ETSI TR 103 282 V2.1.1 (2019-05)

Network Technologies (NTECH);
Options for Number Portability and actual use cases

Reference

RTR/NTECH-0040

Keywords

DNS, enum, NP

ETSI

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Introduction

In voice and multimedia IP-based networks (NGN included), E.164 numbers are, and will continue to be used as the basic (primary) identifier that enables the originating party to establish a call/communication with an end-user or a service. In this context, infrastructure ENUM systems, being an effective mechanism for mapping E.164 numbers to URIs, that identify the network actually serving these E.164 numbers and that are usable inside DNS systems for routing purposes, are at the time of writing being implemented inside networks, or are expected to be implemented at some point in the near future.

On the other hand number portability (NP), has now for some time operated within each country based on standard technical solutions (usually NP mechanisms defined by ITU-T and ETSI on traditional telephone technology), nationally adapted and implemented with country-specific characteristics. Since large investments towards implementing and operating number portability have already been done by the telecommunications operators within each country, and typically such NP solutions work, it is likely that the options to be selected for establishing ENUM mechanisms will be based on safeguarding the national investments already done, following progressive network technological evolutions towards NGN.

So it can be assumed that ENUM mechanisms, when used inside NGN IP-based networks, will in principle conform with the existing national number portability solutions already adopted and working within each country; therefore there will be a number of different options suitable for establishing ENUM mechanisms without necessarily changing or evolving existing NP technical solutions. It is important to remark that ENUM is, first of all, a hierarchical system that extends the DNS system, following in principle the same approach, and ENUM is also a standard "query" protocol to derive, based on E.164 numbers, the appropriate routing information, that is usable inside IP-based networks. These ENUM components are part of the ENUM system, also in the case of ENUM query mechanisms implemented inside existing NP solutions (referred as ENUM-like non-standard solutions).

Although around five years have passed since the first version of the present document was published in June 2014, in most countries, migration from PSTN to IP-based networks (NGN included) is not complete yet. This revised version introduces actual use cases of number portability in 7 countries towards all IP networks in order to verify the estimated direction of number portability described in the original version, which was expected to be "ENUM-like" technology with considerable degrees of variation among the possible solutions.

The present document introduces several use cases of current or proposed number portability solutions at this point toward all IP in 7 countries (Japan, US, Netherlands, Italy, Switzerland, Sweden, Finland) with the cooperation of experts from each country. They are newly described in Annex B.

Although these use cases may include indecisive area it can be said that there are other options than ENUM-like technology concerning all IP Number Portability so that the ENUM-based option may not necessarily be the target for some networks or countries.

1 Scope

The present document aims to lay out and organize the various available options for establishing ENUM or ENUM-like mechanisms for number portability, and to establish a correspondence between these available options and actual use cases that are currently under implementation or are expected to be so in the near future.

Also the present document introduces several use cases of current or proposed number portability solutions at this point toward all IP in 7 countries (Japan, US, Netherlands, Italy, Switzerland, Sweden, Finland) with the cooperation of experts from each country. They are newly described in Annex B in the revised version.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 101 122 (V1.1.1): "Network Aspects (NA); Numbering and addressing for Number Portability".

[i.2] Recommendation ITU-T E.164 Supplement 2 (2014): "Number portability".

[i.3] Recommendation ITU-T E.101 (2009): "Definitions of terms used for identifiers (names, numbers, addresses and other identifiers) for public telecommunication services and networks in the E-series Recommendation".

[i.4] IETF RFC 6116: "The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM)".

[i.5] Recommendation ITU-T E.164 (2010): "The international public telecommunication numbering plan".

[i.6] IETF RFC 5067: "Infrastructure ENUM Requirements".

[i.7] ETSI TR 184 003: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Portability of telephone numbers between operators for Next Generation Networks (NGNs)".

[i.8] GSMA IR.67 version 8.0 (23 November 2012): "DNS/ENUM Guidelines for Service Providers & GRX/IPX Providers".

[i.9] Reference to a Dutch ENUM implementation public information. (e.g.: https://www.coin.nl/index.php/en/).

[i.10] Reference to a North American ENUM implementation public information. (e.g.: http://www.itu.int/ITU-D/finance/work-cost-tariffs/events/tariff-seminars/Geneva-OriginID/pdf/Session2_Lind_ENUM_presentation.pdf).

[i.11] Reference to a German ENUM implementation public information. (e.g. https://ripe64.ripe.net/presentations/93-e-wtklxc-RIPEGlobalVoix-003.pdf).

[i.12] GSMA NG.105 ENUM Guidelines for Service Providers and IPX Providers.

[i.13] TTC standard JJ-90.31-v3: "Common interconnection interface for carrier ENUM".

[i.14] TTC standard JT-E164_Supplement_2: "Number Portability".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

data base query function: function whereby a data base is accessed in order to ascertain whether a telephone number is ported, and if it is, a Routeing Number or a domain name is obtained that can be used to route the call to a destination

donating network: network from which the number has been ported out in the last porting process

donor network: initial network where a number was allocated by the Numbering Plan Administrator before ever being ported

NOTE: Source ETSI TR 101 122 [i.1].

E.164 number: A string of decimal digits that satisfies the three characteristics of structure, number length and uniqueness specified in Recommendation ITU-T E.164 [i.5]. The number contains the information necessary to route the call to the end user or to a point where a service is provided.

NOTE: Source Recommendation ITU-T E.101 [i.3].

ENUM data: data for mapping an E.164 number to an URI

NOTE: Mapping can be done directly or by providing pointers to other ENUM DBs according to ordinary DNS procedures.

ENUM system: real time hierarchical and distributed system that stores ENUM data and used to resolve E.164 numbers to URIs at session initiation

ENUM query: query adhering to the ENUM query protocol in order to resolve a specific E.164 number to a domain name for routing purposes (e.g. a routable URI)

infrastructure ENUM: ENUM system defined in IETF RFC 5067 [i.6] and technically based on IETF RFC 6116 [i.4]

NOTE: The infrastructure ENUM is defined and used only inside a network and among networks for routing purposes.

Location portability: ability of an end user to retain the same telephone number when moving from one location to another, without changing his service provider

NP Routing Information (NPRI): information needed to complete a communication request to a ported telephone number

Numbering Plan Administrator (NPA) data: off-line data published by the Numbering Plan Administrator (NPA) which provide the number block assignments to operators that provide services within the jurisdiction of the NPA

NOTE 1: If the telephone numbers are subject to number portability the actual operator serving a specific telephone number can differ from the one provided by these data, if these data are not kept aligned with NP data. In cases where telephone numbers are assigned directly to end users, the operator chosen by the end user to provide services is due to spread information that he is serving that telephone number.

NOTE 2: Source ETSI TR 184 003 [i.7].

Numbering Plan Administrator (NPA) DB: non-real time administrative data base that stores NPA Data

Number Portability Data (NPD): off-line data linked to ported telephone numbers as they are stored in and retrieved from the NPDB

NOTE 1: This data consist of a list of ported telephone numbers with associated domain names or routeing numbers and optionally further information of traffic and/or administrative nature. Normally these data are provided in a format which requests for further processing in order to render routeing information.

NOTE 2: Source ETSI TR 184 003 [i.7].

Number Portability Data Base (NPDB): non-real time data base that is used to store NP Data

NOTE 1: As an option the NPDB may contain information for all telephone numbers (i.e. also non-ported telephone numbers). Such additional information would be based on NPA Data.

NOTE 2: Source ETSI TR 184 003 [i.7].

Number Portability (NP) query: query function whereby a data base is accessed in order to ascertain whether a telephone number is ported, and if it is, a Routeing Number or a domain name is obtained that can be used to route the call to a destination

Operational Data Base (OpDB): real time data base that store data from the NPDB to be transformed to NRI used for routing

NOTE: Source ETSI TR 184 003 [i.7].

operator: entity providing public telecommunications networks and/or public telecommunication services

NOTE: Source ETSI TR 184 003 [i.7].

ported number: number that has been subject to number portability

NOTE: Source ETSI TR 101 122 [i.1].

recipient network: current serving network where a number is located after being ported

NOTE: Source ETSI TR 101 122 [i.1].

Reference Number Portability Data Base (RefNPDB): non-real time reference NPDB

NOTE 1: It is national matter whether there is one physical RefNPDB or a logical one, which may be distributed over the operators involved.

NOTE 2: Source ETSI TR 184 003 [i.7].

NOTE 3: In some places the term "RefNPDB" is replaced with the term "CRDB".

service portability: ability of an end user to retain the same telephone number when changing from one type of service to another

Service Provider Portability (SPP): ability of an end user to retain the same telephone number when changing from one service provider to another

NOTE: Source ETSI TR 184 003 [i.7].

telephone number; directory number: number adhering to the national E.164 numbering plan, used by the originating party to establish a call/communication to an end user or a service

NOTE: Source Recommendation ITU-T E.101 [i.3]. The E.101 definition has been modified here to be independent of the network technology, e.g. NGN, PSTN/ISDN and other technologies. The E.101 original definition is:

*"**4.22 telephone number; phone number; directory number (DN)**: The number, derived from the E.164 numbering plan, used by the calling party to establish a call to an end user or a service.*
The number may also be used for presentation services like calling line identification presentation (CLIP) and connected line identification presentation (COLP) and may also be published in different directories and/or directory enquiry services".

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACQ	All Call Query
CD	Call Dropback
CLIP	Calling Line Identification Presentation
COLP	Connected Line Identification Presentation
CRDB	Central Reference Data Base
DB	Data Base
DN	Directory Number
DNS	Domain Name System
ENUM	tElephone NUMber mapping
GSMA	Global System For Mobile Communications Association
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPX	Internet Packet eXchange
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
NAPTR	Naming Authority Pointer
NGN	Next Generation Network
NopDB	National Operational Data Base
NP	Number Portability
NPA	Numbering Plan Administrator
NPD	NP Data
NPDB	Number Portability Data Base
NPRI	NP Routing Information
NS	Name Server
NW	Network
OP	Operator
OpDB	Operational Data Base
OR	Onward Routeing
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
QoR	Query on Release
RefNPDB	Reference Number Portability Data Base
SG	Study Group
SIP	Session Initiation Protocol
SIP-I	SIP with encapsulated ISUP
SNPAC	Sweden Number Portability Administrative Center
SPP	Service Provider Portability
TLD	Top Level Domain
TTC	Telecommunication Technology Committee
URI	Uniform Resource Identifier

4 Basic concept of the present document

4.1 Original meaning of ENUM and Number portability

The ENUM system is defined as bound to a distributed, decentralized, hierarchical organization of numbers, in which every provider makes available the numbers, at the time of writing handled, in principle, through a local ENUM system that is part of an infrastructure ENUM hierarchy.

On the one hand if a Central Reference Data Base exists, it is not in principle involved in the real-time handling of the calls, but it can be used as a national repository. For this reason this Administrative Central Reference Data Base is considered technically distinct from the ENUM system; in addition it will not in principle be a pre-requisite for the ENUM system implementation and will not influence nor change the intrinsic characteristics of the ENUM system itself, which is defined in international and ETSI normative and technical specifications.

Thus it is not a requirement for the ENUM implementation to change or evolve existing NP models, since the infrastructure ENUM system can be just integrated inside existing NP solutions; in other cases the ENUM system implementation at national level can deeply impact or change existing NP solutions.

4.2 Background for ENUM-like mechanisms

In IP-based networks telephone numbers are still being used as the basic (primary) identifier. In this context ENUM mechanisms are currently being implemented, or are expected to be implemented at some point in the near future, as a tool for mapping E.164 numbers to URIs. With ENUM system in the present document it is referred only the case of the infrastructure ENUM [i.6]; as a consequence, it uses a "technical" TLD other than the "e164.arpa", which is used for public or User ENUM. An ENUM-like system is a system providing capabilities similar to those provided by the standardized infrastructure ENUM. It should be noted that ETSI TR 184 003 [i.7] describes the opportunity to use also other technologies than ENUM for providing NP in NGN mainly for coping with a very heterogeneous network environment.

4.3 Incorporating NP mechanisms into ENUM-like mechanisms

If ENUM or ENUM-like mechanisms are to be used as a tool for call establishment, giving adequate consideration for Number Portability (NP) would be indispensable.

Since large investments towards NP implementation/operation have already been spent within each country, a reasonable form of implementing ENUM-like mechanisms would be to implement them adhering to the existing NP mechanisms varying from one country to another, based on the NP models and mechanisms that have been standardized by ETSI and ITU-T.

4.4 Actual use cases, studies by other SDOs or other organizations

For example, an ENUM-like mechanism applicable for NP operation is under development by a Dutch ENUM implementation [i.9], based on an approach that utilizes the existing NP mechanism.

GSMA IR.67 [i.8], as another example, sets out the different methods for establishing ENUM-like mechanism, depending on whether the existing NP operation is based on a centralized database approach or a distributed database approach.

NOTE: GSMA undertook a review of IR.67 [i.8], which lead to two separate documents: the newly revised IR.67, which only deals with DNS guidelines and for which enum is out of scope, and a new NG.105 ENUM Guidelines for Service Providers and IPX Providers [i.12], which focuses on enum.

