomadic numbers but not to other numbers. The reason is that the obligation imposed on the FNI is only related to call termination.[36]

The IPvIC of the OFNO is available in Croatia for all number ranges, in Bulgaria for all number ranges assigned to the OFNO and in France for the same number ranges as the IPvIC of the FNI (see above). In Finland and in France, the IPvIC of all MNO analysed support all number ranges.[37]

3.3.4 Supplementary services supported by the IPvIC

Supplementary services such as Call Forwarding (CF) or Calling Line Identification Presentation (CLIP) modify or supplement a basic telephone service. For operators it is important which supplementary services are supported by the IPvIC. If the same supplementary services are supported as in case of TDMvIC then the migration to IPvIC will not lead to any change of the telephone service offered with regard to supplementary services.

In the following two aspects are considered. Firstly, which supplementary services are supported by the IPvIC and secondly, whether the IPvIC enables the operators to handover the same supplementary services as the (previous) TDMvIC.

The supplementary services supported by the IPvIC of the operators analysed are shown in Table 8 (see also Table 35 to Table 37).

With regard to the question whether the IPvIC enables the operators to handover the same supplementary services as the (previous) TDMvIC the results of the analyses are as follows: The IPvIC of four FNI (DE, DK, HR, SI), the OFNO of Croatia and the MNO of Finland provide (basically) the same supplementary services as the TDMvIC (DK, FI, HR, SI) or the supplementary services available based on TDMvIC are at least optionally supported by IPvIC (DE). The IPvIC of the FNI of three countries (ES, FR, IT) and the OFNO of France currently no longer support the following supplementary services which are available with TDMvIC:

- Subaddressing (SUB) (FNI: ES, IT)

[35] The French Federation of Telecommunications is currently working on a solution.
[36] However, it is likely that service numbers and short codes will be included in the RIO after the final decision on the market for fixed network origination.
[37] In France, based on SIP-I but not yet based on SIP.

- Dual Tone Multi Frequency (DTMF) (FNI: FR, OFNO: FR)
- Call Completion Busy Subscriber (CCBS) (FNI: IT)
- User-to-User signalling (UUS) (FNI: ES)

Table 8: Supplementary services supported by the IPvIC*

	FNI								OFNO			MNO	
	DE	DK	ES	FR	HR	IT	SE[38]	SI	BG	FR	HR	FI	FR
Calling Line Identification Presentation (CLIP)	X	X	X	X	X	X	X	X	X	X	X	Basically same as TDMvIC	X
Calling Line Identification Restriction (CLIR)	X	X	X	X	X	X	X	X	X	X	X		X
Call Forwarding (CF)		X	X	X	X	X	X		X	X	X		X
Call Hold (CH)			X	X	X	X	X			X	X		X
Connected Line Identification Presentation (COLP)			X		X	X[39]	X[39]				X		
Call Waiting (CW)			X		X	X	X[39]				X		X
Three Party Call (3PTY)			X		X	X	X[39]				X		
Connected Line Identification Restriction (COLR)			X			X[39]	X[39]						
Call Deflection (CD)						X[39]	X[39]						
User-to-User Signalling (UUS)						X[39]	X[39]						
Malicious Call Identification (MCID)						X	X[39]						

* The table only shows supplementary services that are each supported by at least two (groups of) operators. Several further supplementary services exist, each supported by one (group of) operator only.

Source: BEREC

3.3.5 Codecs supported by the IPvIC

The microphone in a telephone converts the speech of a speaker into an analogue signal and then a codec converts the analogue voice signal into a digital signal which is transmitted through telephony networks to the communication partner where a codec reconverts the digital signal into an analogue signal which is transformed into sounds with a loudspeaker. In order to enable a communication between calling and called subscriber the codecs at both ends need to be compatible.[40] The traditional signalling protocol for voice (ISUP) and therefore also

[38] The IPvIC supports the same supplementary services as the previous TDMvIC

[39] Only based on SIP-I (not SIP)

[40] Otherwise a so-called transcoding is necessary which converts the voice signal from one codec to another codec and vice versa which has a negative impact on the voice quality. Different codecs have been developed in order to increase the speech quality (MOS) and/or decrease the bandwidth demand for a phone call.

the TDMvIC support only the audio codec G.711 which is most commonly used in fixed telephony networks and no other codecs for voice calls. An advantage of IP-based signalling protocols and the IPvIC is that the codec used for the phone call can be negotiated between the parties of the call. This means phone calls are possible also with other audio codecs than G.711 without transcoding i.e. “translation” between different codecs which has a negative effect on the speech quality.

The IPvIC of all operators analysed supports the audio codec standard G.711 (A-law, see Table 38 to Table 40). The IPvIC of the FNI of six countries, the OFNO of two countries and the MNO of Finland also provide the possibility to handover voice traffic based on the codec standard G.729 (ES, FI, FR, IT) or G.729a[41] (DK, HR) or G.722[42] (HR) which are also used in fixed networks. The IPvIC of four FNI (ES, HR, IT, SI) and the OFNO of Croatia also supports the signalling of multi-tone signals (DTMF) based on RFC 2833 (IT, SI) or RFC 4733[43] (ES, HR). Codecs which are usually used in mobile networks are supported by the IPvIC of the MNO in Finland (EFR, AMR-NB) and the FNI and OFNO of France (AMR set 7). A summary is presented in Table 9.

Table 9: Audio codecs supported by IPvIC

	FNI								OFNO			MNO	
	DE[44]	DK	ES	FR	HR	IT	SE	SI	BG	FR	HR	FI	FR
G.711 A-law	X	X	X	X	X	X	X	X	X	X	X	X	X
G.729			X	X		X				X		X	
G.729a		X			X						X		
G.722					X						X		
DTMF			X		X	X		X			X		
EFR												X	
AMR-NB												X	
AMR set 7				X						X			

Source: BEREC

The IPvIC of all operators analysed support fax services. All FNI analysed and the OFNO of Croatia offer IPvIC with the possibility to handover fax services based on both the codec standard G.711 A-law and RFC T.38. The IPvIC of the OFNO of Bulgaria and France as well as the MNO of Finland and France support only one standard the RFC T.38.

[41] G.729a is a compatible extension of G.729. In comparison with the original G.729 codec the version G.729a is less complex and provides a slightly lower voice quality.
[42] G.722 is a 7 kHz wideband audio codec operating at 48, 56 and 64 kbit/s and provides improved speech quality due to a wider speech bandwidth compared to narrowband speech coders like G.711.
[43] RFC 4733 is the successor of RFC 2833
[44] Other codecs may be negotiated without guarantee

3.3.6 Quality of service of the IPvIC

The quality of a voice call is important and therefore also the quality of service (QoS) of network components (e.g. IC link) or networks (e.g. NER[45]) or the complete call (end-to-end) may be specified in interconnection agreements.

The IPvIC of the FNI of Croatia and Italy and the OFNO of Croatia have to have a QoS which is comparable with the QoS of the TDMvIC.

The QoS of the IPvIC analysed is defined with regard to several QoS parameters (see Table 10, and Table 41 to Table 43). The IPvIC of the FNI of three countries (DE[46], IT, SI) and the OFNO of Bulgaria have to fulfil a defined speech quality based on the following QoS parameters:

- One-way Delay (end-to-end) (G.114)
- MOS (LQO) (end-to-end): The Mean Opinion Score (MOS) is a measure for how satisfied a customer is with quality of a call with a value between 1 and 5 (1=bad quality, 5=excellent quality). Listener Quality Only (LQO) means that the customer is listening to what the other party says and rates this quality (not the quality of an interactive phone conversation).
- R-factor: The transmission rating factor R (R-factor) is a similar but different measure than the MOS and used in a tool for network planners (values: 0-100%, see G.107, G.109).
- Codecs that should be used
- Other QoS standards to which the IPvIC should comply with.

The end-to-end one way delay has to be less than 150 ms (BG, DE, SI), the MOS (LQO) higher than 4.0 (end-to-end) (DE), the R-factor higher than 70 (BG), the codecs G.711 (IT, SI) or G.729 (IT) should be used and the standards G.101 (DE) as well as G.107 (SI) and G.168 (SI) should be met.

In four countries analysed, the QoS of the IPvIC is also defined based on the following QoS parameters related to the call set-up:

- Call set-up time
- NER: The Network Effectiveness Ratio (NER) is the ratio of calls where the phone of the called party signals back to the calling party that the called party either takes the

[45] Network Effectiveness Ratio
[46] In Germany, the QoS of the IPvIC is defined with regard to several parameters but due to uncertainties of introductory phase of new technology and not yet finalised market consensus on quality parameters no service level guarantees (SLG) are available and no penalty have to be paid if the QoS targets are not achieved.

call or not although the phone is ringing or the phone is busy at this moment to the total number of calls (exact definition see E.425).

- ASR: The Answer Seizure Ratio (ASR) is the ratio of calls where the called party takes the call to the total number of calls (exact definition see E.425). Therefore, the ASR is lower than the NER and it depends, in contrast to the NER, also on the user behaviour.

