

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

Table of Contents

| | |
|---|-----------|
| Executive Summary | 4 |
| 1 Introduction and objective | 6 |
| 2 Status of IP-based in interconnection for voice services in Europe | 7 |
| 3 Analysis of IP-based interconnection for voice services | 10 |
| 3.1 Overview of the operators analysed | 11 |
| 3.2 General characteristics of the IPvIC | 12 |
| 3.2.1 Obligation to offer IPvIC | 12 |
| 3.2.2 Obligation to offer a RIO for IPvIC | 13 |
| 3.2.3 National specification of IPvIC | 14 |
| 3.2.4 Migration to IPvIC | 15 |
| 3.3 Technical characteristics of the IPvIC | 18 |
| 3.3.1 Number of Pols of the IPvIC | 18 |
| 3.3.2 Signalling protocols at the Pol of the IPvIC | 19 |
| 3.3.3 Number ranges supported by the IPvIC | 21 |
| 3.3.4 Supplementary services supported by the IPvIC | 22 |
| 3.3.5 Codecs supported by the IPvIC | 23 |
| 3.3.6 Quality of service of the IPvIC | 25 |
| 3.3.7 Physical interconnection link and redundancy of the IPvIC | 27 |
| 3.3.8 Network security of the IPvIC | 28 |
| 4 Conclusions | 29 |
| 5 Abbreviations for countries | 31 |
| 6 Further abbreviations | 31 |
| 7 Annex | 35 |

List of Figures

| | |
|--|----|
| Figure 1: Number of countries with an obligation on operators to offer IPvIC (Q1/2015) | 8 |
| Figure 2: Number of countries where operators are offering IPvIC (Q1/2015) | 9 |
| Figure 3: Date from which operators have to offer IPvIC | 12 |
| Figure 4: Minimum period of notice for FNI, OFNO and MNO in France | 17 |

List of Tables

| | |
|--|----|
| Table 1: Obligation to offer IPvIC (Q1/2015)..... | 8 |
| Table 2: Countries where IPvIC is offered (Q1/2015)..... | 10 |
| Table 3: Overview of the cases analysed | 11 |
| Table 4: Traffic types covered by the RIO for IPvIC | 14 |
| Table 5: Technical topics covered by the national specification(s)..... | 15 |
| Table 6: Number of Pols for IPvIC | 19 |
| Table 7: Signalling protocols at the Pol of the IPvIC | 21 |
| Table 8: Supplementary services supported by the IPvIC* | 23 |
| Table 9: Audio codecs supported by IPvIC | 24 |
| Table 10: Quality of service of the IPvIC..... | 26 |
| Table 11: Regulatory context – part 1 | 35 |
| Table 12: Regulatory context – part 2..... | 36 |
| Table 13: Regulatory context – part 3..... | 37 |
| Table 14: TDMvIC, network migration and use of IPvIC – part 1 | 38 |
| Table 15: TDMvIC, network migration and use of IPvIC – part 2 | 39 |
| Table 16: TDMvIC, network migration and use of IPvIC – part 3 | 40 |
| Table 17: RIO on which the IPvIC is based on – part 1..... | 41 |
| Table 18: RIO on which the IPvIC is based on – part 2..... | 42 |
| Table 19: RIO on which the IPvIC is based on – part 3..... | 43 |
| Table 20: National specifications to which the RIO refers to – part 1 | 44 |
| Table 21: National specifications to which the RIO refers to – part 2 | 45 |
| Table 22: National specifications to which the RIO refers to – part 3 | 46 |
| Table 23: Technical aspects defined in the national specification(s) – part 1 | 47 |
| Table 24: Technical aspects defined in the national specification(s) – part 2 | 48 |
| Table 25: Technical aspects defined in the national specification(s) – part 3 | 49 |
| Table 26: Process by which the national specification(s) was (were) defined – part 1 | 50 |
| Table 27: Process by which the national specification(s) was (were) defined – part 2 | 51 |
| Table 28: Process by which the national specification(s) was (were) defined – part 3 | 52 |
| Table 29: Number of Pols of the IPvIC – part 1 | 53 |
| Table 30: Number of Pols of the IPvIC – part 2 | 55 |
| Table 31: Number of Pols of the IPvIC – part 3 | 56 |
| Table 32: Signalling protocol(s) supported by the IPvIC – part 1 | 57 |
| Table 33: Signalling protocol(s) supported by the IPvIC – part 2 | 58 |
| Table 34: Signalling protocol(s) supported by the IPvIC – part 3 | 59 |
| Table 35: Number ranges and supplementary services supported by the IPvIC – part 1 | 60 |
| Table 36: Number ranges and supplementary services supported by the IPvIC – part 2 | 61 |
| Table 37: Number ranges and supplementary services supported by the IPvIC – part 3 | 62 |
| Table 38: Codecs supported by the IPvIC – part 1 | 63 |
| Table 39: Codecs supported by the IPvIC – part 2 | 64 |
| Table 40: Codecs supported by the IPvIC – part 3 | 65 |
| Table 41: QoS of the IPvIC – part 1 | 66 |
| Table 42: QoS of the IPvIC – part 2..... | 67 |
| Table 43: QoS of the IPvIC – part 3..... | 68 |
| Table 44: Physical IC link and redundancy of the IPvIC – part 1..... | 69 |
| Table 45: Physical IC link and redundancy of the IPvIC – part 2..... | 70 |
| Table 46: Physical IC link and redundancy of the IPvIC – part 3..... | 71 |
| Table 47: Network security of the IPvIC – part 1..... | 72 |
| Table 48: Network security of the IPvIC – part 2..... | 73 |
| Table 49: Network security of the IPvIC – part 3..... | 74 |