4.5 Target of the present document

Target of the present document is to organize and provide a conceptual overview of the available options for implementing/establishing ENUM-like mechanisms, using as a basis the actual use cases (for instance a Dutch ENUM implementation [i.9]) and studies undertaken by other organizations (for instance GSMA IR.67 [i.8]). Preferable options for establishing ENUM-like mechanisms would be those by which existing NP mechanisms (already in operation within each country) could be utilized to a maximum extent.

Each of the options is brought under review. Important items to be studied include issues related with the "co-existence/combination" phase of the existing NP mechanism and the newly implemented ENUM-like mechanism.

5 Options for number portability solution

5.1 Overview

It is assumed that the selection of ENUM/ENUM-like mechanisms as required by the transition of networks to an all-IP infrastructure, will be significantly affected by the existing number portability solutions; in particular by the previously adopted number portability database solutions. Based on this perspective, this clause aims to go over the various options for number portability solution, using the below listed existing documents as source:

- ETSI TR 184 003 [i.7]; and
- Recommendation ITU-T E.164 Supplement 2 [i.2].

Figure 5.1, excerpted from Recommendation ITU-T E.164 Supplement 2 [i.2], provides a graphic explanation on the examples of number portability database solution. All of the options shown in figure 5.1 maintain consistency with ETSI TR 184 003 [i.7], in terms of terminology as well as concept.

NOTE: In some places the term "RefNPDB" is replaced with the term "CRDB".

Figure 5.1 is intended to cover the main number portability database solutions that are implemented in various countries around the world.

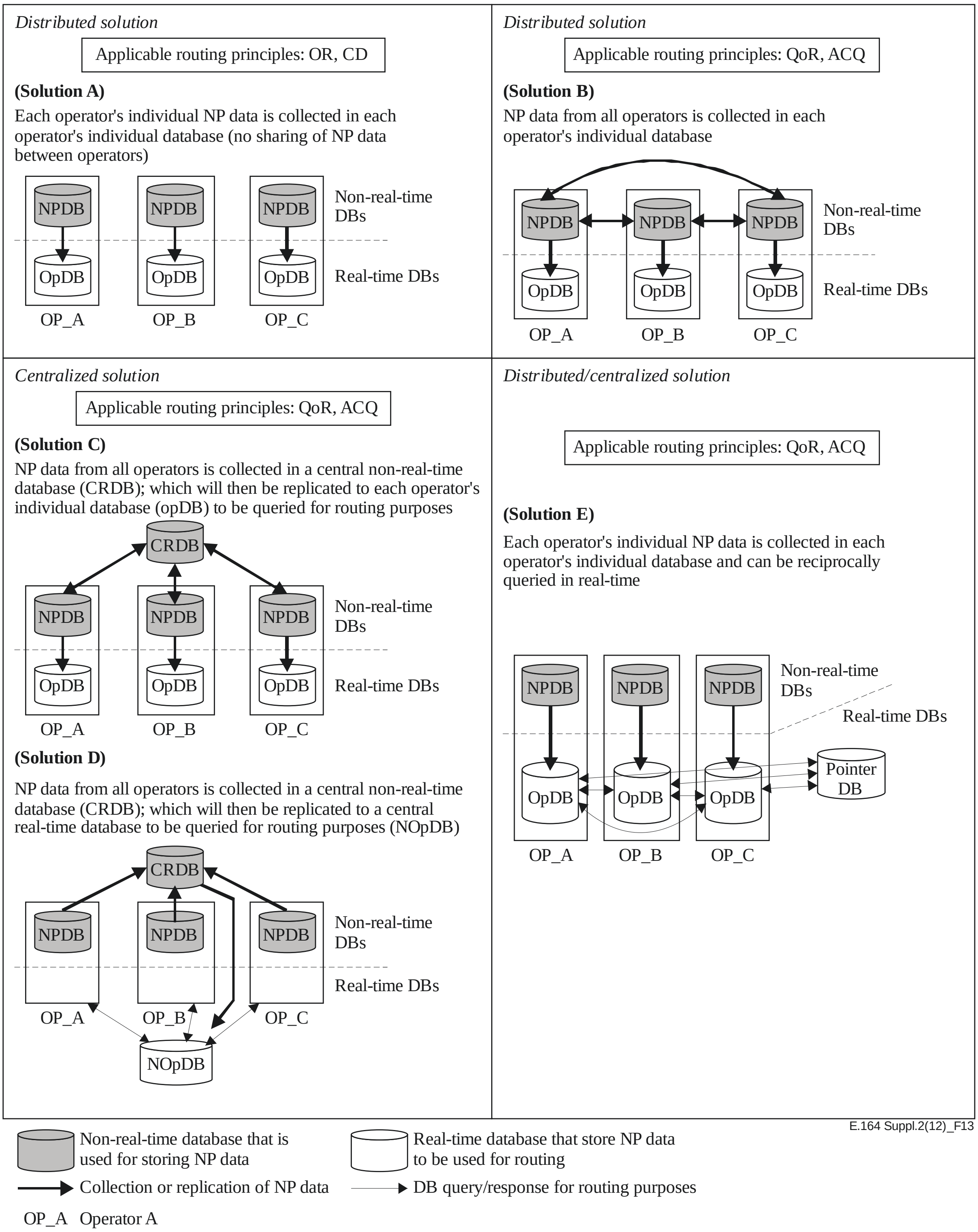


Figure 5.1: Examples of number portability database solution (excerpted from Recommendation ITU-T E.164 Supplement 2 [i.2])

Of the five Solutions in figure 5.1 excerpted from Recommendation ITU-T E.164 Supplement 2 [i.2], Solution A, B and C are at the time of writing adopted in many countries as these Options are deployable on the legacy PSTN environment. Solution D requires the implementation of a central real-time database (NopDB according to ETSI TR 184 003 [i.7]); in which ensuring high reliability will become a major issue.

ENUM like technology can be used by the five Options in figure 5.1, especially in the case of Solution E, as a way of implementing a NP database among other possible implementation Options, mainly in the context of NGN IP-based network.

It should be noted that, Solution E is not listed in clause 6 among existing (currently adapted) options which has been actually implemented for conventional PSTN/PLMN because Solution E is considered to be rather the solution for IP networks (including NGN).

Additional explanations for each of the Solutions are shown in succeeding clauses.

5.2 No sharing of NPDBs among operators (Solution A)

In this option, each operator holds/manages a non-real-time database and a real-time database separately on its own. Database management does not involve any transfer of database information between operators.

5.3 Mesh interconnection of NPDBs (Solution B)

In this option, NP data stored within each operator's individual non-real-time database (the NPDB according to ETSI TR 184 003 [i.7]) are mutually exchanged between operators. This mutual exchange of number portability data information enables each operator's individual non-real-time database and individual real-time database (the OpDB according to ETSI TR 184 003 [i.7]) to hold NP data of all operators.

5.4 RefNPDB (Solution C)

In this option, a central non-real-time database is established to be shared by all the operators. NP data stored within each operator's individual non-real-time database (NPDB) is transferred to this central non-real-time database (RefNPDB); as a result the central non-real-time database will hold NP data from all operators. Each operator then downloads data from this central non-real-time database, thereby enabling each operator's individual non-real-time database (NPDB) and individual real-time database (OpDB) to hold NP data of all operators.

5.5 National OpDB (Solution D)

In this option, a central real-time database, together with a central non-real-time database, is established to be shared by all the operators. NP data stored within each operator's individual non-real-time database is transferred to this central non-real-time database; as a result the central non-real-time database will hold NP data from all operators. This data will then be downloaded (from the central non-real-time database) to the central real-time database. Each operator directly refers to this central real-time database in order to perform real-time processing.

5.6 Realtime Query of OpDB (Solution E)

In this option, each operator's individual NP data is collected in each operator's individual database (no sharing of NP data between operators). However the operators are able to refer, in real-time, the NP data that is stored within each operator's respective real-time databases (OpDB) by utilizing a DB query technology (e.g. ENUM like technology).

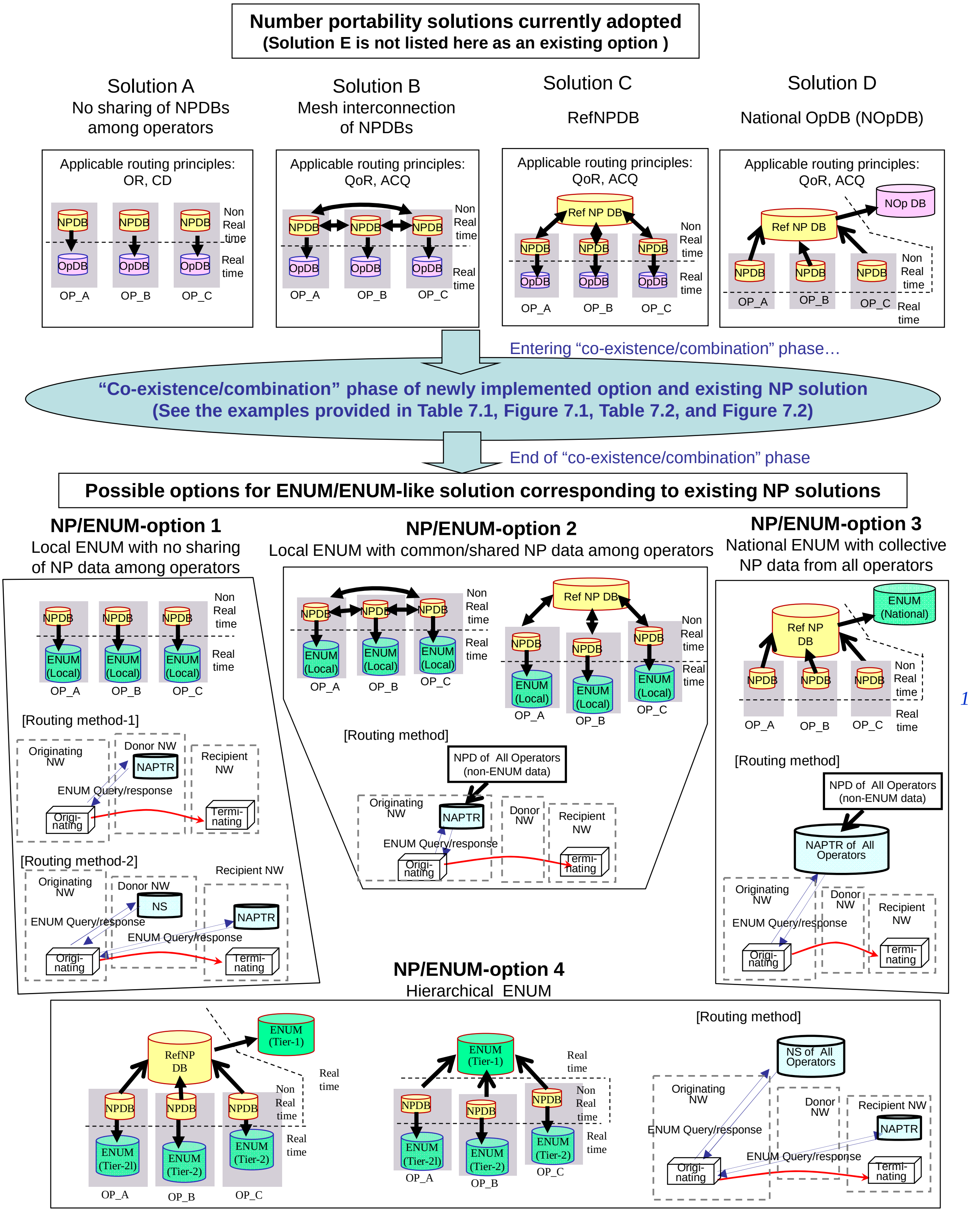
6 Possible options in terms of ENUM/ENUM-like solution for number portability

6.1 Overview

Number portability has now for some time been operated within each country in accordance with the nationally implemented number portability solution that is country-specific and thus varying from one country to another; therefore it is conceivable that, in a country that has, for instance, implemented RefNPDB for number portability operation, viable options for establishing ENUM/ENUM-like mechanisms will be designed on the premise of the continuous utilization of this RefNPDB. On the contrary, for a country where RefNPDB has not been implemented for number portability operation, it is highly likely that the options to be selected for establishing ENUM/ENUM-like mechanisms will be based on a different approach without a RefNPDB. As can be seen in the above examples, it can be assumed that ENUM/ENUM-like mechanisms as required by the transition of networks to an all-IP infrastructure (NGN included), will indeed be significantly affected by the existing number portability solutions previously adopted within each country.

Based on the above perspective, figure 6.1 provides a graphic summary of the different available options potentially suitable for establishing ENUM/ENUM-like mechanisms. Detailed process of creating these options is provided in Annex A of the present document. Each of the options, namely NP/ENUM-option 1, 2, 3 and 4, is brought under review in clauses 6.2 to 6.5 respectively, in terms of general descriptions (placing focus on the methods for database lookup/call routing).

It should be noted that, upon commercial implementation of the above new options, an intermediary phase, allowing for a "co-existence/combination" of the new option implemented and the existing number portability solution, might arise. In order to avoid causing operational hindrance to the number portability service and to ensure its continuous availability for the end-users, it might be necessary to place under review the methods, employed during this new/old combination phase, for performing database lookup and call routing between the new and old networks. A review on some of the different patterns of this "co-existence/combination" is provided in clause 7.



NOTE: The Donor network is not needed as a transit network for the signalling path.