Table 10: Quality of service of the IPvIC

	FNI								OFNO			MNO	
	DE[46]	DK	ES	FR	HR	IT	SE	SI	BG	FR	HR	FI	FR
QoS comparable with TDMvIC					X	X					X		
Speech quality				Not specified in RIO								Not specified in RIO	
One-way delay (end-to-end)	X							X	X				
MOS (LQO) (end-to-end)	X												
R-factor (G.107)									X				
Use of Codec G.711					X	X		X			X		
Use of Codec G.729					X	X					X		
Other standards[47]	X							X					
Call set-up													
Call set-up time	X												
Network Effectiveness Ratio	X								X	X[48]			X[49]
Answer Seizure Ratio									X	X[48]			X[49]
Transport of the IP traffic													
IP packet loss ratio			X				X		X				
IP packet transfer delay			X				X						
IP packet delay variation			X				X		X				
Expedited Forwarding (voice)		X	X										
Assured Forwarding (signalling)		X[50]	X[51]										
Availability of the interconnection													
Defined availability	X		X										

Source: BEREC

The call set-up time is defined with less than 3 sec. for the IPvIC of the German FNI. The IPvIC of the FNI in Germany, the OFNO in Bulgaria and the French OFNO and MNO Bouygues

[47] G.101, G.107, and G.168
[48] Only mentioned in Bouygues Telecom RIO
[49] Only mentioned in Bouygues Telecom RIO
[50] AFb
[51] AF31

Telecom have to have a Network Effectiveness Ratio (NER) higher or equal to 99.5% (DE) or higher than 99.3% (Bouygues Telecom) or 95% (BG) and an Answer Seizure Ratio (ASR) higher than 65% (Bouygues Telecom) or 50% (BG).

The IPvIC of the FNI in three countries (DK, ES, SE) and the OFNO of one country (BG) have to fulfil QoS parameters with regard to the transport of the IP traffic. The IP traffic have to be transported with a defined IP packet loss ratio (BG, ES, SE), IP packet transfer delay (ES, SE) and IP packet delay variation (BG, ES, SE) and the class of service (CoS) for forwarding the IP traffic has to be Expedited Forwarding (EF) for the voice traffic (DK, ES) and Assured Forwarding (AF)[52] for the signalling traffic (DK, ES).

The availability of the interconnection is defined for the IPvIC offered by the FNI of two countries (DE, ES) and has to be higher or equal 99.77% (ES) or 99.5%[53] (DE). In Germany the IPvIC of the FNI has also to fulfil QoS targets with regard to the probability of a dropped connection.[54]

A summary of the results is depicted in Table 10. It can be seen that different QoS parameters are used by the operators analysed and some have not defined any QoS parameter at all (at least not in the RIO).

3.3.7 Physical interconnection link and redundancy of the IPvIC

In order to connect two networks a physical link is necessary. The technical characteristics of the IC link are relevant for the IC partners. Furthermore, in order to achieve a high availability of the interconnection, redundancy may be important.

All operators analysed connect their networks with the network of the IC partner with a direct physical link with one exception (see Table 44 to Table 46). The MNO in Finland exchange their voice traffic via (domestic) exchange points to which their networks are connected to.

The physical IC link of the IPvIC of all operators[55] analysed can only be used to transport voice (and fax) traffic and not to exchange also other traffic (e.g. Internet traffic) between the interconnected networks except in Slovenia where additional services can be transported in the IC link of the IPvIC of the FNI if this is supported by the equipment.

The physical transport interface at the PoI of the IPvIC of all operators analysed is 1 GE with the following exceptions: In Bulgaria, the IPvIC of the OFNO has to be offered with a

[52] AFb in Denmark and AF31 in Spain
[53] per IC partner and excluding the leased line between the networks
[54] See footnote 46
[55] With regard to the FNI in Sweden at least in the RIO of the FNI it is not specified that other traffic than voice traffic can be carried in the IC link of the IPvIC.

standardised Ethernet interface and therefore other interfaces than 1 GE are possible and the IPvIC of the French MNO SFR is available with a transport interface that complies with standards of French Forum of Telecommunications. A 10 GE interface is available at the PoI of the IPvIC of the FNI in Germany and Sweden, two MNO in France and in the near future also at the PoI of the IPvIC of the MNO in Finland. In Germany the IPvIC of the FNI is also available with an SDH interface (155 Mbps).

The physical IC link of the IPvIC of all operators is redundant, however, in two countries (DK, SE) this is only an option and with the exception of the OFNO of Croatia where it is not yet defined whether the physical IC link has to be redundant.

The IPvIC of the FNI in six countries (DE, ES, FR, HR, SE, SI), the OFNO of two countries (FR, HR) and the French mobile network operator Bouygues Telecom has also a redundancy at the level of the border gateway (e.g. SBC). This redundancy is based on an n+1 model (DE, FR) or on load sharing (ES, HR, SI, Bouygues Telecom).

3.3.8 Network security of the IPvIC

For all operators it is of importance to ensure the security of their networks. Especially with regard to the “open” Internet security threats have significantly increased over the last years.

The operators analysed connect their networks with the networks of their IC partners with direct IC links[56] and not over the public Internet (see section 3.3.7) which provides already a substantial protection regarding threats from the Internet.

The IPvIC of all operators analysed are implemented with security measures in order to protect the networks with the following exception (see Table 47 to Table 49). In Finland, Ficora’s recommendation (see section 3.2.3) does not demand the use of security measures. However, the Finnish MNO may have implemented security measures in their own interests.

The following security measures of the IPvIC are used in several countries analysed:

- Use of a Session Border Controller (FNI: ES, FR, HR, SE, SI, OFNO: all, MNO: FR),
- IP addresses are not advertised to the Internet (FNI: DK, ES, FR, SE, OFNO: FR, MNO: FR),
- (E)BGP authentication (FNI: ES, HR, OFNO, HR)

In some countries also the features of the SBC are defined e.g. topology hiding (FNI: ES, SE, SI, OFNO: BG) or firewall (FNI: SE, OFNO: BG).

[56] The MNO in Finland connect their mobile networks over domestic exchange points for voice offered by a provider which is owned by them.

4 Conclusions

In recent years several operators (fixed and mobile) in European countries started to migrate their networks to Next Generation Networks or all-IP networks. When networks are migrated to NGN or all-IP networks, it is “natural” and efficient that also the interconnection for voice services is based on IP (and no longer on TDM).

This report analyses the status of IPvIC in Europe from a high-level perspective and provides details about general and important technical characteristics of IPvIC in ten countries.

The high level analysis of the status of the IPvIC in Europe, which comprises 32 countries, shows that the type of operator which most often offers IPvIC is the OFNO (17 countries where at least some OFNO are offering IPvIC) followed by the FNI (10 countries) and the MNO (6 countries where at least some MNO are offering IPvIC). NRAs imposed the obligation to offer IPvIC most frequently on FNI (13 countries) followed by OFNO (11) and MNO (5).

The general and important technical charcteristics of IPvIC have been analysed in detail for 13 cases in ten countries, for which sufficient information on the IPvIC offer was available. These cases cover FNI of eight countries as well as OFNO in three countries and MNO in two countries. In these countries the IPvIC have the following general characteristics (see section 3.2):

- Obligation to offer IPvIC: All operators considered offer IPvIC based on an obligation except for the MNO in Finland.
- National specification(s): In order to support a common solution for several or all operators at the national level most countries analysed (7 of 10) have developed one (or more) national specification(s) defining the characteristics of the IPvIC in detail.
- Transitional period: The countries (9) which have imposed that the operators analysed have to offer IPvIC support the migration from TDMvIC to IPvIC with the obligation that both types of voice IC have to be offered. In most of these countries (6 of 9) a transitional period is not (yet) defined, and therefore the operators are free to migrate to IPvIC when it is best for them. The other three countries have already defined the transitional period.
- Period of notice of phasing out TDMvIC: This period has already been defined in three countries. In the other countries this is not the case and in most of them the operators analysed have not made formal announcements to phase out TDMvIC so far.

The important technical characteristics of the IPvIC of the cases analysed are as follows (see section 3.3):

- Number of PoIs of the IPvIC: The minimum number of PoIs of the IPvIC which enable operators to handover voice traffic for national destinations based on the regulated termination rates (without additional charges) has been reduced to one or two (8 of 13 cases). This reflects the trend that the number of PoIs is usually reduced with the migration to NGN and all-IP networks.
- Signalling protocol: The signalling protocol to be used at the PoI is SIP (11 of 13). In most of these cases (7 of 11) the use of SIP is further defined with 3GPP specifications (related to IMS). In the two cases with MNO SIP-I (and not SIP) is used at the PoI which is also used within mobile networks.
- Number ranges, codecs and supplementary services supported by IPvIC: The IPvIC supports the same number ranges as the TDMvIC (10 of 13), the audio codec G.711 (all cases) which is typically used in fixed networks and also further audio codecs (9 of 13) as well as fax services (all cases) which all together facilitate the migration from TDMvIC to IPvIC. However, the same supplementary services as TDMvIC are only supported in about the half of the cases analysed.
- QoS: The IPvIC has a defined QoS with regard to certain QoS parameters (at least 11 of 13), whereby different QoS parameters are used in different cases.
- Redundancy and network security of the IPvIC: The networks are interconnected with the networks of the IC partners with direct physical IC links (12 of 13) or via (domestic) exchange points (1 case) and not over the public Internet which provides a significant protection against threats from the Internet. In order to increase the availability, redundancy is used at the level of the physical IC link (12 of 13) and at the level of the border gateway (8 of 13). The operators also apply further security measures (at least 12 of 13).

It can be concluded that from an overall perspective the IPvIC are rather similar. However in detail the characteristics may differ reflecting national circumstances.