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 Poles of the IPvIC: The minimum number of Poles 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 Poles is usually reduced with the migration to NGN and all-IP networks.
- Signalling protocol: The signalling protocol to be used at the Pole 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 Pole 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 TDM¹) 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 continuous 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 harmonisation² 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, 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.

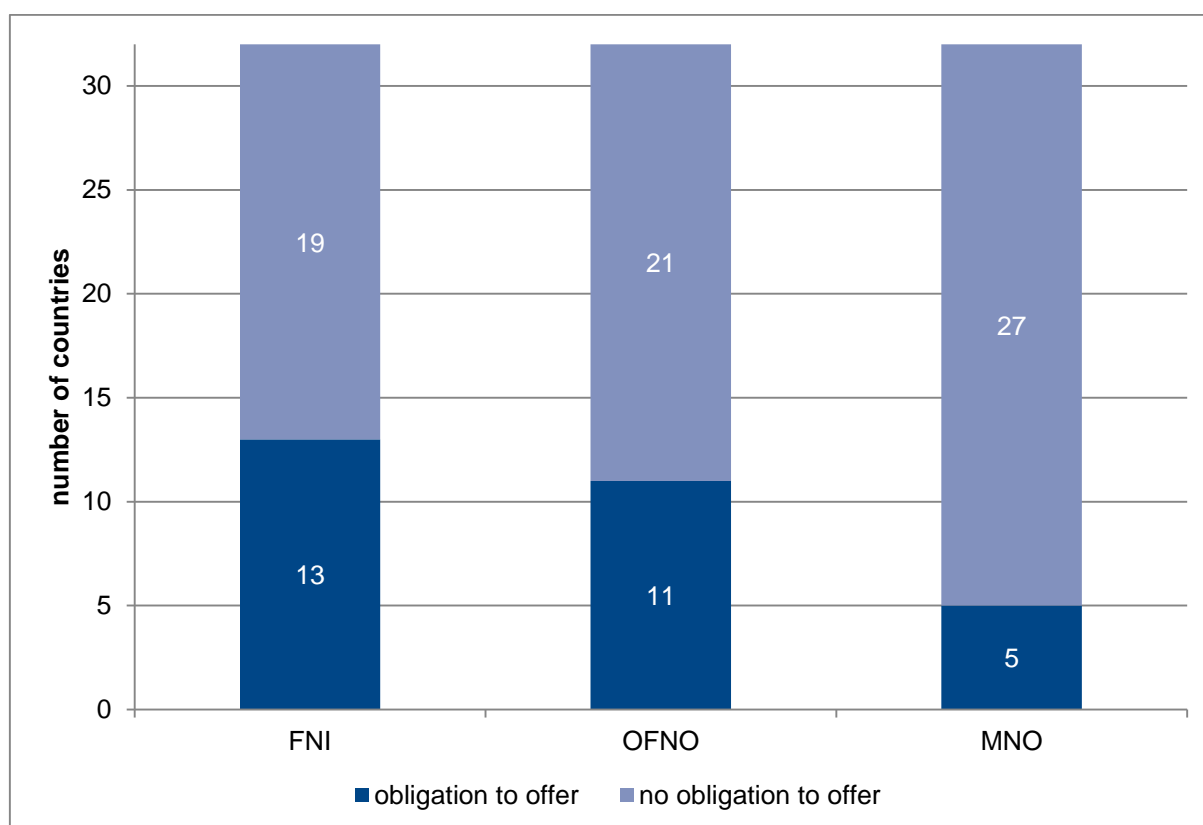
This document starts with an overview of the status of IPvIC in Europe on a general level (section 2). In the next step the IPvIC of the cases considered are analysed. This starts with an overview of the operators analysed (section 3.1) followed by the analysis of general characteristics (section 3.2) 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 IPv6 (Q1/2015)