Figure 6.1: Examples of ENUM/ENUM-like solution for number portability

6.2 Local ENUM with no sharing of NP data among operators (NP/ENUM-option 1)

In this option, each operator holds/manages a non-real-time database (NPDB) and a real-time Local ENUM database separately on its own. Database management does not involve any transfer of database information between the operators: that is, NP data stored within each operator's NPDB are converted to ENUM NAPTR records and stored in the Local ENUM database of each operator.

When a subscriber of the Donor network (i.e. the number range holder) ports out to another (i.e. the Recipient) network, the domain name in the URI/URL for the ported-out subscriber, stored within the Local ENUM database of the Donor operator, will be modified to show the NP data of the ported-out subscriber. The host part of the URI/URL will contain a DNS domain which is assigned to the recipient network.

As for call routing, there are a few possible methods, including the following two:

1) Routing method Example 1 (NP/ENUM-option 1-1)
NAPTR record of the porting subscriber is stored within the database of the Donor network (i.e. the number range holder).
For call routing, the Originating network will query the Local ENUM database of the Donor network (i.e. the number range holder) in order to obtain NP data of the porting subscriber.

2) Routing method Example 2 (NP/ENUM-option 1-2)
NAPTR record of the porting subscriber is stored within the database of the Recipient network. In addition to this, an NS record pointing to the ENUM server of the Recipient network will be stored within the database of the Donor network (i.e. the number range holder).
For call routing, the Originating network firstly queries the Local ENUM database of the Donor network (i.e. the number range holder), and then using the pointer information obtained from this query, secondly queries the Local ENUM database of the Recipient network in order to obtain NP data of the porting subscriber.
This option would be more suitable for countries whose existing number portability solutions **are based on** not sharing NPDB among operators (Option A).

6.3 Local ENUM with common/shared NP data among operators (NP/ENUM-option 2)

In this option, NP data regarding all the operators are stored within each operator's individual non-real-time database (NPDB). This is made possible either by:

i) each operator downloading data from the central non-real-time database (RefNPDB); or by

ii) mutual exchange of database information between each operator's decentralized individual non-real-time database (NPDB).

NP data (regarding all operators) stored within each operator's NPDB are converted to ENUM NAPTR records (regarding all operators) and stored in the Local ENUM database of each operator.

For call routing, the Originating network will query its own Local ENUM database in order to obtain NP data of the porting subscriber.

This option would be more suitable for countries whose existing number portability solutions **are based on** the utilization of RefNPDB/CRDB or mesh interconnection of NPDBs.

6.4 National ENUM with collective NP data from all operators (NP/ENUM-option 3)

In this option, a National ENUM database, together with a central non-real-time database (RefNPDB), is established to be shared by all the operators. NP data stored within each operator's individual non-real-time database is transferred to the RefNPDB; as a result the RefNPDB will hold NP data regarding all the operators. NP data (regarding all operators) stored within the RefNPDB are converted to ENUM NAPTR records (regarding all operators) and stored in the National ENUM database.

For call routing, each operator directly queries this National ENUM database in order to perform real-time processing.

This option would be more suitable for countries whose existing number portability solutions **are based on** the utilization of central NP databases.

6.5 Hierarchical ENUM (NP/ENUM-option 4)

In this option, hierarchical architecture is adopted for the ENUM database: that is, Tier-2 ENUM databases are established on the operator level and a Tier-1 ENUM database is established on the national level.

Each operator holds/manages a non-real-time database (NPDB) and a real-time Tier-2 ENUM database separately on its own. NP data stored within each operator's NPDB are converted to ENUM NAPTR records and stored in the Tier-2 ENUM database of each operator.

In addition to this, a Tier-1 ENUM database is established on the national level to be shared by all the operators. NS records pointing to Recipient networks will be stored within this Tier-1 ENUM database.

When a subscriber of an operator ports out to another (i.e. the Recipient) operator, this Recipient operator will create an NAPTR record of the ported-in subscriber and store it within its Tier-2 ENUM database. At the same time, an NS record pointing to the Recipient network will be created within the Tier-1 ENUM database.

For call routing, the Originating network firstly queries the Tier-1 ENUM database, and then using the pointer information obtained from this query, secondly queries the Tier-2 ENUM database of the Recipient operator in order to obtain NP data of the porting subscriber.

This option would be more suitable for countries whose existing number portability solutions **are based on** the utilization of central NP databases.

Figure 6.2 shows example of call setup process for Hierarchical ENUM (NP/ENUM-option 4).

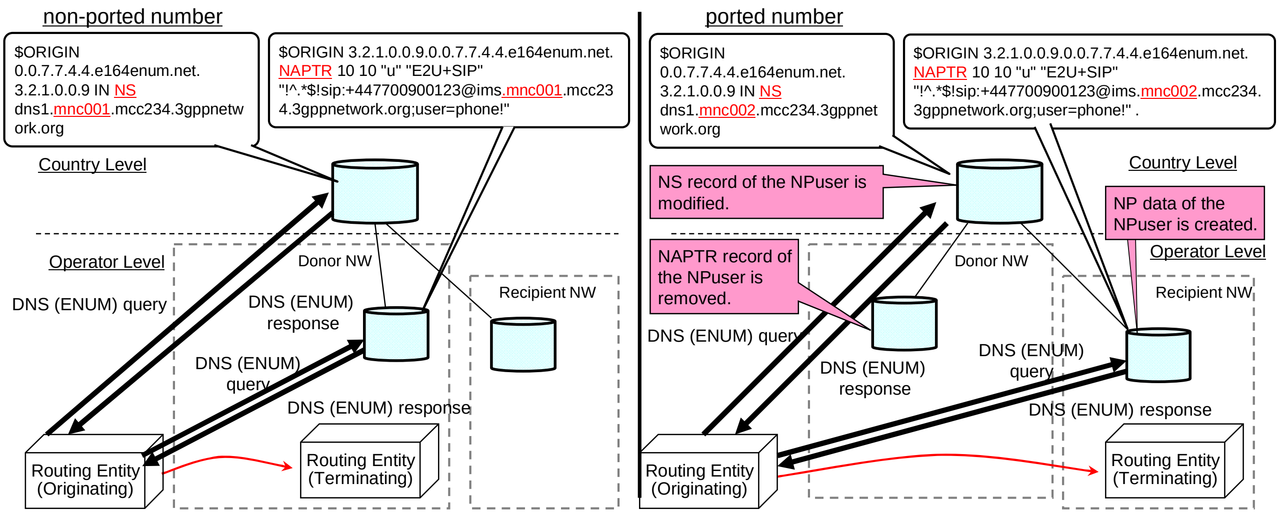


Figure 6.2: Example of call setup process for Hierarchical ENUM (NP/ENUM-option 4)

7 Review on the new/old combination phase

7.0 General

As mentioned in the previous clauses, an intermediary phase might arise upon implementation of the new NP/ENUM-options, allowing for a "co-existence/combination" of the new option implemented and the existing number portability solution (NP solutions for the latter are described in detail in clause 5). In order to avoid causing operational hindrance to the number portability service and to ensure its continuous availability for the end-users, it might be necessary to place under review the methods, employed during this new/old combination phase, for call routing between the new and old networks and for database lookup to enable that routing. Variation of the new/old combination can be vast in number depending on how existing and new networks are combined. However, since Solution C and Solution A can at the time of writing be regarded as the number portability solutions adopted in most countries, this clause places under review specifically two types of transition/combination, as shown below:

- Solution C => NP/ENUM-option 2; and
- Solution A (supporting onward routing) => NP/ENUM-option 1

7.1 Example 1: Call routing/database lookup method employed during the new/old combination phase for transition type "Solution C => Option 2"

Example 1 addresses the transition type where Solution C has been deployed as the existing number portability database solution, and Option 2 is expected to be implemented in accordance with the transition to an all-IP/NGN infrastructure. Relevant networks in example 1 fall broadly into two categories:

i) existing PSTN/PLMN and all-IP/NGN in which Solution C has been deployed (hereinafter referred to as the "OLD" network); and

ii) IP/NGN network in which Option 2 will be implemented (hereinafter referred to as the "NEW" network).

From the aspect of functional capability enabling the provision of number portability service, these networks can also be classified into three categories:

a) the "ORIGINATING" network;

b) the "DONOR" network; and

c) the "RECIPIENT" network.

With regards to the combination of NEW/OLD and ORIGINATING/DONOR/RECIPIENT, there will be eight possible combinations in all; however, due to the fact that the "DONOR" network has no role to play within this "Solution C => Option 2" transition, there will be four possible combinations in all (see table 7.1). For each of the combinations listed in table 7.1, a graphic explanation of the potential call routing and the database lookup method to enable that routing is provided in figure 7.1. It should be noted that in order to be able to address Pattern [3] in figure 7.1 where the call needs to be routed from the "ORIGINATING" "NEW" network to be terminated on the "RECIPIENT" "OLD" network, the "NEW" network can possibly be required to maintain a legacy OpDB in addition to the new ENUM database. This holds true in cases where the NP data indicating the "RECIPIENT" "OLD" network is not stored within the ENUM database of the "ORIGINATING" "NEW" network.

Table 7.1: Combination of networks for transition type "Solution C => Option 2"

NETWORK CATEGORY			PATTERN
Originating	Donor	Recipient	
OLD		OLD	[1]
		NEW	[2]
NEW		OLD	[3]
		NEW	[4]

OLD: existing network
NEW: IP/NGN network supporting ENUM/ENUM-like mechanisms

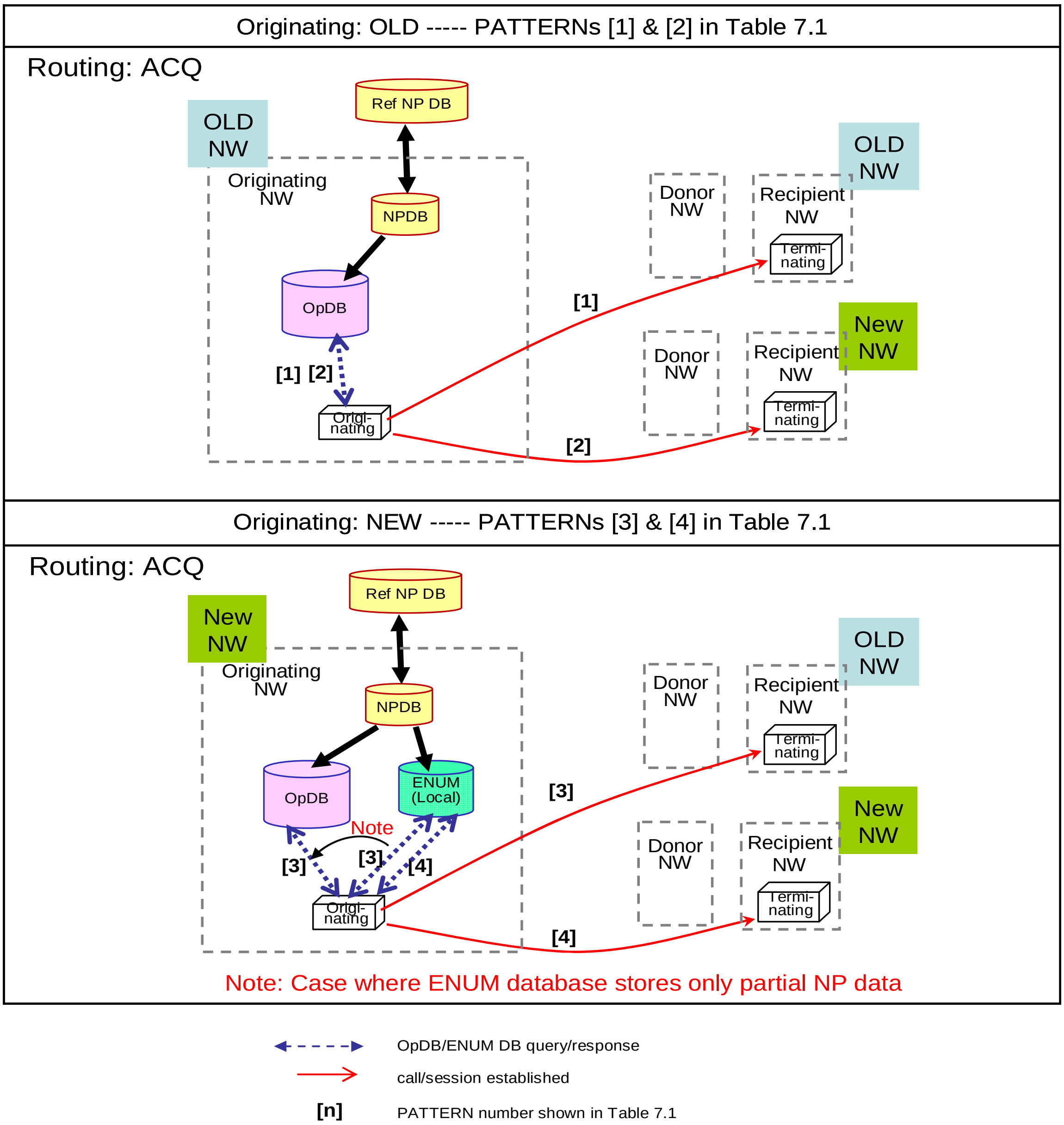


Figure 7.1: Example of call routing/database lookup method for transition type "Solution C => Option 2"

7.2 Example 2: Call routing/database lookup method employed during the new/old combination phase for transition type "Solution A => Option 1"

Example 2 addresses the transition type where Solution A has been deployed as the existing number portability database solution, and Option 1 (supporting onward routing) is expected to be implemented in accordance with the transition to an all-IP/NGN infrastructure. Relevant networks in example 2 fall broadly into two categories:

i) existing PSTN/PLMN in which Solution A has been deployed (hereinafter referred to as the "OLD" network); and

ii) IP/NGN network in which Option 1 will be implemented (hereinafter referred to as the "NEW" network).