5 Abbreviations for countries

Abbreviation	Country
AT	Austria
BE	Belgium
BG	Bulgaria
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France

Abbreviation	Country
FYROM	Former Yugoslavian Republic of Macedonia
GR	Greece
HR	Croatia
IE	Ireland
IT	Italy
LI	Liechtenstein
LT	Lithuania
LU	Luxembourg
ME	Montenegro
NL	Netherlands
NO	Norway

Abbreviation	Country
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
SE	Sweden
SI	Slovenia
SK	Slovakia
TR	Turkey
UK	United Kingdom

6 Further abbreviations

3GPP 3rd Generation Partnership Project

3PTY Three Party Call

ACL Access Control List

AF Assured Forwarding

AKNN Working Group for technical and operational Numbering and Network Interconnection Issues

ALG Application Level Gateway

AMR Adaptive Multi Rate

ANO Alternative Network Operator

ARCEP Regulatory Authority for Electronic Communications and Postal Services (France)

ASR Answer Seizure Ratio

BEREC	Body of European Regulators for Electronic Communications
BGP	Border Gateway Protocol
BU-LRIC	Bottom-Up Long Run Incremental Costs
CDIV	Call Diversion
CF	Call Forwarding
CH	Call Hold
CLIP	Calling Line Identification Presentation
CLIR	Calling Line Identification Restriction
COLP	Connected Line Identification Presentation
COLR	Connected Line Identification Restriction
CONF	Conference
CoS	Class of Service
CPS	Carrier Pre-Selection
CRC	Communications Regulation Commission (Bulgaria)
CS	Carrier Selection
CUG	Closed User Group
CW	Call Waiting
DOS	Denial of Service
DTAG	Deutsche Telekom AG
DTMF	Dual Tone Multi Frequency
EBGP	External BGP
EF	Expedited Forwarding
EFR	Enhanced Full Rate
ETSI	European Telecommunications Standards Institute
FFT	French Federation of Telecommunications

FICORA	Finnish Communication Regulatory Authority
FNI	Fixed Network Incumbent
FTR	Fixed Termination Rate
GE	Gigabit Ethernet
GSM	Global System for Mobile Communication
GSMA	Global System for Mobile Communications Association
HAKOM	Croatian Regulatory Authority for Network Industries
HT	Hrvatski Telekom (Croatian Telecom)
IC	Interconnection
IMS	IP Multimedia Subsystem
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPvIC	IP-based interconnection for voice services
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
ITU-T	International Telecommunication Union – Telecommunication Standardisation Sector
LQO	Listening Quality Objective
MNO	Mobile network Operator(s)
MOS	Mean Opinion Score
MWI	Message Wait Indication
NB	Narrow Band
ND	Not defined
NGN	Next Generation Network
NIA	No Information Available

NRA	National Regulatory Authority
OAO	Other Authorised Operators
OFNO	Other Fixed Network Operator(s) (than FNI)
QoS	Quality of Service
PE	Provide Edge
PoI	Point of Interconnection
RFC	Request for Comments
RIO	Reference Interconnection Offer
SBC	Session Border Controller
SDH	Synchronous Digital Hierachy
SLG	Service Level Guarantees
SIP	Session Initiation Protocol
SIP-I	SIP with encapsulated ISUP
SSH	Secure Shell
TDM	Time Division Multiplexing
TDMvIC	TDM-based interconnection for voice services
TLS	Transport Layer Security
VPN	Virtual Private Network

7 Annex

Table 11: Regulatory context – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator has the obligation to offer IPvIC	Yes	Yes, if asked by another operator	Yes	Yes	Yes
According to the regulatory decision	Market 3 decision initially in Dec. 2012, continued in Dec. 2013	Market 3[57] decision in July 2011 and Market 1 (former market 3) decision in December 2014	Markets 2 and 3 decision in Aug. 2013	Markets 2 and 3 decision in Apr. 2010.[58] Decision no. 128/11/CIR	Market 3 decision in Sep. 2014
Operator has the obligation to make IPvIC available from	Jan. 2013	Jan. 2013 for calls towards IP accesses[59] July 2016 for calls towards PSTN access[59]	Aug. 2013	Jan. 2013	Nov. 2014
Operator has to offer IPvIC for which type of operators	Fixed and mobile	Fixed and mobile	Fixed and mobile	Fixed and mobile	Fixed and mobile

Source: BEREC

[57] Under relevant market list of 2007
[58] Next round market analysis to be started soon.
[59] if asked by another operator

Table 12: Regulatory context – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator has the obligation to offer IPvIC	Yes	Yes[60]	Yes	Yes	Yes, if asked by another operator
According to the regulatory decision	Market 3 decision in September 2014	Market 3 decision in Oct. 2013	Market 1 (former market 3) decision in March 2015	Market 3, Decision No 1361 of 31 May 2012	Market 1 (former market 3) decision in December 2014
Operator has the obligation to make IPvIC available from	Obligation to offer RIO for IPvIC and to offer IPvIC on reasonable request.	Oct. 2013.	July 2015	Jan. 2017	1st July 2015, if asked by another operator
Operator has to offer IPvIC for which type of operators	Fixed and mobile	Fixed and mobile	Fixed and mobile	Fixed[61]	Fixed and mobile

Source: BEREC

[60] According to Market 3 decision in Oct. 2013, TeliaSonera is obliged to meet any reasonable request to interconnect on a technology neutral basis, i.e. it includes IPvIC.
[61] IPvIC is not used by MNO because MNO do not demand IPvIC from OFNO.

Table 13: Regulatory context – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Operator has the obligation to offer IPvIC	No (on voluntary basis)	Yes, if asked by another operator		
According to the regulatory decision	Not appl.	Market 2 (former market 7) decision of December 2014		
Operator has the obligation to make IPvIC available from	Not appl.	1st July 2015, if asked by another operator		
Operator has to offer IPvIC for which type of operators	Not appl. (IPvIC is offered for fixed and mobile operators on a voluntary basis)	Fixed and mobile		

Source: BEREC

Table 14: TDMvIC, network migration and use of IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator is obliged to continue to offer TDM-based interconnection for voice services (TDMvIC) at least for a certain time	Yes. No defined deadline	18 months transitional period[62].	Yes. No defined deadline	Yes. Currently no defined deadline	Yes. For at least one year with a six month notice period.
Share of IC traffic handed over based on IPvIC and TDMvIC	< 10% IPvIC, >90% TDMvIC	For Orange, Q4 2014: 30%IPvIC / 70% TDMvIC	No information available	Q1 2015: 15.8% IPvIC / 84.2% TDMvIC	0% IPvIC/100% TDMvIC
Operator has announced to phase out TDMvIC	TDC: expected to be phased out over the years up to 2020	No	Yes, the date envisaged is 31.12.2016	No	No
Operator has migrated its fixed network already to NGN (all-IP network)	Partly	Partly	Partly	Partly (4.4%)	Partly (67%)
Operator has already implemented IPvIC	Yes	Yes	Yes	Yes	Yes
IPvIC is already used by other operators	Yes	Yes	Yes	Yes	No[63]

[62] According to Market 1 and 2 decision of Dec. 2014: IPvIC and TDMvIC should be offered both under regulated conditions during 18 months before the operator may start changing the terms of the TDMvIC offer. In addition, any price increase, commercial shutdown of TDMvIC should be announced with a 12 months' notice; any technical shutdown should be announced with a 24 months' notice

[63] FNI (Telekom Slovenije) has the obligation to make IPvIC available from November 2014. Currently IPvIC is in the testing phase. Probably first operator will use IPvIC soon.

Source: BEREC

Table 15: TDMvIC, network migration and use of IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator is obliged to continue to offer TDM-based interconnection for voice services (TDMvIC) at least for a certain time	Yes. No defined deadline.	Yes. No defined deadline	Yes, for at least until 31 December 2017 with a one year notice period.	Yes. No defined deadline	18 months transitional period[62]
Share of IC traffic handed over based on IPvIC and TDMvIC	0% IPvIC/100% TDMvIC (IPvIC is not available yet)	No information available	No information available	No information available	No information available
Operator has announced to phase out TDMvIC	No	No formal announcement made	Yes, but without formal announcement	No	Bouygues Telecom: 01/01/2017 Others: No
Operator has migrated its fixed network already to NGN (all-IP network)	Partly	Partly	• OFNO: completely • Incumbent: partly (more than 70%[64])	Yes[65]	Yes
Operator has already implemented IPvIC	No[66]	Yes	OFNO Yes, Incumbent not yet	Yes	Yes
IPvIC is already used by other operators	No[67]	Yes	Yes between OFNO	Yes	Yes

Source: BEREC

[64] It will be finished by the end of 2015.
[65] OFNOs have fully migrated their networks to all-IP networks and their voice telephony services are entirely based on IP (mainly SIP) signaling and transport.
[66] No FNI (Telefonica España) does not have implemented IPvIC for national voice interconnections but for international interconnections (Telefonica Group)
[67] Not for national but for international voice interconnections (see footnote 66)

Table 16: TDMvIC, network migration and use of IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Operator is obliged to continue to offer TDM-based interconnection for voice services (TDMvIC) at least for a certain time	Not appl.	18 months transitional period[62].		
Share of IC traffic handed over based on IPvIC and TDMvIC	Rough estimate: 80% IPvIC / 20% TDMvIC	No information available		
Operator has announced to phase out TDMvIC	Only IPvIC (no TDMvIC) is used between mobile network operators[68]	TDMvIC tariff increase from January 2016.	TDMvIC tariff increase from October 2015	Yes[69]
Operator has migrated its fixed network already to NGN (all-IP network)	Not appl.	Not appl.		
Operator has already implemented IPvIC	Yes	Yes		
IPvIC is already used by other operators	Yes (between three MNOs)	Yes		

Source: BEREC

[68] About 20% of the voice traffic which terminates in mobile networks is handed over from fixed networks and abroad and is still based on TDMvIC.
[69] (i) Not possible to ask for new TDMvIC from January 2015 (ii) Not possible to ask for additional TDMvIC capacities from January 2016 (iii) TDMvIC tariff will increase by March 2016 (iv) Closing of TDMvIC by January 2017

Table 17: RIO on which the IPvIC is based on – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator already published a Reference Interconnection Offer (RIO) with IPvIC which is approved by NRA	Yes[70] DBA does not formally approve RIOs[71]	RIO published[72] ARCEP does not formally approve RIOs	No, approval procedure (BK3d-13/033) pending based on Draft RIO of Feb. 2013 with last update of June 2015[73]	Yes	Yes[74]. AKOS does not formally approve RIOs
RIO of the operator includes the following traffic types:					
In the network of the operator:					
• Termination	Yes	Yes	Yes	Yes	Yes
• Origination[75]	No	No[76]	Yes	Yes	No[77]
• Transit	No	No	Yes	Yes	Yes
• Access to services	No	No[78]	Yes	Yes	Yes
• Other	No	No	No	No	International services[79]
In the network of the IC partner:					
• Termination	No	No	Yes (optional)	No	Yes
• Access to services	No	No	Yes (optional)	No	Yes
• Other	No	No	No	No	International services[79]