Table 1: Obligation to offer IPv6 (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 IPv6 (DK, ES). In Denmark, MNO have the obligation to offer IPv6 only under specific conditions.

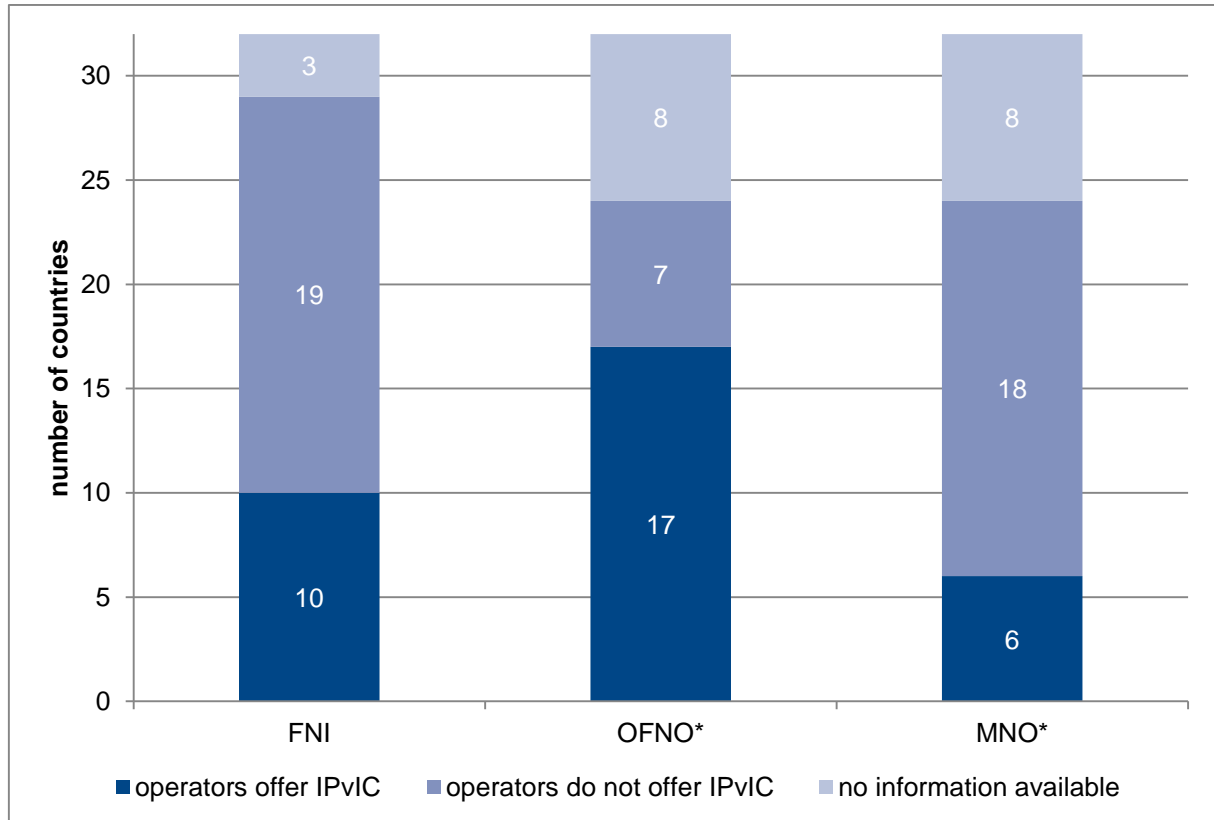
*** In FYROM, OFNO have the obligation to offer IPv6 from 01.01.2017.