From the aspect of functional capability enabling the provision of number portability service, these networks can also be classified into three categories:

a) the "ORIGINATING" network;

b) the "DONOR" network; and

c) the "RECIPIENT" network.

Hence, with regards to the combination of NEW/OLD and ORIGINATING/DONOR/RECIPIENT, there will be eight possible combinations in all (see table 7.2).

For each of the combinations listed in table 7.2, a graphic explanation of the potential call routing and the database lookup method to enable that routing is provided in figure 7.2. Concerning the various Patterns depicted in figure 7.2, the following two points need to be taken into consideration:

- In order to be able to address Patterns [3] & [4] in figure 7.2 where the call is routed from the "ORIGINATING" "OLD" network to the "DONOR" "NEW" network, the "DONOR" "NEW" network will be required to maintain a legacy OpDB, in addition to the new ENUM database, and perform onward routing.
- In order to be able to address Patterns [5] & [6] in figure 7.2 where the call is routed from the "ORIGINATING" "NEW" network to the "DONOR" "OLD" network, the "ORIGINATING" "NEW" network will be required to perform onward routing.

Table 7.2: Combination of networks for transition type "Solution A => Option 1 (supporting Routing Method 1)"

NETWORK CATEGORY			PATTERN
Originating	Donor	Recipient	
OLD	OLD	OLD	[1]
		NEW	[2]
	NEW	OLD	[3]
		NEW	[4]
NEW	OLD	OLD	[5]
		NEW	[6]
	NEW	OLD	[7]
		NEW	[8]

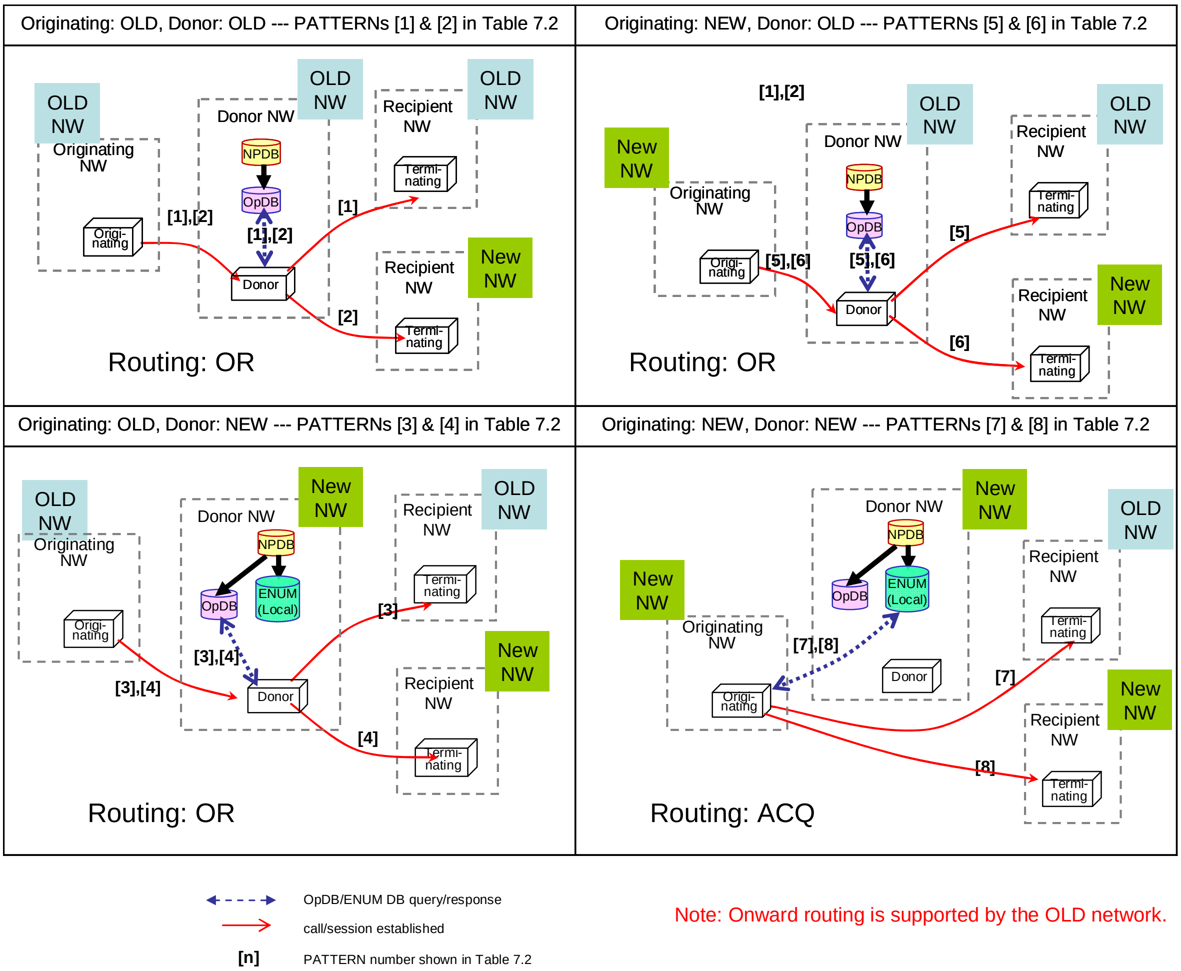


Figure 7.2: Example of call routing/database lookup method for transition type "Solution A => Option 1"

8 Conclusions

Although various kinds of methods for realizing a number portability with respect to IP address-based networks such as NGN could possibly be listed, actual use cases can be categorized into several feasible options considering that ENUM-like mechanism will probably be selected due to the fact that E.164 numbers still are used as the primary identifier and also continuation from the existing number portability solution will definitely be an important requirement in each country. The present document is revised in order to introduce several use cases of current or proposed number portability solutions in the context of all IP network architectures in 7 countries. Although these use cases might include indecisive area it can be said that other options than ENUM-like technology concerning all IP Number Portability and the ENUM-based option might not necessarily be the target for some networks or countries.

Annex A: Conceptual overview of options for ENUM-like solution

A.1 Procedure for creating options for ENUM-like solution based on actual use cases

Target of this clause is to organize and provide a graphic and conceptual overview of the available options for implementing/establishing ENUM-like mechanisms, using as a basis the actual use cases (for instance a Dutch ENUM implementation [i.9], a North American ENUM implementation [i.10], a German ENUM implementation [i.11]) and studies undertaken by other Organizations (for instance GSMA IR.67 [i.8]). Preferable options for establishing ENUM-like mechanisms would be those by which existing NP mechanisms (already in operation within each country) could be utilized to a maximum extent.

This clause proposes a blueprint of the procedure for the creation of options for establishing ENUM-like mechanisms.

Figure A.1.1 shows the procedure for creating options for ENUM-like solution.

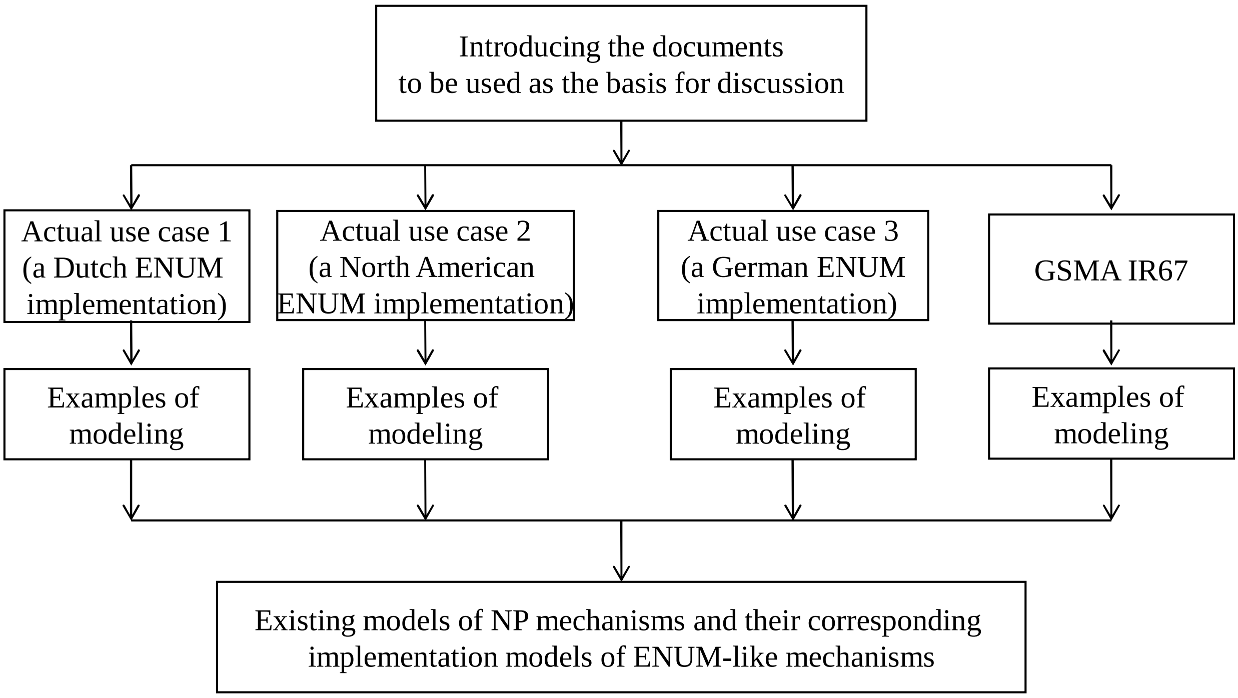


Figure A.1.1: Procedure for creating options for ENUM-like solution

A.2 Documents to be referred

A.2.1 ETSI TR 184 003

NP use cases covered in ETSI TR 184 003 [i.7] range widely from use cases based on existing legacy networks to use cases based on IP-based networks (including NGN). Use cases based on ENUM-like mechanisms are also covered in ETSI TR 184 003 [i.7].

Establishing a correspondence between these use cases covered in ETSI TR 184 003 [i.7] and the actual use cases (for instance a Dutch ENUM implementation [i.9]) or studies undertaken by other SDOs or industry fora (for instance GSMA IR.67 [i.8]) enables to support validity of the available options for ENUM-like solution created in the present document.

Figure A.2.1 illustrates the NP use cases covered in ETSI TR 184 003 [i.7].

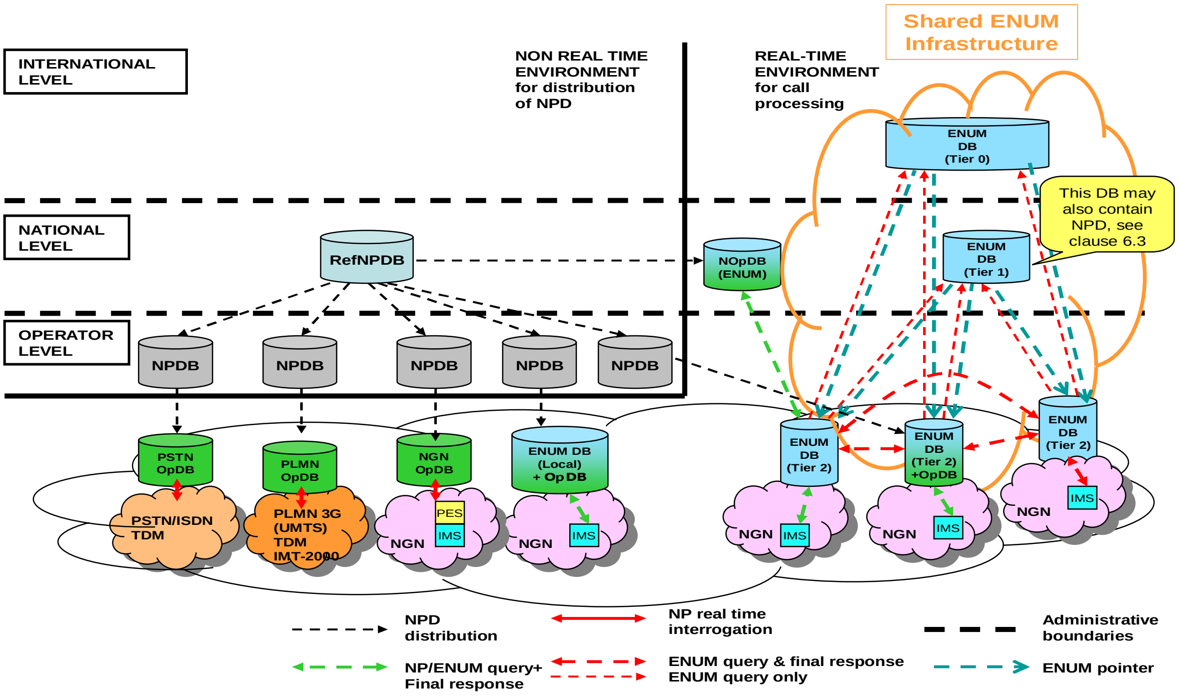


Figure A.2.1: NP use cases covered in ETSI TR 184 003 [i.7]

A.2.2 Recommendation ITU-T E.164 Supplement 2

Graphically represented NP solutions of the existing various NP mechanisms are provided in the revised version of Recommendation ITU-T E.164 Supplement 2 [i.2], approved at the SG 2 meeting held in June 2014. As these NP solutions provided in Recommendation ITU-T E.164 Supplement 2 [i.2] maintain consistency with ETSI TR 184 003 [i.7], they can be directly used as the examples of solutions for existing NP mechanisms to be laid out in the present document.