Source: BEREC

[70] See https://wholesale.tdc.dk/wholesale/produkter/aftaler/Sider/standard.aspx (Termination via SIP)
[71] However. DBA supervises the RIO in order to ensure compliance with the relevant market decision and obligations.
[72] See http://www.orange.com/fr/content/download/22374/467149/version/1/file/ODR+Interco+nouvelle+modalit%C3%A9+IP+-+10+avril+2014.pdf
[73] See http://www.bundesnetzagentur.de/cln_1431/DE/Service-Funktionen/Beschlusskammern/1BK-Geschaeftszeichen-Datenbank/BK3-GZ/2013/2013_0001bis0999/2013_001bis099/BK3-13-033/BK3-13-033_Standardangebotsverfahren.html?nn=350652
[74] See http://www.telekom.si/operaterji/rio-mobilni/RIO%20IP_1_12_2014.pdf
[75] Traffic origination to indirect service providers based on carrier (pre) selection
[76] Call origination traffic from the fixed network is offered by Orange only based on TDMvIC not on IPvIC.
[77] FNI (Telekom Slovenije) does no longer have the obligation to provide carrier selection or carrier pre-selection (available based on TDMvIC on a commercial basis).
[78] Currently available only based on TDMvIC (not on IPvIC).
[79] International traffic e.g. OFNO – FNI (Telekom Slovenije) – foreign operator

Table 18: RIO on which the IPvIC is based on – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator already published a Reference Interconnection Offer (RIO) with IPvIC which is approved by NRA	No. Approval procedure pending based on draft RIO of Dec. 2014	Yes[80] PTS does not formally approve RIOs	Yes HAKOM does not formally approve RIOs[81]	OFNO do not have the obligation to publish a RIO	SFR, Bouygues Telecom[82], Free[83]: Yes Colt: No[84] ARCEP does not formally approve RIOs
RIO of the operator includes the following traffic types:					
In the network of the operator:					
• Termination	Yes	Yes	Yes	Not appl.	Yes
• Origination[75]	No[85]	Yes	Only incumbent	Not appl.	No
• Transit	No	Yes	No	Not appl.	No
• Access to services	No[85]	Yes	Yes	Not appl.	No[86]
• Other	No	No	No	Not appl.	No
In the network of the IC partner:					
• Termination	No[87]	No	Yes	Not appl.	No
• Access to services	No[88]	No	Yes	Not appl.	No
• Other	No	No	No	Not appl.	No

Source: BEREC

[80] See https://www.teliaoperator.se/ProdukterTjanster/Regleradeprodukter/Samtrafik/Dokument.html.
[81] Operators have to incorporate the conditions of HAKOM's decision on IP interconnection conditions in their RIO 15 days after it enters into force. Although HAKOM does not formally approve RIOs HAKOM has the possibility to intervene after RIO is published.
[82] See http://www.corporate.bouyguestelecom.fr/wp-content/uploads/2015/02/OFFRE-DE-REFERENCE-Janvier-20153.pdf
[83] See http://www.iliad.fr/documentation/Free_Interco_Contrat_Cadre_V15-01-01.pdf
[84] No obligation to publish RIO if operator has less than 1,000,000 subscribers (sum of fixed and mobile).
[85] Currently the RIO only includes termination traffic but not origination traffic, because the origination market (Market 2/2007) is not yet approved.
[86] Currently available only based on TDMvIC (not on IPvIC).
[87] The RIO only includes termination services of Telefonica. The same PoI and procedures are used for the termination of voice traffic in the network of the IC partner (even if the IC partner is not obliged to offer a RIO).
[88] The RIO only includes services of Telefonica.

Table 19: RIO on which the IPvIC is based on – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Operator already published a Reference Interconnection Offer (RIO) with IPvIC which is approved by NRA	No	RIO published ARCEP does not formally approve RIOs	RIO published ARCEP does not formally approve RIOs	RIO published ARCEP does not formally approve RIOs
RIO of the operator includes the following traffic types:				
In the network of the operator:				
• Termination	Not appl.	Yes	Yes	Yes
• Origination[75]	Not appl.	No	No	No
• Transit	Not appl.	No	No	No
• Access to services	Not appl.	No	No	No
• Other	Not appl.	No	No	No
In the network of the IC partner:				
• Termination	Not appl.	No	No	No
• Access to services	Not appl.	No	No	No
• Other	Not appl.	No	No	No

Source: BEREC

Table 20: National specifications to which the RIO refers to – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
RIO refers to further national specifications (Yes/No)	No	Yes	Yes	Yes	No
List of national specifications to which the RIO refers to	Not appl.	Specifications by FFT[89]: • FFT Doc 10.001 (5/2014)[90] • FFT Doc 09.002 (July 2009)[91]	Specifications by AKNN[92]: • Concept for Interconnection of NGN[93] • NGN Ic Interface[94] • Examination QoS in NGN[95]	• Agcom decision n. 128/11/CIR[96] (general framework of IP-IC technical specifications). • Specification by the Ministry for Economic Development: Technical specification ST 769[97]	Not appl.

Source: BEREC

[89] French Federation of Telecommunications
[90] http://www.fftelecoms.org/sites/fftelecoms.org/files/contenus_lies/sip_profile_v1.2.1.pdf
[91] http://www.fftelecoms.org/sites/default/files/contenus_lies/architecture_principes_et_recommandations_-_version_anglaise.pdf
[92] Working group for technical and operational numbering and network interconnection issues (see http://www.aknn.de/index.php/1731/0/)
[93] http://www.aknn.de/fileadmin/uploads/oeffentlich/Konzept_Next_Generation_Network_V_2_0_0.pdf
[94] http://www.aknn.de/fileadmin/uploads/oeffentlich/Spec_UAKS_NGN_Ic_Interface_V1_0_0.pdf
[95] Not formally adopted by AKNN but referred to in the RIO
[96] http://www.agcom.it/documentazione/documento?p_p_auth=fLw7zRht&p_p_id=101_INSTANCE_kidx9GUnIodu&p_p_lifecycle=0&p_p_col_id=column-1&p_p_col_count=1&_101_INSTANCE_kidx9GUnIodu_struts_action=%2Fasset_publisher%2Fview_content&_101_INSTANCE_kidx9GUnIodu_assetEntryId=643110&_101_INSTANCE_kidx9GUnIodu_type=document
[97] Main document: http://www.isticom.it/documenti/normazione/pdf/ST%20769%20versione%201.pdf
Part A: http://www.isticom.it/documenti/normazione/pdf/ST%20769%20Parte%20A%20versione%201.pdf
Part B: http://www.isticom.it/documenti/normazione/pdf/ST%20769%20Parte%20B%20versione%201.pdf

Table 21: National specifications to which the RIO refers to – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators/	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
RIO refers to further national specifications (Yes/No)	Yes	No[98]	Yes	Not appl.	No
List of national specifications to which the RIO refers to	Specification by Telefónica (SIP interface definition) which in 2013 was agreed between operators at "Forum for IPvIC" hosted by CNMC[99]	Not appl. RIO refers to the following interconnect specifications by TeliaSonera: • No 8211-A 357[100] • No 8211-A 353[101] • No 8211-A 354[102] • No 8211-A 355[103] • No 8211-A 356[104]	RIO refers to the HAKOM's decision on IP interconnection conditions**Error! Bookmark not defined.**	Not appl. CRC currently develops a decision which lists specifications which have to be met by OFNO (a draft decision is already available[105])	Not appl.

Source: BEREC

[98] RIO does not refer to national specifications. Specifications below are those of TeliaSonera.
[99] At this forum operators also agreed on a specification by ASTEL (group of alternative operators) which specifies SIP-I and to which the RIO of Telefónica does not refer to.
[100] https://www.teliaoperator.se/dms/teliaoperator/Dokument/ReglProdukt/Samtrafik/8211_A357_SIP_rev_3_0.pdf
[101] https://www.teliaoperator.se/dms/teliaoperator/Dokument/ReglProdukt/Samtrafik/8211_A353_SIP_I__rev_4_0.pdf
[102] https://www.teliaoperator.se/dms/teliaoperator/Dokument/ReglProdukt/Samtrafik/8211_A354_Media_rev_3_0.pdf
[103] https://www.teliaoperator.se/dms/teliaoperator/Dokument/ReglProdukt/Samtrafik/8211_A355__IP_network_rev_3_0.pdf
[104] https://www.teliaoperator.se/dms/teliaoperator/Dokument/ReglProdukt/Samtrafik/8211_A356_Address_formats_for_Swedish_national_SIP_and_SIP_I_ver_1__0.pdf
[105] http://www.crc.bg/files/_bg/resh_798-18_12_2014-IP_interconnect-prilojenie.pdf

Table 22: National specifications to which the RIO refers to – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
RIO refers to further national specifications (Yes/No)	Not appl.	Yes	No	No
List of national specifications to which the RIO refers to	Not appl. However, interconnection profiles are agreed by the operators and described in Ficora's recommendations[106, 107] These profiles should be complied with by operators that use IPvIC.	Refers to the SIP-I specifications by FFT. The latest is FFT Doc 11.001 v1.2 (5/2014)[108]	Not appl.	Not appl.