Source: BEREC

The share of countries where MNO have the obligation to offer IPv6 is significantly lower (five countries, 16%). An explicit obligation might not be necessary in all cases since, for example, the operator(s) may offer IPv6 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

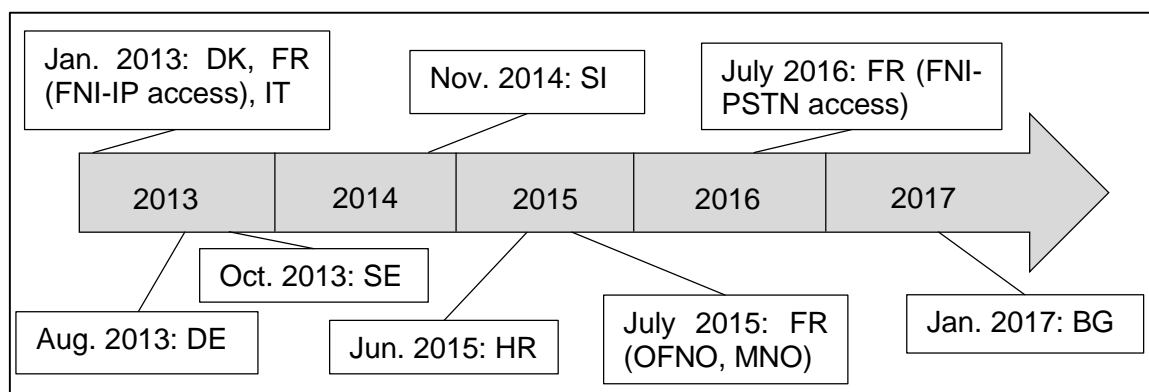
This section discusses general aspects of the obligation to offer IPvIC, the obligation to offer a RIO for IPvIC, whether a national specification for IPvIC exists and how it was developed, and certain aspects with regard to the transition from TDMvIC to IPvIC.

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 | | | | | | | | | | | | | | | |
| Termination | X | X | X | X | X | X | X | X | No obligation to offer RIO | X | X | No obligation to offer RIO | 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 (BG⁸, HR, IT) or recommendation (FI) or in a technical specification (IT⁹) 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 operators¹⁰ 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 | 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 | | 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 Pols of the IPvIC

The number of points of interconnection (Pol) is an important characteristic of interconnections between networks. Interconnections for voice services based on traditional technology (TDMvIC) typically use different Pols 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 Pols.