Figure A.2.2 shows NP solutions of the existing NP mechanisms in Recommendation ITU-T E.164 Supplement 2 [i.2].

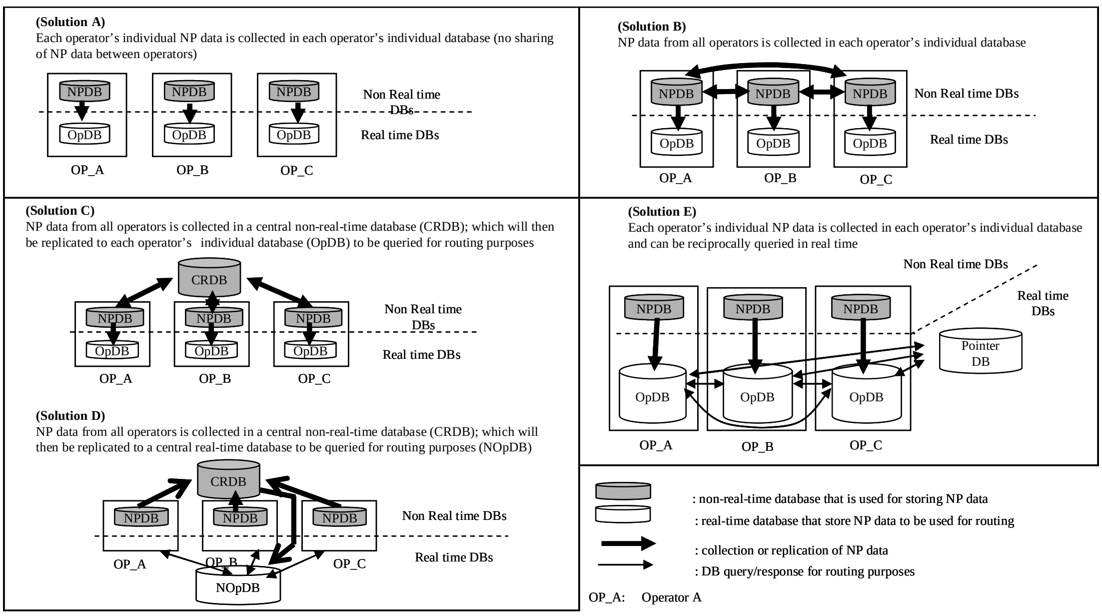


Figure A.2.2: Solutions of the existing NP mechanisms in Recommendation ITU-T E.164 Supplement 2 [i.2]

A.2.3 GSMA IR.67

Different use cases for ENUM-like mechanisms, depending on whether the existing NP operation is based on a centralized database approach or a distributed database approach, are provided in GSMA IR.67 "ENUM Options for Number Portability". GSMA IR.67 [i.8] is a helpful reference when setting out in the present document the available options for implementing/establishing ENUM-like mechanisms that have correspondence (or some kind of continuality) with existing NP solutions.

Figure A.2.3 shows use cases for ENUM-like mechanisms in GSMA IR.67 [i.8].

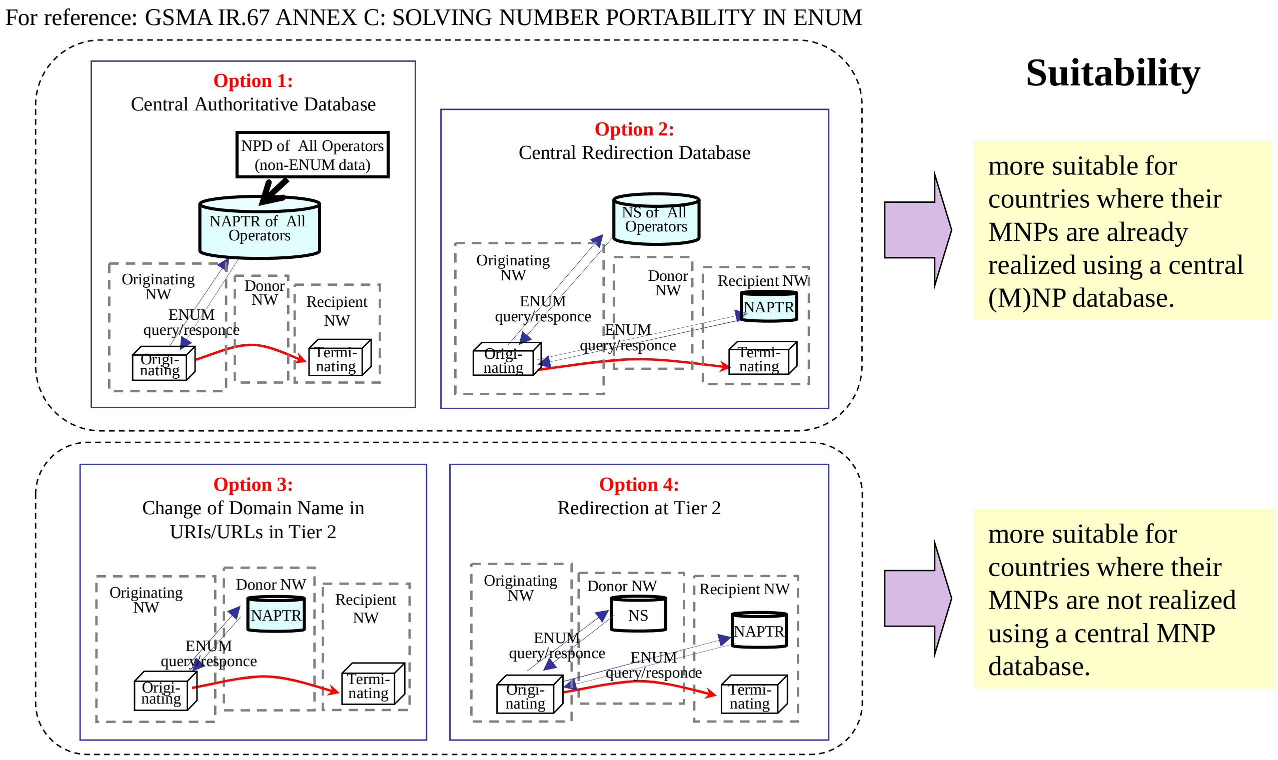


Figure A.2.3: Use cases for ENUM-like mechanisms in GSMA IR.67 [i.8]

A.3 Creating conceptual overview of options for ENUM-like solution - 1

A.3.1 Establishing a correspondence between the use cases covered in ETSI TR 184 003 and the actual use cases in the United States/the Netherlands

ENUM-like mechanisms capable of working in collaboration with existing NP systems are scheduled for implementation in the United States and the Netherlands.

Therefore, these actual use cases in the United States and the Netherlands can be listed as appropriate reference examples for the available options for implementing/establishing ENUM-like mechanisms that are laid out in the present document.

Figure A.3.1 shows correspondence between ETSI TR 184 003 [i.7] and the actual use cases.

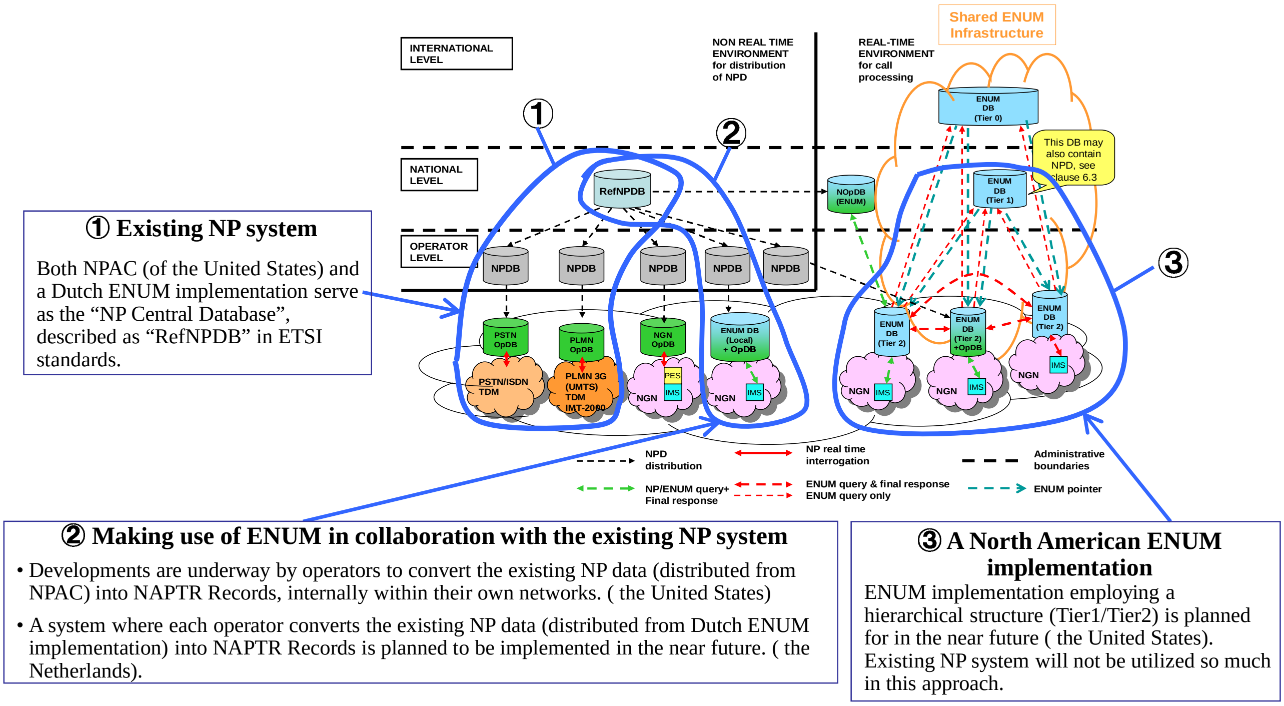


Figure A.3.1: Correspondence between ETSI TR 184 003 [i.7] and the actual use cases

A.3.2 Creating options for ENUM-like solution based on actual use cases in the United States/the Netherlands

Two options for establishing ENUM-like mechanisms can be extracted from the actual use cases under progress in the United States and the Netherlands.

Figure A.3.2 shows creating options for ENUM-like solution based on actual use cases.

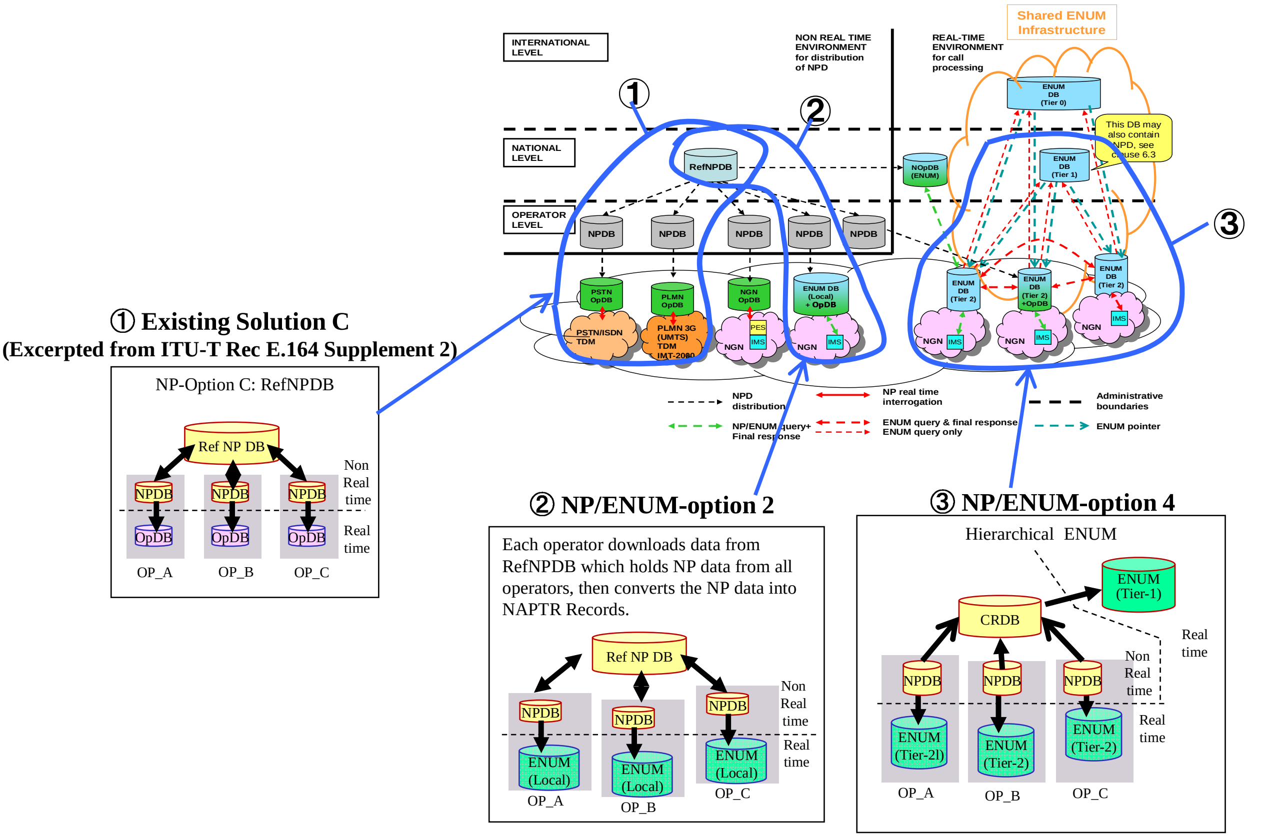


Figure A.3.2: Creating options for ENUM-like solution based on actual use cases (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

A.4 Creating conceptual overview of options for ENUM-like solution - 2

A.4.1 Establishing a correspondence between the use cases covered in ETSI TR 184 003 and GSMA IR.67

Different use cases for ENUM-like mechanisms, depending on whether the existing NP operation is based on a centralized database approach or a distributed database approach, are provided in GSMA IR.67. Correspondence between the use cases covered in ETSI TR 184 003 [i.7] and GSMA IR.67 [i.8] can be established as can be seen in figure A.4.1.