Source: BEREC

[106] https://www.viestintavirasto.fi/attachments/suositukset/Suositus_201-2014_S_-_Finnish_profile_for_SIP-I_interworking.pdf
[107] https://www.viestintavirasto.fi/attachments/suositukset/Suositus_202-2014_S_-_Finnish_profile_for_SIP_interworking.pdf
[108] http://www.fftelecoms.org/sites/fftelecoms.org/files/contenus_lies/fft_interco_ip_-_sip-i_profile_v1_2_.pdf

Table 23: Technical aspects defined in the national specification(s) – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
The following major technical aspects are further specified in the national specification(s):					
• IC architecture	Not appl.	Yes	Yes	Yes	Not appl.
• Signalling protocol (at PoI)	Not appl.	Yes	Yes	Yes	Not appl.
• Number ranges supported	Not appl.	No	No	Yes	Not appl.
• Supplementary services supported	Not appl.	Yes	Yes	Yes	Not appl.
• Codecs supported	Not appl.	Yes	Yes	Yes	Not appl.
• QoS	Not appl.	Yes, but no QoS objectives	Yes	Yes	Not appl.
• Physical interface	Not appl.	Yes	No	Yes	Not appl.
• Redundancy	Not appl.	Yes	No	Yes	Not appl.
• Security	Not appl.	Yes (high level principles)	No	Yes	Not appl.
• Other major technical aspects (which?)	Not appl.	No	Yes, emergency calls	Yes, emergency calls	Not appl.

Source: BEREC

Table 24: Technical aspects defined in the national specification(s) – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators)	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
The following major technical aspects are further specified in the national specification(s):				Below information is provided for the draft decision of CRC (see Table 21)	Alternatives comply to national specifications on a voluntary basis[109]
• IC architecture	Yes	Not appl.	FNI: Yes, OFNO: No (specified in RIO)	No	Yes
• Signalling protocol (at PoI)	Yes[110]	Not appl.	Yes	Yes	Yes
• Number ranges supported	Yes	Not appl.	Yes	No	No
• Supplementary services supported	Yes	Not appl.	Yes	Yes	Yes
• Codecs supported	Yes	Not appl.	Yes	Yes	Yes
• QoS	Yes, but no QoS objectives	Not appl.	Yes, but no QoS objectives	Yes	Yes, but no QoS objectives
• Physical interface	No	Not appl.	Yes	Yes	Yes
• Redundancy	No	Not appl.	Yes	Yes	Yes
• Security	Yes (high level principles)	Not appl.	Yes	Yes	Yes (high level principles)
• Other major technical aspects (which?)	Yes, number portability information	Not appl.	Yes, emergency call, number portability	No	No

Source: BEREC

[109] Alternatives (SFR, Bouygues Telecom, Colt) participated in the FFT task force which developed FFT national specifications (see Table 27).
[110] Both SIP and SIP-I are defined in national specifications (see Table 21). However, the RIO of Telefónica's only proposes SIP.

Table 25: Technical aspects defined in the national specification(s) – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
The following major technical aspects are further specified in the national specification(s):			SFR and Bouygues Telecom comply to national specifications on a voluntary basis[111]	
• IC architecture	No	Yes	Yes	
• Signalling protocol (at PoI)	Yes	Yes	Yes	
• Number ranges supported	Yes	Yes	Yes	
• Supplementary services supported	Yes	Yes	Yes	
• Codecs supported	Yes	Yes	Yes	
• QoS	No	Yes, but no QoS objectives	Yes, but no QoS objectives	
• Physical interface	No	Yes	Yes	
• Redundancy	Yes	Yes	Yes	
• Security	No	Yes	Yes	
• Other major technical aspects (which?)	No	No	No	

Source: BEREC

[111] They participated in the FFT task force which developed FFT national specifications (see Table 28).

Table 26: Process by which the national specification(s) was (were) defined – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Short description of the process how the further national specification(s) was(were) defined	Not appl.	National dialogue between major operators, in compliance with international standards.	AKNN, an industry body of network operators has produced specifications, which were used in drafting the reference offer.	See footnote 112	Not appl.
Operators and other stakeholders which were involved	Not appl.	Task force composed of: FFT board, Orange, SFR, Bouygues Telecom, Colt	AKNN membership, i.e. German operators and manufacturers.[113]	Telecom Italia, OAO, AGCOM	Not appl.
Was it possible to achieve consensus between all stake-holders involved? (Yes/No)	Not appl.	Yes[114]	Yes	Yes	Not appl.
If consensus was achieved, how was it possible, by which process?	Not appl.	Standardization task force within FFT, which gathers all involved operators worked on a common standard.	Within the AKNN specifications have to be approved unanimously by network operators. Consensus between all stakeholders is achieved by discussions within the working groups of AKNN.	See footnote 115	Not appl.
If consensus was not achieved, reasons why NRA accepted the reference to the national specification(s) in the RIO	Not appl.	Not appl.	Not appl. (approval process is still ongoing)	Not appl.	Not appl.

Source: BEREC

[112] Following the publication of AGCOM resolution n. 128/11/CIR (December 2011) the Interconnection Commission of the Ministry for Economic Development (MiSE) has started the drafting, discussion and convergence processes among operators of the technical specification of IP interconnection. A process of revision of the technical specification of IP interconnection will be carried out after the migration to IP of main OAO.

[113] A membership list is available at http://www.aknn.de/index.php/615/0/

[114] However, Free chose to not take part in the discussions of the FFT task force and then, as regard to fixed interconnection, complied with the recommendations issued by the task force.

[115] Consensus has been reached thanks to AGCOM intervention who held a technical committee with OAO and Telecom Italia to discuss and solve several open issues that arose during the definition process of technical specification by the Ministry for Economic Development.

Table 27: Process by which the national specification(s) was (were) defined – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Short description of the process how the further national specification(s) was(were) defined	CNMC (former CMT) started a forum with all operators, for the definition of technical specifications for IPvIC in May 2012. As a result, two signalling protocol specifications were approved in 2013: SIP and SIP-I	Not appl.	End of 2014 HAKOM started a forum with all operators, for the definition of technical specifications for IPvIC in compliance with international standards.	An advisory body consisting of representatives of CRC and interested fixed network operators was established. This advisory body adopted a common position on which the draft CRC decision is based on.	National dialogue between major operators, in compliance with international standards.
Operators and other stakeholders which were involved	All relevant fixed network operators and mobile operators were involved.	Not appl.	All relevant fixed network operators and mobile operators were involved.	BTC (incumbent) and other fixed network operators[116]	Task force composed of: FFT board, Orange, SFR, Bouygues Telecom, Colt
Was it possible to achieve consensus between all stakeholders involved? (Yes/No)	Yes, although two specifications (SIP and SIP-I) were approved because there was no consensus about the mandatory protocol to be used. (Telefonica's RIO only proposes SIP)	Not appl.	Consensus was achieved between all operators involved in the standardization process	Yes, partially on some issues	Consensus was achieved between all operators involved in the standardization process engaged at the FFT task force.[114]
If consensus was achieved, how was it possible, by which process?	By the collaboration of CNMC (former CMT) in the process, throughout meetings with stakeholders. The process lasted one year.	Not appl.	By the collaboration of HAKOM in the process, throughout meetings with stakeholders.	With discussions and mediation of CRC the advisory body aimed to achieve the maximum consensus between the stakeholders possible.	Standardization task force within FFT, which gathers all involved operators worked on a common standard.
If consensus was not achieved, reasons why NRA accepted the reference to the national specification(s) in the RIO	Not appl.	Not appl.	Not appl.	Not appl.	Not appl.

Source: BEREC

[116] ITD, Blizoo, Varna Net, Mobiltel, Telenor, GCN, Goldtelecom, Vestitel, NetIsSat, Netfinity, Telecom1, ETC, Interroute, Nexcom

Table 28: Process by which the national specification(s) was (were) defined – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Short description of the process how the further national specification(s) was(were) defined	Ficora's recommendation was drafted in a working group consisted of network operators and NRA (& national hearing).	National dialogue between major operators, in compliance with international standards.		
Operators and other stakeholders which were involved	Network operators (mobile, fixed, VoIP, company operating the number portability infrastructure (Numpac Ltd))	Task force composed of: FFT board, Orange, SFR, Bouygues Telecom, Colt		
Was it possible to achieve consensus between all stake-holders involved? (Yes/No)	Yes	Consensus was achieved between all operators involved in the standardization process engaged at the FFT task force.[114]		
If consensus was achieved, how was it possible, by which process?	Specification was defined based on practical implementation experience.	Standardization task force within FFT, which gathers all involved operators worked on a common standard.		
If consensus was not achieved, reasons why NRA accepted the reference to the national specification(s) in the RIO	Not appl.	Not appl.		