In four countries (DK-TDM end user¹⁵, ES¹⁶, IT, SE), the IPvIC of the FNI is based on different Pols for subscribers in different areas and the IC partner have either to connect to (at least) one Pol 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 Pols 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 user²³, FR, HR, SI), the FNI has reduced the minimum number of Pols 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) Pol 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 Pols (DE). The IPvIC is offered by the FNI with more than 2 Pols (4/6/10/22) in four countries (HR/DK/FR/DE) and the ANOs can choose one or two Pols out of these Pols.

In Bulgaria, the IPvIC of the OFNO is generally based on one Pol on a voluntary basis. In Croatia, the minimum and total number of Pols of the IPvIC of the OFNO is not yet defined by the NRA. In France, the minimum number of Pols of the IPvIC of the OFNO and the MNO is two. In Finland, the minimum number of Pols of the IPvIC offered by the MNOs is two according to a recommendation of the NRA (FI²⁴) and the total number of Pols is three.

3.3.2 Signalling protocols at the Pol 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 Pol.

¹⁷ 2 Pols for voice traffic to VoIP end users of the FNI and 6 Pols 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 Pols. In order to avoid unregulated transit rates, it is sufficient to connect to one Pol of each area. However, if redundancy is required, it is necessary to connect to both Pols of an area

¹⁹ For OFNO the NRA has not yet defined the minimum or total number of Pols.

²⁰ 22 Pols on 12 locations

²¹ Currently OFNO use generally 1 Pol

²² Orange 4 Pols, Bouygues Telecom 3 Pols.

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 Pol 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 Pol.

The following signalling protocols are used at the Pol 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 3GPP²⁸ 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 protocol²⁹) 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 Independent 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 Bulgaria³³ 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.729a⁴¹ (DK, HR) or G.722⁴² (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 4733⁴³ (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. NER⁴⁵) 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 (DE⁴⁶, 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 | | | | | | | | | | | | | |
| 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 operators⁵⁵ 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 Pol 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 Pol of the IPvIC of the FNI in Germany and Sweden, two MNO in France and in the near future also at the Pol 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 links⁵⁶ 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 characteristics 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 PIs of the IPvIC: The minimum number of PIs 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 PIs is usually reduced with the migration to NGN and all-IP networks.
- Signalling protocol: The signalling protocol to be used at the PI 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 PI 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 |
| Pol | 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 | <ul style="list-style-type: none"> • 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.bouyguetelecom.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 : <ul style="list-style-type: none"> • FFT Doc 10.001 (5/2014)⁹⁰ • FFT Doc 09.002 (July 2009)⁹¹ | Specifications by AKNN ⁹² : <ul style="list-style-type: none"> • Concept for Interconnection of NGN⁹³ • NGN Ic Interface⁹⁴ • Examination QoS in NGN⁹⁵ | <ul style="list-style-type: none"> • Agcom decision n. 128/11/CIR⁹⁶ (general framework of IP-IC technical specifications). • Specification by the Ministry for Economic Development: Technical specification ST 769⁹⁷ | Not appl. |

Source: BEREC

⁸⁹ French Federation of Telecommunications⁹⁰ http://www.fftelecoms.org/sites/fftelecoms.org/files/contenus_lies/sip_profile_v1.2.1.pdf⁹¹ http://www.fftelecoms.org/sites/default/files/contenus_lies/architecture_principes_et_recommandations_-_version_anglaise.pdf⁹² 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.pdf⁹⁴ http://www.aknn.de/fileadmin/uploads/oeffentlich/Spec_UAKS_NGN_Ic_Interface_V1_0_0.pdf⁹⁵ Not formally adopted by AKNN but referred to in the RIO⁹⁶ http://www.agcom.it/documentazione/documento?p_p_auth=fLw7zRht&p_p_id=101_INSTANCE_kidx9GUnlodu&p_p_lifecycle=0&p_p_col_id=column-1&p_p_col_count=1&_101_INSTANCE_kidx9GUnlodu_struts_action=%2Fasset_publisher%2Fview_content&_101_INSTANCE_kidx9GUnlodu_assetEntryId=643110&_101_INSTANCE_kidx9GUnlodu_type=document⁹⁷ 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: <ul style="list-style-type: none"> • No 8211-A 357¹⁰⁰ • No 8211-A 353¹⁰¹ • No 8211-A 354¹⁰² • No 8211-A 355¹⁰³ • No 8211-A 356¹⁰⁴ | 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/suosituksset/Suositus_201-2014_S_-_Finnish_profile_for_SIP-I_interworking.pdf