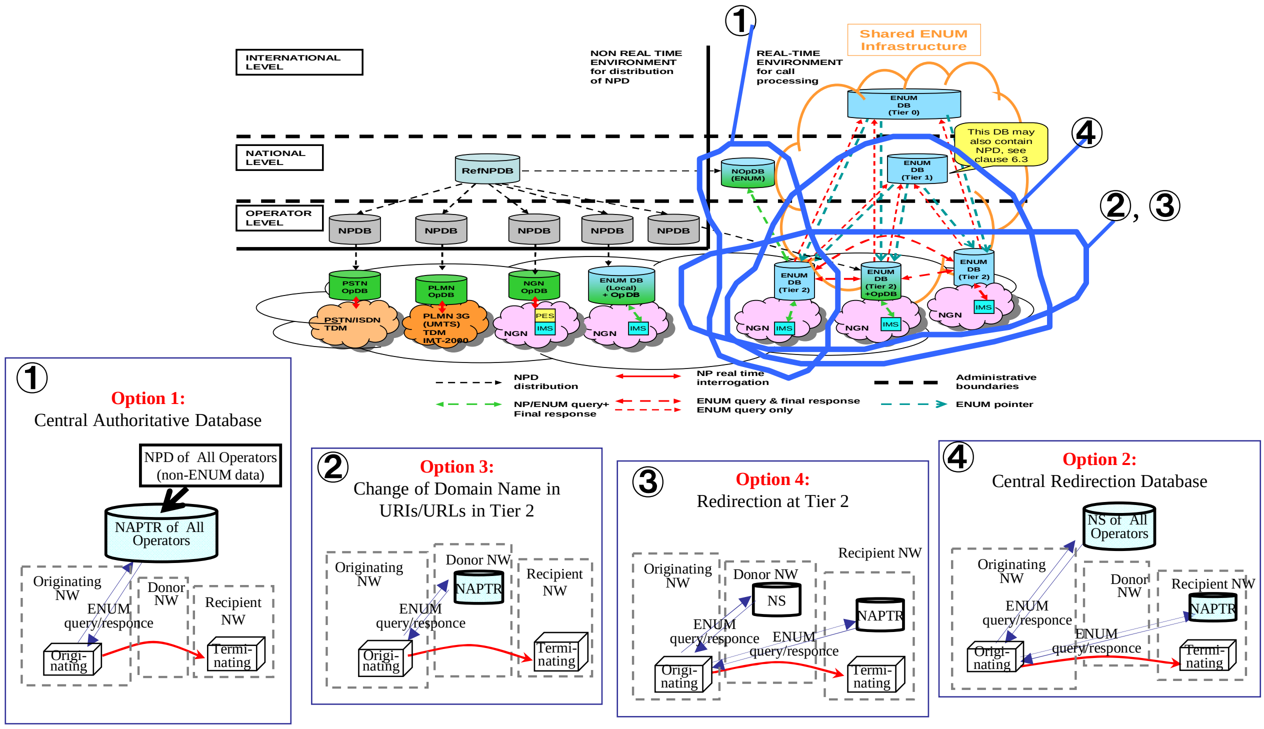


Figure A.4.1: Correspondence between the use cases in ETSI TR 184 003 [i.7] and GSMA IR.67 [i.8]

A.4.2 Creating options for ENUM-like solution based on use cases provided in GSMA IR.67

Three options for establishing ENUM-like mechanisms can be extracted from the use cases provided in GSMA IR.67 [i.8].

Figure A.4.2 shows creating options for ENUM-like solution based on use cases provided in GSMA IR.67 [i.8].

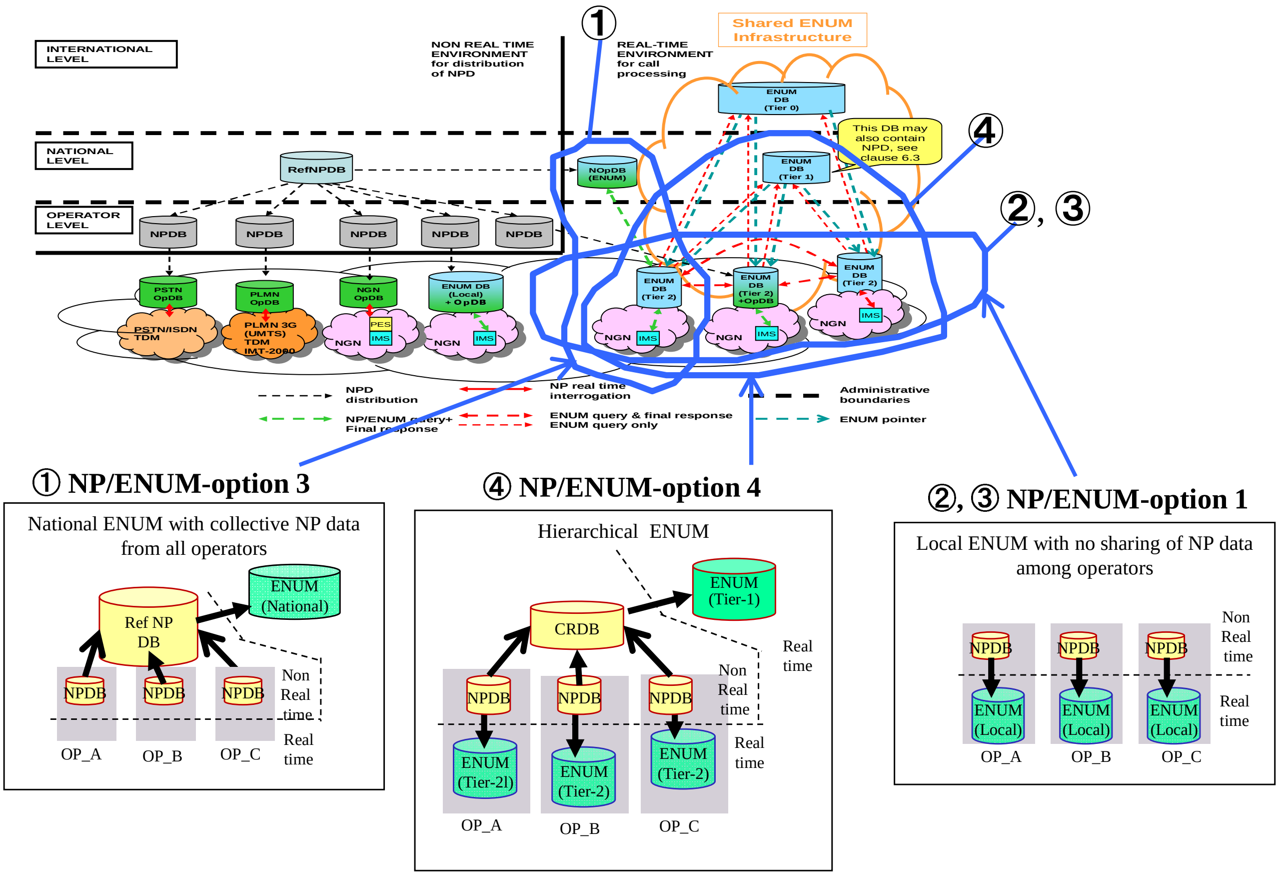


Figure A.4.2: Creating options for ENUM-like solution based on use cases provided in GSMA IR.67 [i.8]

A.5 Creating conceptual overview of options for ENUM-like solution - 3

A.5.1 Creating options for ENUM-like solution based on a German ENUM implementation

Correspondence between ETSI TR 184 003 [i.7] and a German ENUM implementation, together with a corresponding option for establishing ENUM-like mechanism are shown in figure A.5.1.

NOTE: Among descriptions from (1) to (6) on System architecture of a German ENUM implementation in figure A.5.1, description (2) is solely related to number portability. Others are not related to number portability and are not expected to have any impact on regulatory requirement.

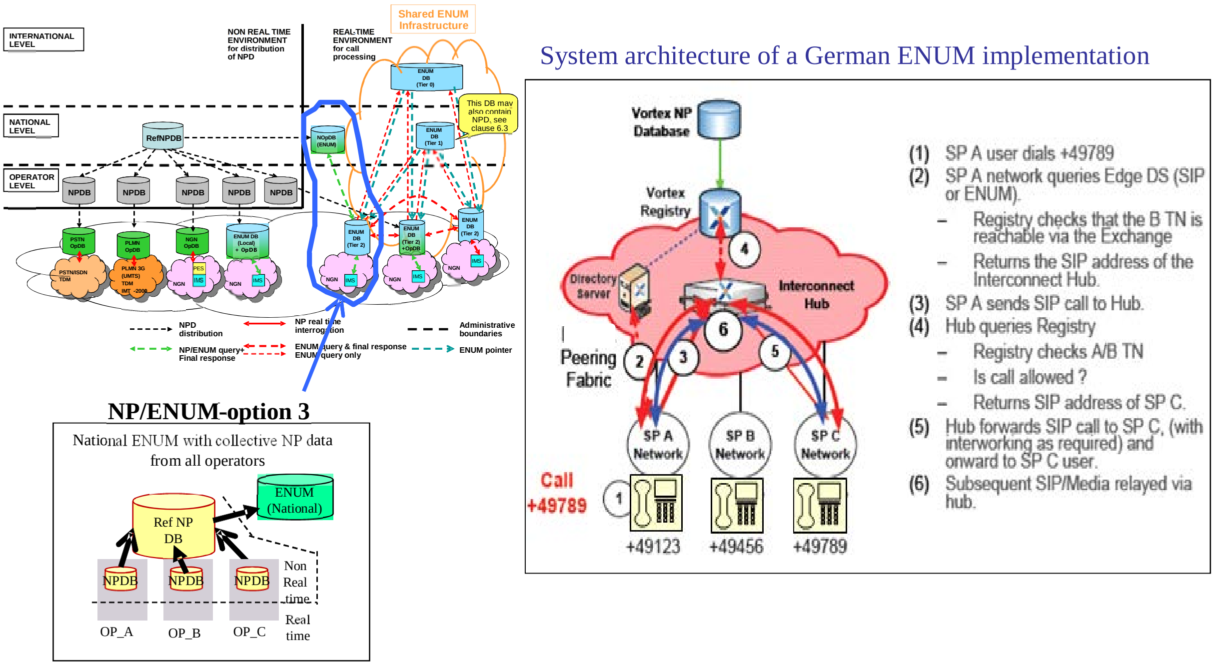


Figure A.5.1: Creating options for ENUM-like solution based on a German ENUM implementation use case

A.6 Existing options for establishing NP mechanisms and their corresponding options for establishing ENUM-like mechanisms

Based on the actual use cases and studies undertaken by other SDOs, available options for establishing ENUM-like mechanisms, with which existing NP mechanism could be utilized to a maximum extent, are shown in figure A.6.1. Since large investments towards NP implementation/operation have already been spent within each country, a reasonable form of implementing ENUM-like mechanism would be to implement it as some sort of an extension of the already existing NP mechanism.

With regards to option 4 for ENUM-like mechanism, however, new implementation will be necessary on a relatively large scale and the existing NP system will not be utilized as much in comparison to the rest of the options for implementing ENUM-like mechanisms.