Source: BEREC

Table 29: Number of PoIs of the IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Total number of points of interconnection (PoIs) for IPvIC nationwide	6 PoIs (each available for IPvIC and TDMvIC) No/3 areas (no areas for VoIP end users, 3 areas for TDM end users with 2 PoIs in each area)	10 PoIs[117]	22 PoIs on 12 locations No areas	32 PoIs 16 Gateway areas 2 PoIs per gateway area	2 PoIs
Minimum number of PoIs mandated by RIO (to allow for redundancy and local rates)	1/6 (for VoIP end users: 1 or 2 in case of redundancy, for TDM end users: 6, optional with redundancy)	2[118]	2 on 2 different locatons for redundancy, 1 for small local operators, 1 for local rates[119]	32[18]	1 PoI
The minimum number of PoIs mandated by RIO has been imposed by NRA? (Yes/No)	Yes	No	Yes	No	No
If imposed by NRA, reasons for demanding this minimum number of PoIs (and not more/less)	To support flexibility. For VoIP end users alternative operators can choose to interconnect at only one PoI (of any of the 6 PoIs), for redundancy reason also at more PoIs	Not appl.	For small operators 1 PoI is sufficient and 2 PoIs seem not to be proportionate	Not appl.	Not appl.
Total number of points of interconnection (PoIs) for previous TDMvIC nationwide	6 (the same 6 PoIs that are available for IPvIC)	360	474	660	44 PoIs (2 IX, 11 SX and 31 PX)[120]

Source: BEREC

[117] 5 PoP locations each with 2 PoIs
[118] According to national specifications of FFT the PoI has to be redundant. Therefore, the minimum number of PoI is two. The operators can handover traffic for all destinations in France at each of the two PoIs and have to pay (only) the regulated local rates (no unregulated transit charges).
[119] ANOs have to select two out of 22 PoIs (not less and not more). Two PoIs are needed for redundancy, not for local rates. Small local operators may interconnect at just 1 PoI. Any traffic can be handed over at any PoI for the same price.
[120] IX - International Exchange, SX - Secondary Exchange, PX - Primary Exchange

Table 30: Number of PoIs of the IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Total number of points of interconnection (PoIs) for IPvIC nationwide	19 areas / 19 PoI Each PoI with redundancy	4 PoIs 2 areas 2 PoIs per area	FNI: 4 PoIs OFNO: not defined yet	Currently OFNO use generally 1 PoI	No information available
Minimum number of PoIs mandated by RIO (to allow for redundancy and local rates)	19 PoIs (each PoI with redundancy)	4[18]	FNI: 2[121] OFNO: not defined yet	Not appl.[122]	2[118]
The minimum number of PoIs mandated by RIO has been imposed by NRA? (Yes/No)	No	No	Yes	Not appl.	No
If imposed by NRA, reasons for demanding this minimum number of PoIs (and not more/less)	Not appl.	Not appl.	For redundancy reason[123]	Not appl.	Not appl.
Total number of points of interconnection (PoIs) for previous TDMvIC nationwide	21, corresponding to the 21 geographical transit areas of Telefonica, since last market 3 analysis (586 local exchanges in the past).[124]	26 PoIs 13 areas 2 PoIs per area	2 international, 9 regional and 26 local exchanges	Not appl.[125]	No information available

Source: BEREC

[121] In transition period as long as operator has TDMvIC with incumbent 1 PoI is enough.
[122] OFNO do not have the obligation to publish a RIO (see Table 18) and to offer at least a certain number of PoIs.
[123] Number of PoIs was proposed by incumbent. During the negotiation process HAKOM only insisted on redundancy which is ensured by 2 PoI.
[124] In the last market 3 decision (September 2014) it was decided to impose to incumbent Telefonica the BU-LRIC FTR with a minimum number of 21 PoI (no longer different levels of interconnection, no longer the obligation to interconnect to 586 exchanges as before)
[125] From the very beginning the OFNO use IPvIC based on H.323 or SIP

Table 31: Number of PoIs of the IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Total number of points of interconnection (PoIs) for IPvIC nationwide	3 PoIs	4	NIA	3
Minimum number of PoIs mandated by RIO (to allow for redundancy and local rates)	2[126]	2[118]		
The minimum number of PoIs mandated by RIO has been imposed by NRA? (Yes/No)	Not appl.	No		
If imposed by NRA, reasons for demanding this minimum number of PoIs (and not more/less)	Not appl.	Not appl.		
Total number of points of interconnection (PoIs) for previous TDMvIC nationwide	2 PoIs for each MNO	6	6	3

Source: BEREC

[126] Two PoIs is the minimum based on Ficora's regulation on redundancy (not Ficora's recommendation mentioned in Table 22).

Table 32: Signalling protocol(s) supported by the IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator has the obligation to use a certain signalling protocol (Yes(which?)/No)	No	No	No	Yes (section 5 of ST 769): • SIP (IETF) • SIP-I (ITU-T)	No
Signalling protocol(s) used by the operator at the PoI of the IPvIC	SIP (IETF)	SIP (IETF) including specifications of 3GPP (IMS)	SIP (IETF) including specifications of 3GPP (IMS)	• SIP (IETF) including specifications of 3GPP (IMS) • SIP-I (ITU-T)	• SIP (IETF)[127] • SIP-I (ITU-T)
Signalling protocol(s) is(are) specified by reference to the following international standards	• SIP: RFC 3261, RFC 3262, RFC 3325, RFC 2327 (SDP) • Interworking ISUP-SIP: RFC 3398, RFC 3578 • Fax: T.38	• List of 16 RFC e.g. RFC 3261, RFC 3262, RFC 3264, RFC 3311, RFC 3312, RFC 4566 • 3GPP TS 24.628, 3GPP TS 24.229	• ETSI TS 124 503 V8.3.0 (2009-01)	SIP: • List of RFCs e.g. RFC 3261, RFC 2327, RFC 2833, RFC 3262, RFC 3264 RFC 3311 etc • ETSI TS 129 165 V8.4.0 SIP-I: • ITU-T Q.1912.5 Profil C	• SIP: RFC 3261, mapping SIP/ISUP: ITU-T Q.1912.5, Profile B, Q.850 release code • SIP-I: ITU-T Q.1912.5, Profile C

Source: BEREC

[127] For mapping SIP/ISUP ITU-T Q.1912.5 Profile B is used

Table 33: Signalling protocol(s) supported by the IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Operator has the obligation to use a certain signalling protocol (Yes(which?)/No)	No	No	SIP (IETF) (optional for mobile networks SIP-I)[128]	SIP (IETF) or SIP-I (ITU-T)	No
Signalling protocol(s) used by the operator at the PoI of the IPvIC	• SIP (IETF) including specifications of 3GPP (IMS)	• SIP (IETF) • SIP-I (ITU-T)	SIP (IETF) including specifications of 3GPP (IMS)	• SIP (IETF)	SIP (IETF) including specifications of 3GPP (IMS)
Signalling protocol(s) is(are) specified by reference to the following international standards	• List of RFC, e.g. RFC 3261, RFC 3262, RFC 3264, RFC 3311, RFC 4566 etc • 3GPP TS 24.528, 29.165	SIP:[129] • List of RFCs related to SIP and SDP SIP-I:[130] • ITU-T Q.1912.5 Profil C • List of RFCs related to SIP and SDP	• List of 17 RFC, e.g. RFC 3261, RFC 3262, RFC 3264, RFC 3311, RFC 3312, RFC 3323, RFC 3325, RFC 3326, RFC 3407, RFC3556 • 3GPP TS 24.628, 3GPP TS 24.229 • Fax: T.38	• SIP RFC 3261 • ITU-T Q.1912.5 Profile C	• List of 16 RFC e.g. RFC 3261, RFC 3262, RFC 3264, RFC 3311, RFC 3312, RFC 3323, RFC 3325, RFC 3326, RFC 3407, RFC3506, RFC 3966, RFC 4028, RFC 4566, RFC 5009, RFC 5806 • 3GPP TS 24.628, 3GPP TS 24.229

Source: BEREC

[128] The IPvIC between fixed network operators is only allowed to be based on SIP. However, if MNO demand an IPvIC based on SIP-I this is also allowed.
[129] See TeliaSonera Interconnect Specification No 8211-A353 (section 4)
[130] See TeliaSonera Interconnect Specification No 8211-A357 (section 4)

Table 34: Signalling protocol(s) supported by the IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Operator has the obligation to use a certain signalling protocol (Yes(which?)/No)	No	No		
Signalling protocol(s) used by the operator at the PoI of the IPvIC	SIP-I (national)	SIP-I[131]		
Signalling protocol(s) is(are) specified by reference to the following international standards	• SIP-I: ITU-T Q.1912.5; & national ISUP3 (SFS5869) • GSMA & 3GPP specifications	- List of 18 IETF RFC (2046, 2976, 3204, 3261, 3262, 3264, 3311, 3312, 3323, 3325, 3326, 3407, 3556, 3966, 4028, 4040, 4566, 4733) - List of 4 3GPP TS (24.528, 29.231, 26.071, 26.171) - List of 5 ITU-T recommendations (Q.1912.5, G.711, G.729, G.729 Annex A, G.722)		

Source: BEREC

[131] The target protocol is SIP but not implemented yet for mobile networks.

Table 35: Number ranges and supplementary services supported by the IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
List of number ranges supported by IPvIC	Same as for TDMvIC	All interpersonal numbers ((non-) geographical numbers, mobile numbers, international numbers)	All number ranges	SIP, SIP-I: a, b, c, d, e, f, g, h (ECS nomadic numbers, +55)[132]	SIP, SIP-I: All number ranges
Number ranges supported by previous TDM-based interconnection but no longer by IPvIC	None	Not yet: service numbers and short codes[133]	None	None	SIP, SIP-I: None
List of supported supplementary services	CLIP, CLIR, Call forwarding	CLIP, CLIR, Call forwarding, Call Hold[134]	OIP, OIR (optional e.g. CDIV, HOLD, CONF, CUG)	SIP, SIP-I: • CLIP/CLIR, MCID, CFB/CFNR/CFU, CH, CW, 3PTY SIP-I only: • COLP, COLR, CD, UUS (type 1)	SIP, SIP-I: CLIP and CLIR (other services are subject to agreement)
Supplementary services supported by previous TDM-based interconnection but no longer by IPvIC	The main supplementary services are the same	DTMF	CDIV, HOLD, CONF, CUG are optional in IPvIC	CCBS, Sub Addressing	SIP, SIP-I: None

Source: BEREC

[132] (a) geographical numbers, (b) service numbers (e.g. free phone numbers, premium rate numbers), (c) emergency numbers, (d) harmonized European short codes (116xxx), (e) public national short codes, (f) location independent corporate numbers, (g) mobile numbers, (h) international numbers

[133] Currently FFT works on that.