¹⁰⁷ https://www.viestintavirasto.fi/attachments/suosituksset/Suositus_202-2014_S_-_Finnish_profile_for_SIP_interworking.pdf

¹⁰⁸ http://www.ffttelecoms.org/sites/ffttelecoms.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 Pol) | 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 Pol) | 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 stakeholders 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 stakeholders 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 Pols 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 (Pols) for IPvIC nationwide | 6 Pols (each available for IPvIC and TDMvIC) No/3 areas (no areas for VoIP end users, 3 areas for TDM end users with 2 Pols in each area) | 10 Pols ¹¹⁷ | 22 Pols on 12 locations No areas | 32 Pols 16 Gateway areas 2 Pols per gateway area | 2 Pols |
| Minimum number of Pols 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 locations for redundancy, 1 for small local operators, 1 for local rates ¹¹⁹ | 32 ¹⁸ | 1 Pol |
| The minimum number of Pols 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 Pols (and not more/less) | To support flexibility. For VoIP end users alternative operators can choose to interconnect at only one Pol (of any of the 6 Pols), for redundancy reason also at more Pols | Not appl. | For small operators 1 Pol is sufficient and 2 Pols seem not to be proportionate | Not appl. | Not appl. |
| Total number of points of interconnection (Pols) for previous TDMvIC nationwide | 6 (the same 6 Pols that are available for IPvIC) | 360 | 474 | 660 | 44 Pols (2 IX, 11 SX and 31 PX) ¹²⁰ |

Source: BEREK

¹¹⁷ 5 PoP locations each with 2 Pols¹¹⁸ According to national specifications of FFT the Pol has to be redundant. Therefore, the minimum number of Pol is two. The operators can handover traffic for all destinations in France at each of the two Pols and have to pay (only) the regulated local rates (no unregulated transit charges).¹¹⁹ ANOs have to select two out of 22 Pols (not less and not more). Two Pols are needed for redundancy, not for local rates. Small local operators may interconnect at just 1 Pol. Any traffic can be handed over at any Pol for the same price.¹²⁰ IX - International Exchange, SX - Secondary Exchange, PX - Primary Exchange

Table 30: Number of Pols 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 (Pols) for IPvIC nationwide | 19 areas / 19 Pol Each Pol with redundancy | 4 Pols 2 areas 2 Pols per area | FNI: 4 Pols OFNO: not defined yet | Currently OFNO use generally 1 Pol | No information available |
| Minimum number of Pols mandated by RIO (to allow for redundancy and local rates) | 19 Pols (each Pol with redundancy) | 4 ¹⁸ | FNI: 2 ¹²¹ OFNO: not defined yet | Not appl. ¹²² | 2 ¹¹⁸ |
| The minimum number of Pols 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 Pols (and not more/less) | Not appl. | Not appl. | For redundancy reason ¹²³ | Not appl. | Not appl. |
| Total number of points of interconnection (Pols) 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 Pols 13 areas 2 Pols per area | 2 international, 9 regional and 26 local exchanges | Not appl. ¹²⁵ | No information available |

Source: BERECA

¹²¹ In transition period as long as operator has TDMvIC with incumbent 1 Pol 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 Pols.

¹²³ Number of Pols was proposed by incumbent. During the negotiation process HAKOM only insisted on redundancy which is ensured by 2 Pol.