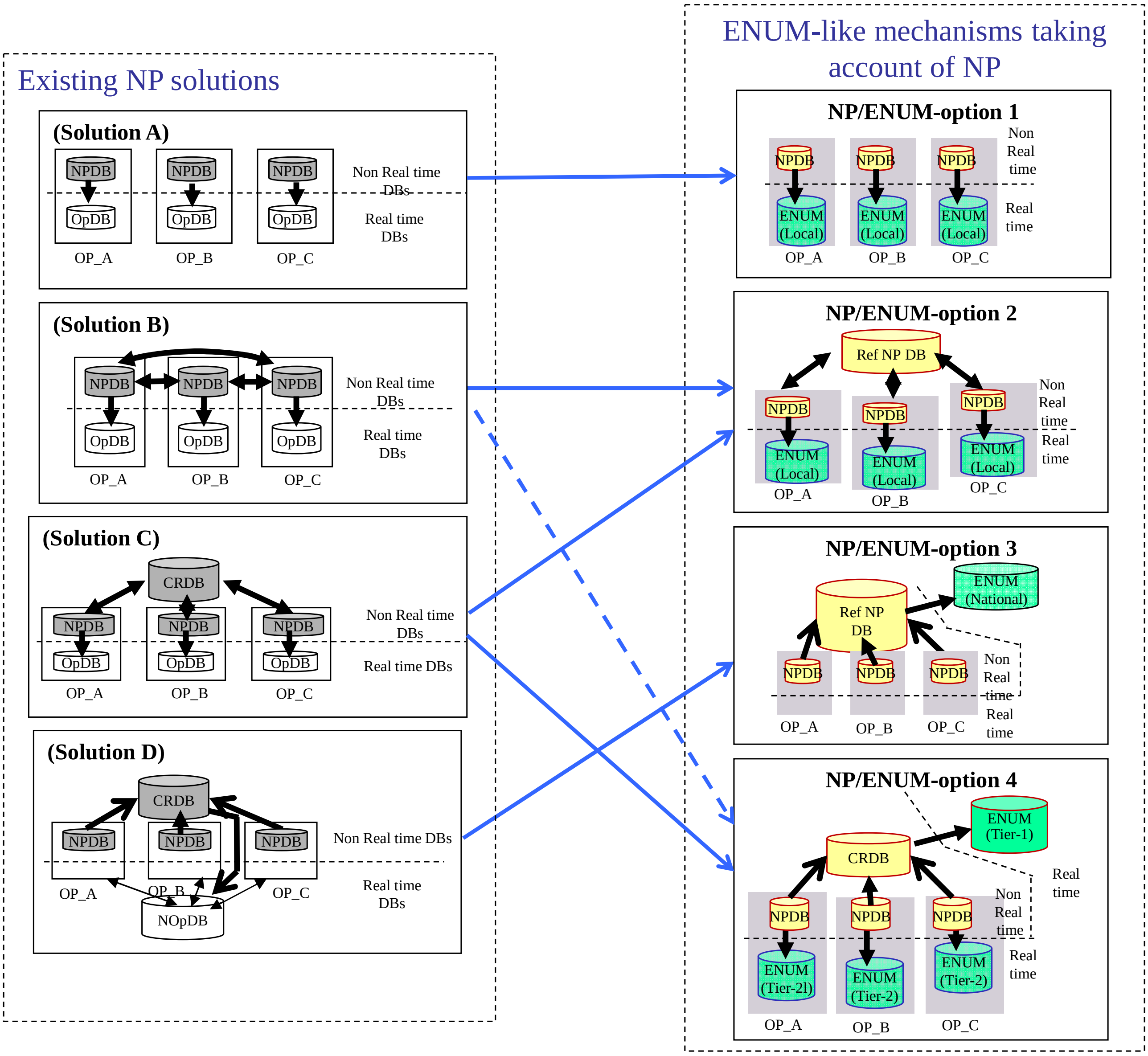


Figure A.6.1: Existing NP solutions and their corresponding options for ENUM-like mechanisms

Annex B: Several Use cases of Number Portability toward all IP

B.1 Use Case in Japan [ENUM-like]

Standardization of number portability architecture in Japan (see note) concerning the ongoing transition of networks to an all-IP infrastructure (NGN included) is introduced in this clause. In Japan "Local ENUM with no sharing of NP data among operators" based on the Recommendation ITU-T E.164 Supplement 2 [i.2] was recommended as future solution and incorporated into the national standard of number portability architecture created in 2015 (see note). Operators in Japan will follow the national standard in the near future. The details are given in figure B.1.1 and figure B.1.2.

NOTE: JJ-90.31-v3 [i.13] by TTC of Japan and JT-E164_Supplement_2 [i.14] by TTC of Japan (for this only Japanese language version is published except the general edition.)

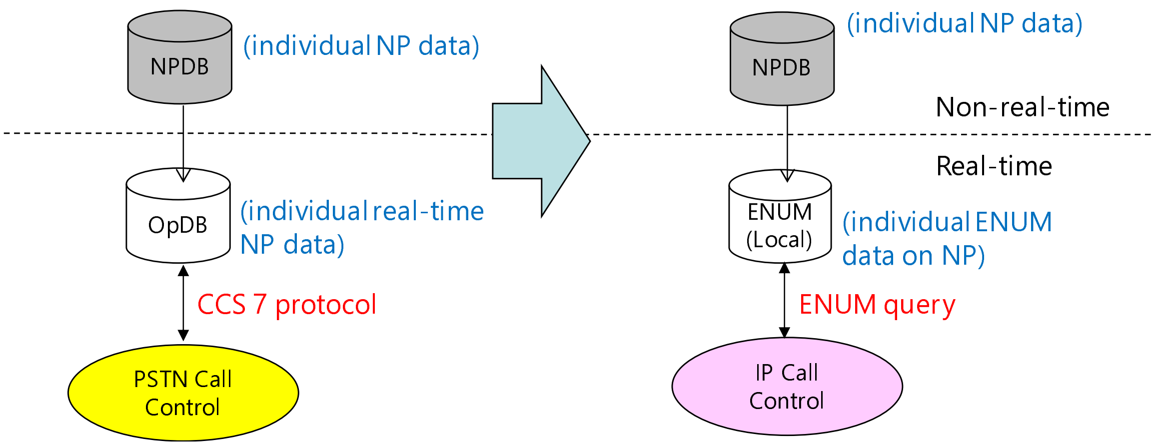


Figure B.1.1: Description of NP use case in Japan [ENUM-like]

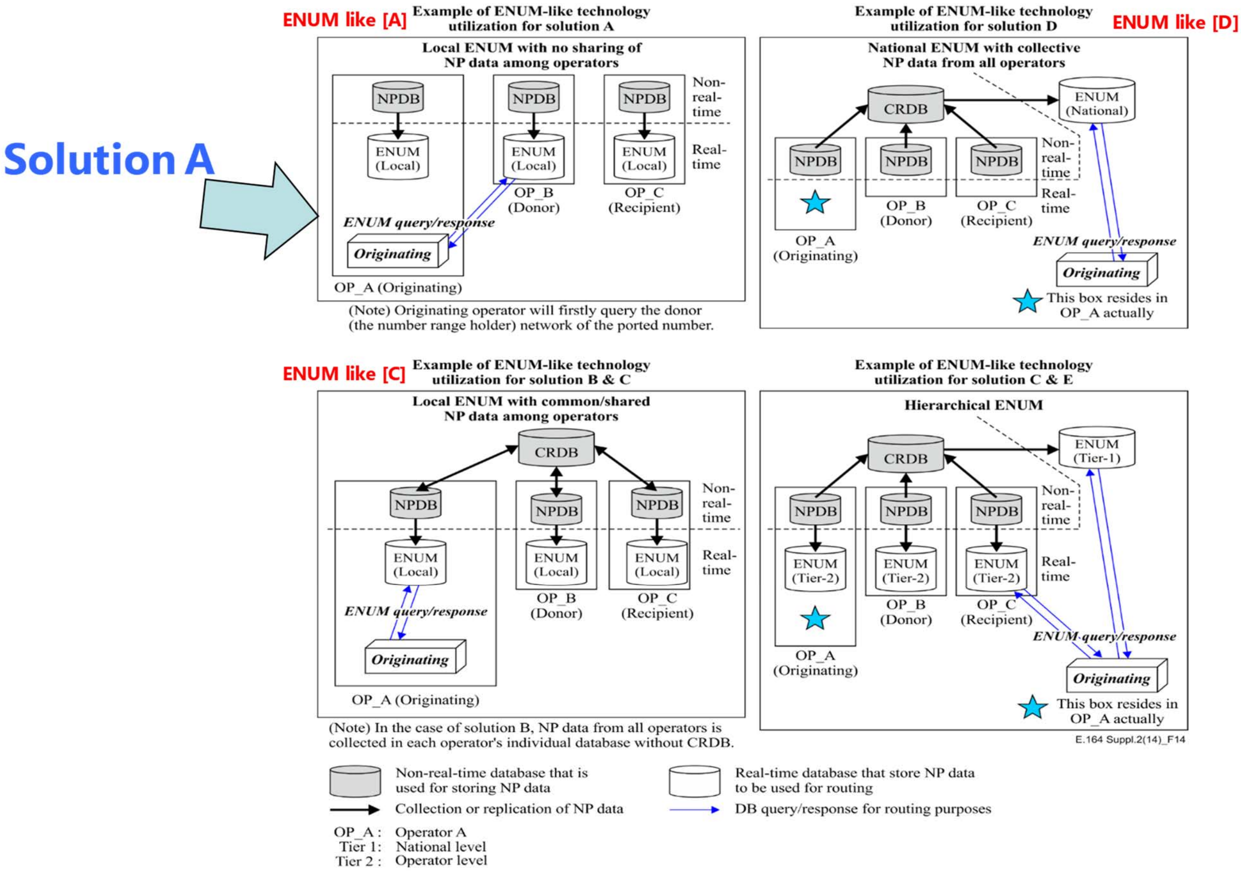


Figure B.1.2: Mapping to E.164 Supplement 2; NP use case in Japan [ENUM-like] (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

B.2 Use Case in the United States [non-ENUM like]

In the US, the existing number portability infrastructure can be categorized as solution C (NP data from operators is collected in a central non-real-time database (CRDB), which will then be replicated to each operator's individual database (OpDB)).

It can be considered that at the time of writing in the US and for the time being, existing CRDB and NPDB will be used even in all IP architectures although the direction might not be decisive yet.

In the future ENUM-like technology may be partially used inside IP Call Control domain depending on each individual operator's choice.

The details are given in figure B.2.1 and figure B.2.2.

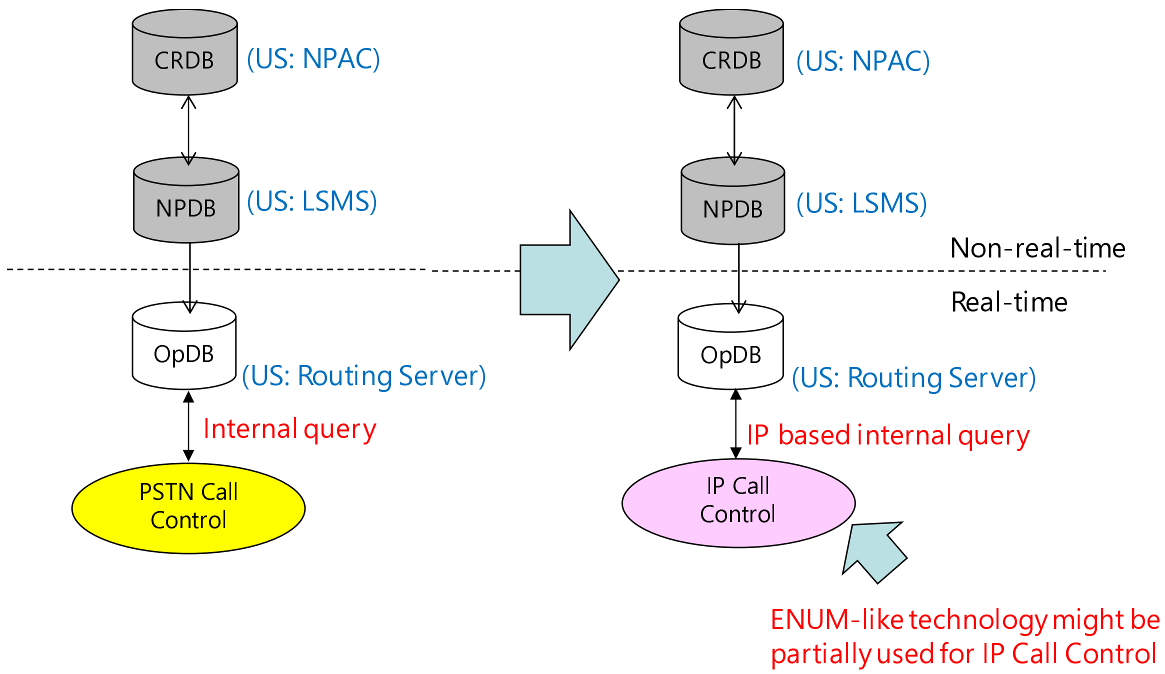


Figure B.2.1: Description of NP use case in the US [non-ENUM like]