[134] According to FFT Doc 10.001 (May 2014), sections 1.1 and 13

Table 36: Number ranges and supplementary services supported by the IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	All fixed operators Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
List of number ranges supported by IPvIC	Geographical numbers and nomadic numbers (RIO only covers termination services).[135]	a, b, c, d, e, f, g, h, i – M2M[136]	All number ranges	All number ranges assigned to OFNO	All interpersonal numbers ((non-) geographical numbers, mobile numbers, international numbers)
Number ranges supported by previous TDM-based interconnection but no longer by IPvIC	None	None	None	Not appl.[125]	Not yet: service numbers and short codes[133]
List of supported supplementary services	CLIP, CLIR, COLP, COLR, Call Forwarding, Call Hold, Call Waiting, Call Transfer, 3PTY	SIP, SIP-I:[137] • CLIP, CLIR, DDI, HOLD, Call Forwarding (CFNR, CFB, CFU) SIP-I only:[138] • COLP. COLR, MCID, SUB, CD, CW, ECT, CCBS, CCNR, CONF, 3PTY, CUG, UUS, MWI	CLIP, CLIR, CNIP, CNIR, CONP, COLP, CLIPRO, Call Hold, Call Waiting, Call Forwarding, Call Transfer, ACR, 3-way conference	CLIP, CLIR, Call forwarding, DTMF	CLIP, CLIR, Call forwarding, Call Hold[139]
Supplementary services supported by previous TDM-based interconnection but no longer by IPvIC	Sub Addressing, User to User signaling[140]	Not specified in RIO	None	Not appl.[125]	DTMF

Source: BEREC

[135] However, other number ranges are expected to be included in the future, when on the market for call origination also the obligation to offer IPvIC will be imposed. The national specification includes any type of number ranges.
[136] (a) geographical numbers, (b) service numbers (e.g. free phone numbers, premium rate numbers), (c) emergency numbers, (d) harmonized European short codes (116xxx), (e) public national short codes, (f) location independent corporate numbers, (g) mobile numbers, (h) international numbers, (i) other numbers
[137] See TeliaSonera Interconnect Specification No 8211-A357 (section 4.1) and No 8211-A353 (section 4.1)
[138] See TeliaSonera Interconnect Specification No 8211-A353 (section 4.1)
[139] According to FFT Doc 10.001 (May 2014), sections 1.1 and 13
[140] All supplementary services not mandatory can be used on bilateral agreement.

Table 37: Number ranges and supplementary services supported by the IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
List of number ranges supported by IPvIC	All number ranges	All number ranges	At least mobile numbers	At least mobile numbers
Number ranges supported by previous TDM-based interconnection but no longer by IPvIC	None	All number ranges supported by TDMvIC are supported by SIP-I		
List of supported supplementary services	Basically all supplementary services that are used in TDMvIC are also implemented in IPvIC (national GFI9803)	The specifications following supplementary services: - Calling Line Identification Presentation (CLIP), - Calling Line Identification Restriction (CLIR), - Call Forwarding, - Call Hold, - Call Waiting, - User to user information, - Terminal portability		
Supplementary services supported by previous TDM-based interconnection but no longer by IPvIC	Not appl.	No information is available		

Source: BEREC

Table 38: Codecs supported by the IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
List of audio codecs supported by IPvIC	• G.711A-law • G.729a	G.711 A-law (default)[141] Otherwise AMR set 7 or G.729	G.711 A-law[142]	SIP, SIP-I: • G.711 A-law • G.729 (no Annex B) • RFC 2833 (DTMF)[143]	SIP, SIP-I: • G.711 A-law (recommended) • RFC 2833 (DTMF)
Fax services are supported by IPvIC? (Yes/No)	Yes	Yes[144]	Yes	Yes	SIP, SIP-I: Yes
List of fax codecs supported by IPvIC	• T.38 • G.711 A-law	• G.711 A-law • T.38 if bilaterally agreed • V.152 optional[145]	• G.711 A-law • AKNN recommended T.38	• G.711 A-law (media type “audio”) • T.38 (media type “image”)[143]	SIP, SIP-I: • G.711 • T.38

Source: BEREC

[141] According to FFT Doc. 09.002 (July 2009), section 4.2.2
[142] Other codecs may be negotiated without guarantee
[143] See Draft RIO of Oct. 2012, section 7, p. 19
[144] But fax traffic is not included in QoS commitments
[145] According to FFT Doc 10.001 (May 2014), section 11

Table 39: Codecs supported by the IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
List of audio codecs supported by IPvIC	• G.711 A-law (10 and 20 msec packet) • G.729 (20 and 30 msec packet) • RFC 4733 (DTMF)	SIP, SIP-I: G.711 A-law	• G.711 A-law (20 ms) • ITU-T G.729a (20ms) • ITU-T G.722 (Wide Band) • RFC 4733 (DTMF)	G.711 A-law	G.711A-law (default)[146] Otherwise AMR set 7 or G.729
Fax services are supported by IPvIC? (Yes/No)	Yes	SIP, SIP-I: Yes	Yes	Yes	Yes[147]
List of fax codecs supported by IPvIC	• T.38 (media type "image") • G.711, pass-through optionally.	SIP, SIP-I: G.711 A-law	• G.711 • T.38	• G.711 A-law • Required: T.38	• G.711 A-law (default) • T.38 if bilaterally agreed • V.152 optional[148]

Source: BEREC

[146] According to FFT Doc. 09.002 (July 2009), section 4.2.2
[147] But no commitment of interoperability because it depends on the costumers equipement.
[148] According to FFT Doc 10.001 (May 2014), section 11

Table 40: Codecs supported by the IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
List of audio codecs supported by IPvIC	• G.711 A-law • G.729 • NB-AMR • GSM EFR	G.711A-law (default)		
Fax services are supported by IPvIC? (Yes/No)	Yes	Yes, but there is no guaranty of end to end interoperability		
List of fax codecs supported by IPvIC	T.38	• G.711 A-law • T.38 if bilaterally agreed • V.152 optional		

Source: BEREC

Table 41: QoS of the IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Speech quality (objective/not defined)	Not specified in RIO	Defined indicator but no objective.	• Requirements of G.101 / ETSI EG 202 086 have to be fulfilled • MOS (LQO) >4.0 (end-to-end) • Delay < 150 ms (end-to-end)(G.114)	The codecs to be used are: G.711, G.729 In any case the speech quality has to be comparable with TDMvIC	• G.711[149] • G.114 • G.107[150] • G.168[151]
Call set-up time (objective/not defined)	Not specified in RIO	Not specified in RIO	Max. 3 s	Comparable with TDMvIC	Not specified in RIO
Network Effectiveness Ratio (NER) (objective/not defined)	Not specified in RIO	Not specified in RIO	Within network of DTAG and within network of IC partner: >= 99.5%	Comparable with TDMvIC	Not specified in RIO
Probability of a dropped connection (objective/not defined)	Not specified in RIO	Not specified in RIO	<0.01%	Comparable with TDMvIC	Not specified in RIO
Availability of the IC link per PoI (objective/not defined)	Not specified in RIO	Not specified in RIO	• >= 99.5% (per IC partner and excluding the leased line bet-ween the networks) • Availability of leased line between the networks >= 98.5%	Comparable with TDMvIC	Not specified in RIO
Other QoS parameters (parameter and objective)	CoS of IP transport: - Media: Expedited Forwarding (EF) - Signalling: Assured Forwarding, burstable (AFb)	Not specified in RIO	Not specified in the draft RIO	Comparable with TDMvIC	CoS of IP transport: - Media: Expedited Forwarding (EF) - Signalling: Assured Forwarding (AF31)

Source: BEREC

[149] Packetization time 20 ms, jitter-buffer >= 10 ms
[150] Minimum voice quality – delay <= 300 ms
[151] Echo cancellation: echo return loss > 30 dB, tail length > 128 ms. However, FNI (Telekom Slovenije) does not require this method and values can be agreed upon with operator.

Table 42: QoS of the IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Speech quality (objective/not defined)	Not defined.	Not specified in RIO	Comparable with TDMvIC	Required:[152] • R-factor>70 (G.107,G.109) • One way Delay < 150 ms (G.114)	Defined indicator but no objective.
Call set-up time (objective/not defined)	Not defined	Not specified in RIO	Comparable with TDMvIC	Not defined in CRC's draft decision[153]	Not specified in RIO
Network Effectiveness Ratio (NER) (objective/not defined)	Not defined	Not specified in RIO	Comparable with TDMvIC	Required:[152] NER>95% (E.425)	Bouygues Telecom: NER>99,3%
Probability of a dropped connection (objective/not defined)	Not defined	Not specified in RIO	Comparable with TDMvIC	Not defined in CRC's draft decision[153]	Not specified in RIO
Availability of the IC link per PoI (objective/not defined)	>= 99.77%	Not specified in RIO	Comparable with TDMvIC	Not defined in CRC's draft decision[153]	Not specified in RIO
Other QoS parameters (parameter and objective)	IC GbE link QoS: IPLR < 10^{-7}, IPTD < 3 ms, IPDV < 20 µs E2E QoS: IPLR < 1%, IPTD < 150 ms, IPDV < 100 ms In IP network, TOS/DiffServ values defined for voice ("5/EF") and signalling ("3/AF31")	Guidelines for each IP network: • IPLR < 0.02%. • IPTD < 50ms (one-way delay). • IPDV < 4ms	Comparable with TDMvIC	Required:[152] • ASR>50% (E.425) • Packet delay variation< 50ms • IPLR<0.1%	Bouygues Telecom: Answer Seizure Ratio of at least 65% for calls to the operator's clients, 55% for calls to roamers (computed for a 3 months period)

Source: BEREC

[152] By CRC's draft decision (see Table 21)
[153] See Table 21

Table 43: QoS of the IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Speech quality (objective/not defined)	Not specified in Ficora's recommendation.	Defined indicator but no objective.		
Call set-up time (objective/not defined)	Not specified in Ficora's recommendation	Not specified in RIO		
Network Effectiveness Ratio (NER) (objective/not defined)	Not specified in Ficora's recommendation	Not specified in RIO	Not specified in RIO	NER>99,3%
Probability of a dropped connection (objective/not defined)	Not specified in Ficora's recommendation	Not specified in RIO		
Availability of the IC link per PoI (objective/not defined)	Not specified in Ficora's recommendation	Not specified in RIO		
Other QoS parameters (parameter and objective)	Not specified in Ficora's recommendation	Not specified in RIO	Not specified in RIO	Answer Seizure Ratio of at least 65% for calls to the operator's clients, 55% for calls to roamers (computed for a 3 months period)