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 Pol (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 Pols 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 (Pols) for IPvIC nationwide | 3 Pols | 4 | NIA | 3 |
| Minimum number of Pols mandated by RIO (to allow for redundancy and local rates) | 2 ¹²⁶ | 2 ¹¹⁸ | | |
| The minimum number of Pols mandated by RIO has been imposed by NRA? (Yes/No) | Not appl. | No | | |
| If imposed by NRA, reasons for demanding this minimum number of Pols (and not more/less) | Not appl. | Not appl. | | |
| Total number of points of interconnection (Pols) for previous TDMvIC nationwide | 2 Pols for each MNO | 6 | 6 | 3 |

Source: BEREC

¹²⁶ Two Pols 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): <ul style="list-style-type: none"> • SIP (IETF) • SIP-I (ITU-T) | No |
| Signalling protocol(s) used by the operator at the Pol of the IPvIC | SIP (IETF) | SIP (IETF) including specifications of 3GPP (IMS) | SIP (IETF) including specifications of 3GPP (IMS) | <ul style="list-style-type: none"> • SIP (IETF) including specifications of 3GPP (IMS) • SIP-I (ITU-T) | <ul style="list-style-type: none"> • SIP (IETF)¹²⁷ • SIP-I (ITU-T) |
| Signalling protocol(s) is(are) specified by reference to the following international standards | <ul style="list-style-type: none"> • SIP: RFC 3261, RFC 3262, RFC 3325, RFC 2327 (SDP) • Interworking ISUP-SIP: RFC 3398, RFC 3578 • Fax: T.38 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • ETSI TS 124 503 V8.3.0 (2009-01) | <p>SIP:</p> <ul style="list-style-type: none"> • 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 <p>SIP-I:</p> <ul style="list-style-type: none"> • ITU-T Q.1912.5 Profil C | <ul style="list-style-type: none"> • 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 Pol of the IPvIC | <ul style="list-style-type: none"> SIP (IETF) including specifications of 3GPP (IMS) | <ul style="list-style-type: none"> SIP (IETF) SIP-I (ITU-T) | SIP (IETF) including specifications of 3GPP (IMS) | <ul style="list-style-type: none"> SIP (IETF) | SIP (IETF) including specifications of 3GPP (IMS) |
| Signalling protocol(s) is(are) specified by reference to the following international standards | <ul style="list-style-type: none"> List of RFC, e.g. RFC 3261, RFC 3262, RFC 3264, RFC 3311, RFC 4566 etc 3GPP TS 24.528, 29.165 | <p>SIP:¹²⁹</p> <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> SIP RFC 3261 ITU-T Q.1912.5 Profile C | <ul style="list-style-type: none"> 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 Pol of the IPvIC | SIP-I (national) | SIP-I ¹³¹ | | |
| Signalling protocol(s) is(are) specified by reference to the following international standards | <ul style="list-style-type: none"> • SIP-I: ITU-T Q.1912.5; & national ISUP3 (SFS5869) • GSMA & 3GPP specifications | <ul style="list-style-type: none"> - 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: <ul style="list-style-type: none"> - 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 | <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • G.711 A-law • G.729 (no Annex B) • RFC 2833 (DTMF)¹⁴³ | SIP, SIP-I: <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • T.38 • G.711 A-law | <ul style="list-style-type: none"> • G.711 A-law • T.38 if bilaterally agreed • V.152 optional¹⁴⁵ | <ul style="list-style-type: none"> • G.711 A-law • AKNN recommended T.38 | <ul style="list-style-type: none"> • G.711 A-law (media type "audio") • T.38 (media type "image")¹⁴³ | SIP, SIP-I: <ul style="list-style-type: none"> • G.711 • T.38 |

Source: BEREC

¹⁴¹ According to FFT Doc. 09.002 (July 2009), section 4.2.2¹⁴² Other codecs may be negotiated without guarantee¹⁴³ See Draft RIO of Oct. 2012, section 7, p. 19¹⁴⁴ But fax traffic is not included in QoS commitments¹⁴⁵ 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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • T.38 (media type "image") • G.711, pass-through optionally. | SIP, SIP-I: G.711 A-law | <ul style="list-style-type: none"> • G.711 • T.38 | <ul style="list-style-type: none"> • G.711 A-law • Required: T.38 | <ul style="list-style-type: none"> • G.711 A-law (default) • T.38 if bilaterally agreed • V.152 optional¹⁴⁸ |