Source: BEREC

Table 44: Physical IC link and redundancy of the IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Networks are connected with each other with (direct IC link and/or via other networks)	Direct IC link	Direct IC link between major operators [154]	Direct IC link (used IP addresses are not publicly routed)	Direct IC link	Direct IC link
IC link of the IPvIC is used for (voice services only / also for additional services (e.g. Internet access))	Voice only	For voice services only. Separate PoI for Internet traffic.	Voice services only	Voice service only	Can be used also for additional services if supported by equipment
Physical transport interface and bandwidth options at the PoI	Typically 1 GE	Minimal 1 GE	• SDH: 155 Mbps, • 1 GE: 150/300/600/ 1,000 Mbps, • 10 GE: 2 to 10 Gbps in steps of 1 Gbps	SDH: 155 Mbps, 1 GE: 1,000 Mbps	1 GE (or other supported by both parties)
Redundancy of the physical connection at the network level (Yes/No)	Yes (option, not an obligation)[155]	Yes, minimum 1 IC link, redundant, each with different equipment	Yes, 2 IC links, each IC link can carry total voice IC traffic	Yes, 2 IC links, each IC link can carry 70% of voice IC traffic (peak traffic)	Yes (option)
Redundancy at the level of the border gateway (e.g. SBC) (Yes/No)	Not specified in RIO	Yes, N+1 model (N nominal SBCs / 1 back-up SBC) or load sharing between I-SBC equipment[156]	Yes, 2 or more SBCs, if 1 SBC is no longer available the other SBC(s) can take over the traffic of this SBC	No	Yes, georedundant SBC based on load sharing principle

Source: BEREC

[154] Major operators typically connect their networks based on a direct link. Small operators connect their networks indirectly by transit through the network of a major operator.
[155] The degree of redundancy (e.g. 100% or only 50%) is an option for the OFNO to decide.
[156] See FFT Doc 09.002 (July 2009), p. 8, section 4.2.4.3

Table 45: Physical IC link and redundancy of the IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	HT (incumbent)/Other fixed network operators	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Networks are connected with each other with (direct IC link and/or via other networks)	Direct IC link	Direct link	Direct IC link	Direct link	Direct IC link between major operators[154]
IC link of the IPvIC is used for (voice services only / also for additional services (e.g. Internet access))	Voice and fax[157]	Not specified in RIO	For voice and fax services only. Separate PoI for Internet traffic.	Voice and fax	For voice services only. Separate PoI for Internet traffic.
Physical transport interface and bandwidth options at the PoI	1 GE[158]	1 GE, 10 GE	Minimal 1 GE	Required:[152] Ethernet interface and minimum bandwidth of 10 Mbps	Minimal 1 GE
Redundancy of the physical connection at the network level (Yes/No)	Yes. 2 IC links with different equipments. Each IC link should be able to carry the total voice IC traffic.	Geographical redundant links are preferred (option)	Geographical redundant links are mandatory for incumbent, for OFNO not defined yet	Yes	Yes, minimum 1 IC link, redundant, each with different equipment
Redundancy at the level of the border gateway (e.g. SBC) (Yes/No)	Yes. For each serving area, 2 SBC share the traffic.	Yes, “High availability SBC”	Yes, load sharing between I-SBC equipment is available	No information available	Yes, N+1 model (N nominal SBCs / 1 back-up SBC) or load sharing between I-SBC equipment[159]

Source: BEREC

[157] However, existing PoIs of TDMvIC or ULL can also be used for IPvIC based on a dedicated fibre for IPvIC.
[158] Proposed in draft RIO of Telefonica but ANOs request also 10 GE
[159] See FFT Doc 09.002 (July 2009), p. 8, section 4.2.4.3

Table 46: Physical IC link and redundancy of the IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Networks are connected with each other with (direct IC link and/or via other networks)	Via interconnection exchange points	Direct IC link between major operators		
IC link of the IPvIC is used for (voice services only / also for additional services (e.g. Internet access))	Voice only	For voice services only. Separate PoI for Internet traffic.		
Physical transport interface and bandwidth options at the PoI	1 GE, 10 GE (coming) Bandwidth options: 10 Mbps, 100 Mbps, 1Gbps[160]	1 or 10 Gigabits/s	Not specified in RIO[161]	1 or 10 Gigabits/s
Redundancy of the physical connection at the network level (Yes/No)	Geographical redundant links to two different interconnection exchange points (1 IC link to each)	Yes, minimum 1 IC link, redundant, each with different equipment		
Redundancy at the level of the border gateway (e.g. SBC) (Yes/No)	Not specified in Ficora's recommendation	Not specified in RIO[162]	Not specified in RIO[162]	At least 2 I-SBC

Source: BEREC

[160] Physical interface is specified by the company (Numpac) that runs the interconnection points.
[161] The physical transport interface complies with the standards of FFT.
[162] Redundancy at the level of the border gateway complies with standards of FFT.

Table 47: Network security of the IPvIC – part 1

Characteristic	Denmark	France	Germany	Italy	Slovenia
Operator which offers IPvIC	TDC (incumbent)	Orange (incumbent)	DTAG (incumbent)	Telecom Italia (incumbent)	Telekom Slovenije (incumbent)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Security measures to protect the network	• In TDCs MPLS network closed VPN connections are used • SBC protection: IP addresses of SBCs are not advertised to the public Internet and only exchanged between TDC and IC partner	Each operator is responsible for securing the traffic from its side. FFT recommends the following:[163] • Possibility to block ports based on a list of authorized addresses, ports and protocols • Use of public IPv4 addresses within each interconnection without announce-ment on the Internet • Make flow IP-tight (e.g. VPN) • Different SBCs secure signalling and media (e.g. distributed SBC) • At the router level: access control to a list of well-defined source addresses	• Detailed rules on security of collocation rooms • Some general obligations to cooperate in security issues, to not use PoIs for types of traffic not covered by the agreement etc.	• Border gateway functionality with firewall • Use of public IP addresses • Geographical redundancy of IP point-to-point physical or logical connections (signalling and media)	SBC with the security measures: Layer 3 and Layer 4: • Detects and drops malformed or malicious TCP/IP packets • Access Control Lists • Dynamic pinholes for media • Traffic policing • Topology hiding for media Application Security: • Detects and drops malformed or malicious SIP/H.323 messages (ALG) • Topology hiding for SIP/H.323 sessions • Authentication, Integrity, Confidentiality measures (TLS, SSH) • Session constraints • Dynamic blacklisting

Source: BEREC

[163] See FFT Doc 09.002 (July 2009), section 4.2.4.2

Table 48: Network security of the IPvIC – part 2

Characteristic	Spain	Sweden	Croatia	Bulgaria	France
Operator which offers IPvIC	Telefónica (incumbent)	TeliaSonera (incumbent)	Other fixed network operators/Incumbent (HT)	Other fixed network operators (OFNO)	Alternatives (SFR, Bouygues Telecom, Free, Colt)
Operator offers IPvIC with its (fixed and/or mobile network)	Fixed network	Fixed network	Fixed network	Fixed network	Fixed network
Security measures to protect the network	At NNI: • BGP authentication • IPsec with Authentication Header without encryption • Avoid progress of Ping commands and traceroute. • IP address will be specific for each IC operator and geographical area.[164] At SBC: The use of SBC with the following features is foreseen: • Control of access of signalling and media packets, adapting the content. • All the signalling and media flows must be handled by SBC • Packet inspection • Topology hiding, traffic policy etc	SIP and SIP-I:[165] SBC of TeliaSonera • prevent unauthorised SIP or IP messages • provide topology hiding • provide session limiting • prevent DOS attacks • SIP ALG function • SIP header manipulation • act as a dynamic Firewall SIP-I only:[166] • Call servers have SIP-I based screening mask IP transport:[167] • IP addresses are not advertised to the public Internet • ACL filters (PE, SBC) only allow agreed traffic • Encryption of signalling or media is not allowed	• SBC • EBGP authentication	Required:[152] Session Border Controller integrating security functions (provide topology hiding, traffic filtering, firewall, authentication, authorization) and Point-to-Point physical connection	Each operator is responsible for securing the traffic from its side. FFT recommends the following:[163] • Possibility to block ports based on a list of authorized addresses, ports and protocols • Use of public IPv4 addresses within each interconnection without announcement on the Internet • Make flow IP-tight (e.g. VPN) • Different SBCs secure signalling and media (e.g. distributed SBC) • At the router level: access control to a list of well-defined source addresses

Source: BEREC

[164] IP address will be public and not visible on the Internet
[165] See TeliaSonera Interconnect Specification No 8211-A357 (section 4.9) and No 8211-A353 (section 4.9)
[166] See TeliaSonera Interconnect Specification No 8211-A353 (section 4.9)
[167] See TeliaSonera Interconnect Specification No 8211-A355 (section 4.6)

Table 49: Network security of the IPvIC – part 3

Characteristic	Finland	France	France	France
Operator which offers IPvIC	TeliaSonera, Elisa, DNA	Orange	SFR	Bouygues Telecom
Operator offers IPvIC with its (fixed and/or mobile network)	Mobile network	Mobile network	Mobile network	Mobile network
Security measures to protect the network	Not specified in national specifications	Each operator is responsible for securing the traffic from its side. FFT recommends the following:[163] • Possibility to block ports based on a list of authorized addresses, ports and protocols • Use of public IPv4 addresses within each interconnection without announcement on the Internet • Make flow IP-tight (e.g. VPN) • Different SBCs secure signalling and media (e.g. distributed SBC) • At the router level: access control to a list of well-defined source addresses		

Source: BEREC