Source: BEREC

¹⁴⁶ According to FFT Doc. 09.002 (July 2009), section 4.2.2¹⁴⁷ But no commitment of interoperability because it depends on the costumers equipment.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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> G.711¹⁴⁹ G.114 G.107¹⁵⁰ G.168¹⁵¹ |
| 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 Pol (objective/not defined) | Not specified in RIO | Not specified in RIO | <ul style="list-style-type: none"> >= 99.5% (per IC partner and excluding the leased line between 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 ms¹⁵⁰ Minimum voice quality – delay <= 300 ms¹⁵¹ 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 <ul style="list-style-type: none"> • 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 Pol (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: <ul style="list-style-type: none"> • IPLR < 0.02%. • IPTD < 50ms (one-way delay). • IPDV < 4ms | Comparable with TDMvIC | Required: ¹⁵² <ul style="list-style-type: none"> • 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 Pol (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 Pol 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 Pol | Typically 1 GE | Minimal 1 GE | <ul style="list-style-type: none"> • 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 Pol for Internet traffic. | Voice and fax | For voice services only. Separate Pol for Internet traffic. |
| Physical transport interface and bandwidth options at the Pol | 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 Pols 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 GE¹⁵⁹ 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 Pol for Internet traffic. | | |
| Physical transport interface and bandwidth options at the Pol | 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 | <ul style="list-style-type: none"> 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 | <p>Each operator is responsible for securing the traffic from its side. FFT recommends the following:¹⁶³</p> <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Detailed rules on security of collocation rooms Some general obligations to cooperate in security issues, to not use Pols for types of traffic not covered by the agreement etc. | <ul style="list-style-type: none"> Border gateway functionality with firewall Use of public IP addresses <ul style="list-style-type: none"> Geographical redundancy of IP point-to-point physical or logical connections (signalling and media) | <p>SBC with the security measures:</p> <p>Layer 3 and Layer 4:</p> <ul style="list-style-type: none"> Detects and drops malformed or malicious TCP/IP packets Access Control Lists Dynamic pinholes for media <ul style="list-style-type: none"> Traffic policing Topology hiding for media <p>Application Security:</p> <ul style="list-style-type: none"> Detects and drops malformed or malicious SIP/H.323 messages (ALG) Topology hiding for SIP/H.323 sessions <ul style="list-style-type: none"> 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 | <p>At NNI:</p> <ul style="list-style-type: none"> • 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 <p>At SBC:</p> <p>The use of SBC with the following features is foreseen:</p> <ul style="list-style-type: none"> • 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 | <p>SIP and SIP-I:¹⁶⁵</p> <p>SBC of TeliaSonera</p> <ul style="list-style-type: none"> • prevent unauthorised SIP or IP messages • provide topology hiding • provide session limiting • prevent DOS attacks <ul style="list-style-type: none"> • SIP ALG function • SIP header manipulation <ul style="list-style-type: none"> • act as a dynamic Firewall <p>SIP-I only:¹⁶⁶</p> <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • SBC • EBGP authentication | <p>Required:¹⁵²</p> <p>Session Border Controller integrating security functions (provide topology hiding, traffic filtering, firewall, authentication, authorization) and Point-to-Point physical connection</p> | <p>Each operator is responsible for securing the traffic from its side. FFT recommends the following:¹⁶³</p> <ul style="list-style-type: none"> • 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 Internet¹⁶⁵ 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 | <p>Each operator is responsible for securing the traffic from its side. FFT recommends the following:¹⁶³</p> <ul style="list-style-type: none"> • Possibility to block ports based on a list of authorized addresses, ports and protocols <ul style="list-style-type: none"> • 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