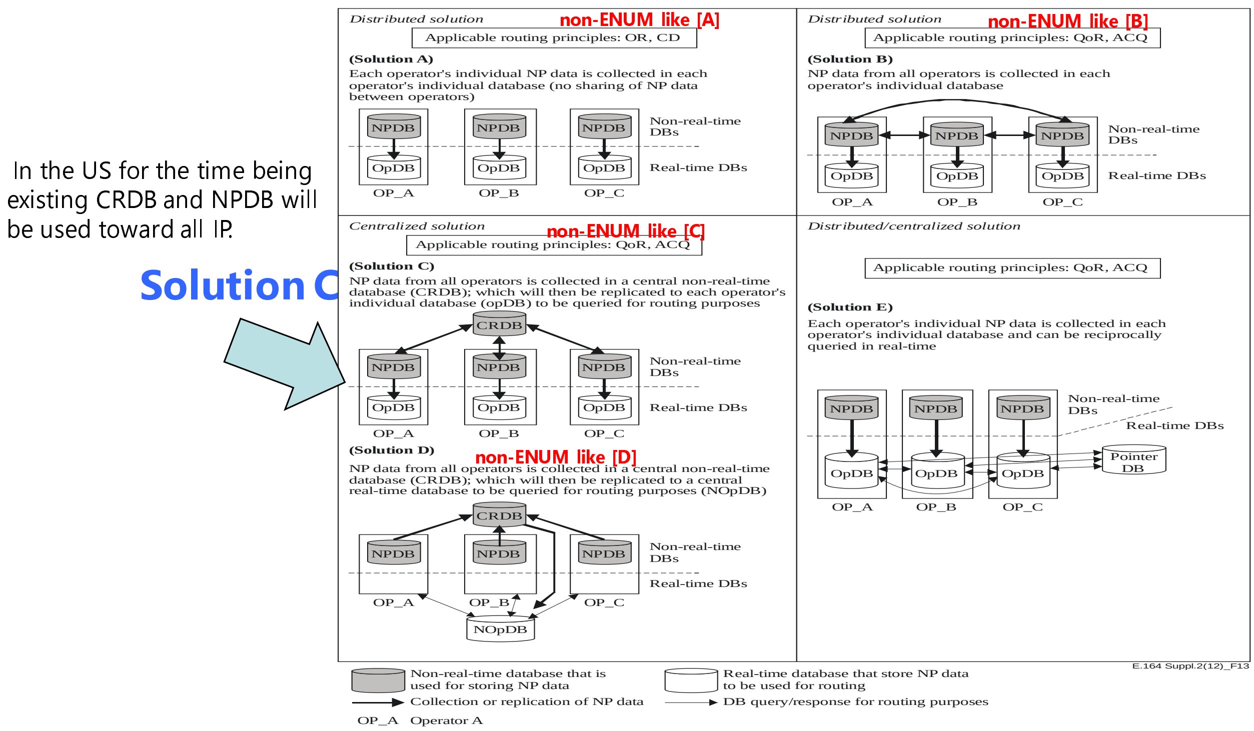


Figure B.2.2: Mapping to E.164 Supplement 2; NP use case in the US [non-ENUM like] (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

B.3 Use Case in the Netherlands [Both non-ENUM-like and ENUM-like could be used optionally]

In the Netherlands, two Options were considered. Option 1; At the time of writing operators can use non-ENUM like [C] and ENUM like [C] optionally. Option 2; I is foreseen that operators will be able to use non-ENUM like [C] and ENUM like [D] optionally.

The details are given in figure B.3.1, figure B.3.2 and figure B.3.3.

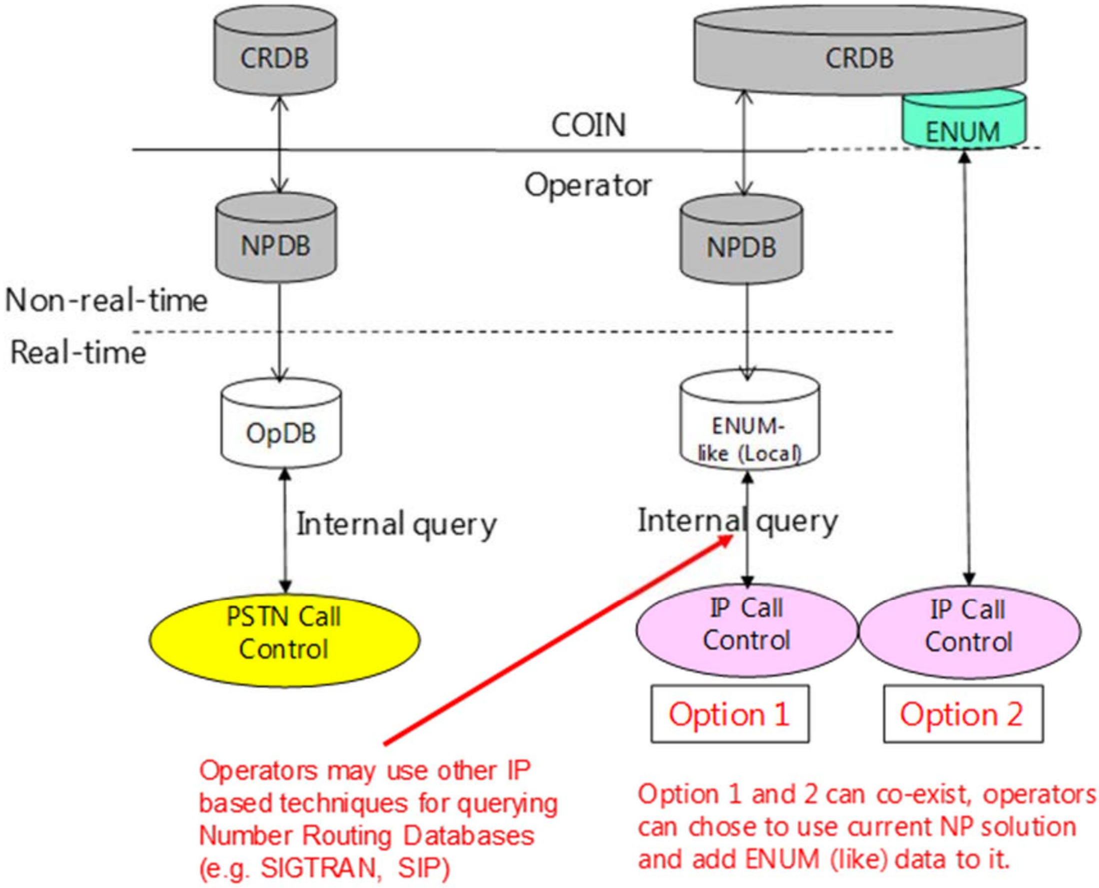


Figure B.3.1: Description of NP use case in the Netherlands [Both non-ENUM-like and ENUM-like could be used optionally]

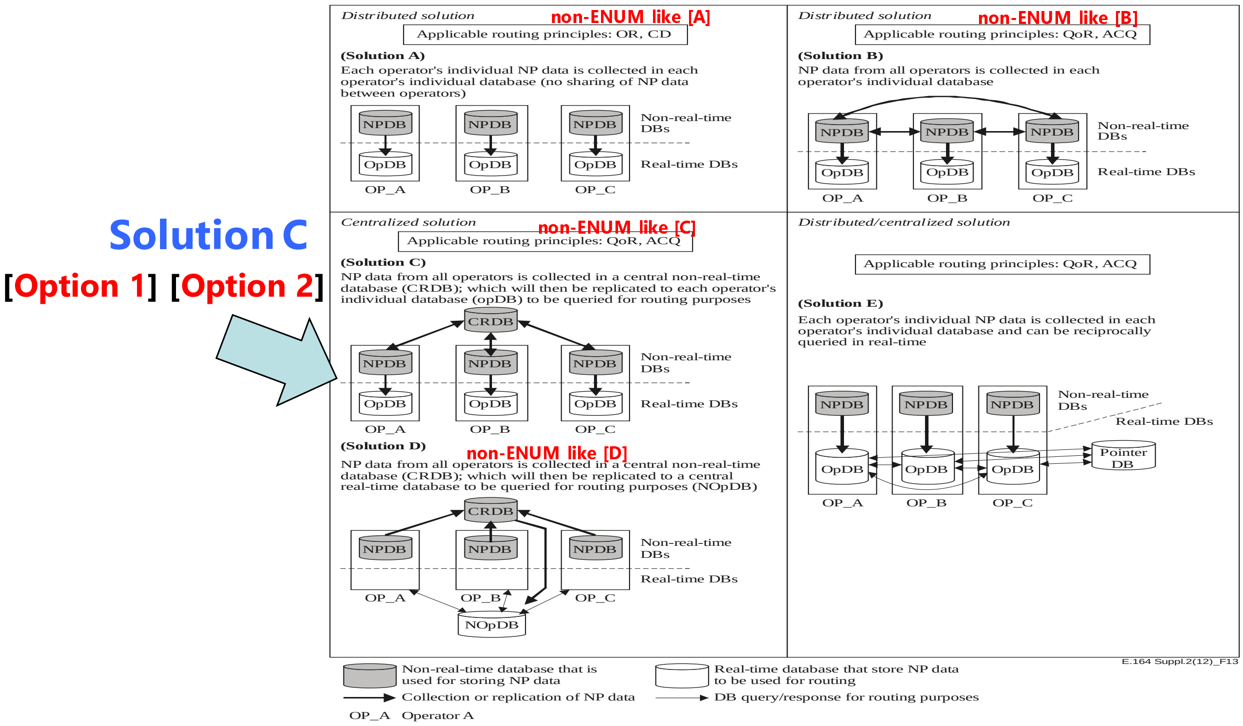


Figure B.3.2: Mapping to E.164 Supplement 2; NP use case in the Netherlands [non-ENUM-like] (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

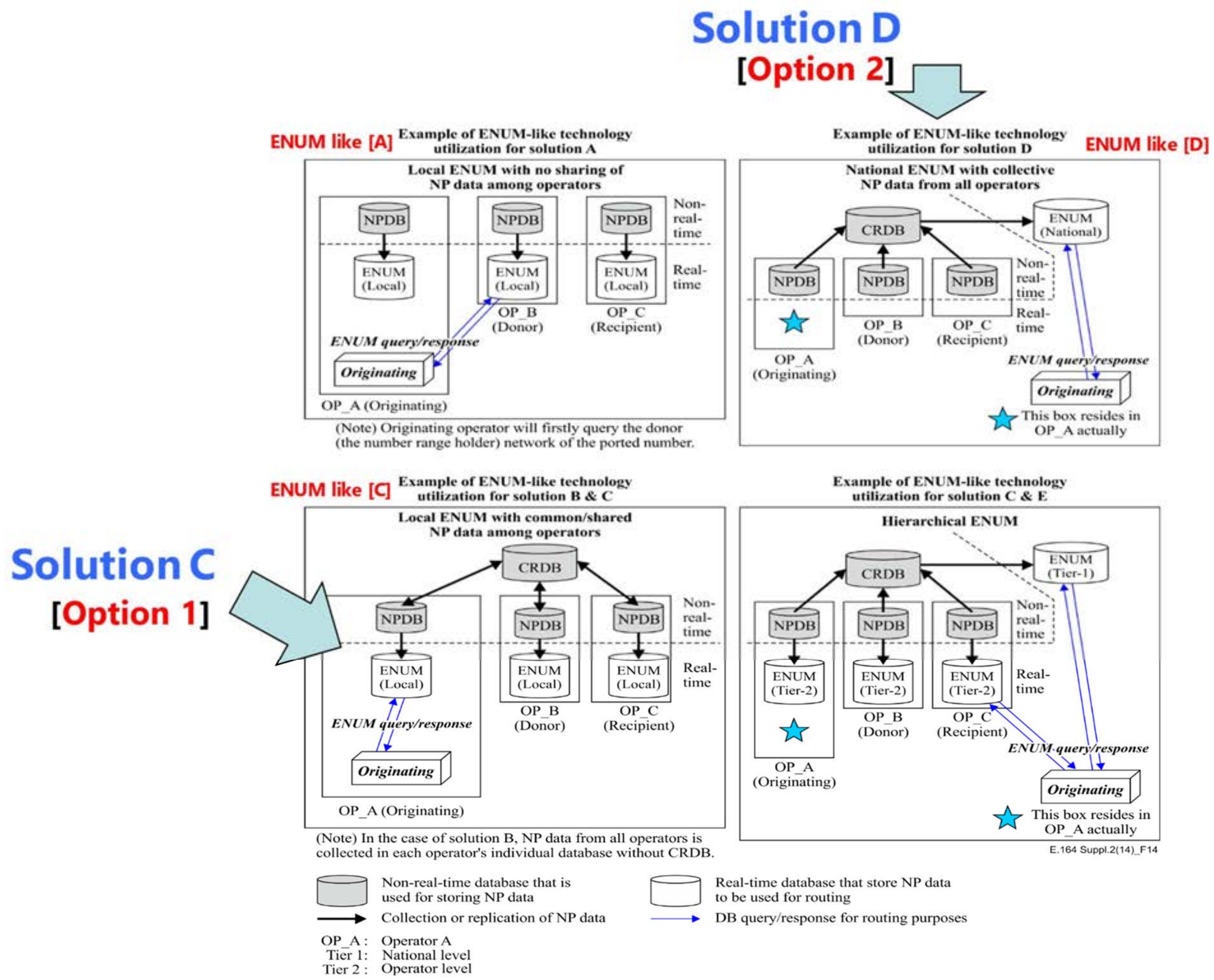


Figure B.3.3: Mapping to E.164 Supplement 2; NP use case in the Netherlands [ENUM-like] (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

B.4 Use Case in Italy [non-ENUM like]

In Italy, the solution that is in use for fixed networks is different from the one from mobile networks.

For fixed networks at the time of writing onward routing is used. There is at the time of writing on-going work to consider whether it is necessary to change this.

For mobile networks currently the NP data of all mobile numbers is synchronized and ACQ is used. All DBs contain the same global information. No change for this mechanism for all IP NW is foreseen. In this case IP call control will use IP based internal query. The operator DB is organized in two levels as follows:

- First level: the information is exchanged among all the mobile operators.
- Second level:
  - the mobile operator exchanges the routing information only with one mobile operator of the first level;
  - the fixed network operator receives the routing information only from one mobile operator of the first level.

The details are given in figure B.4.1 and figure B.4.2.

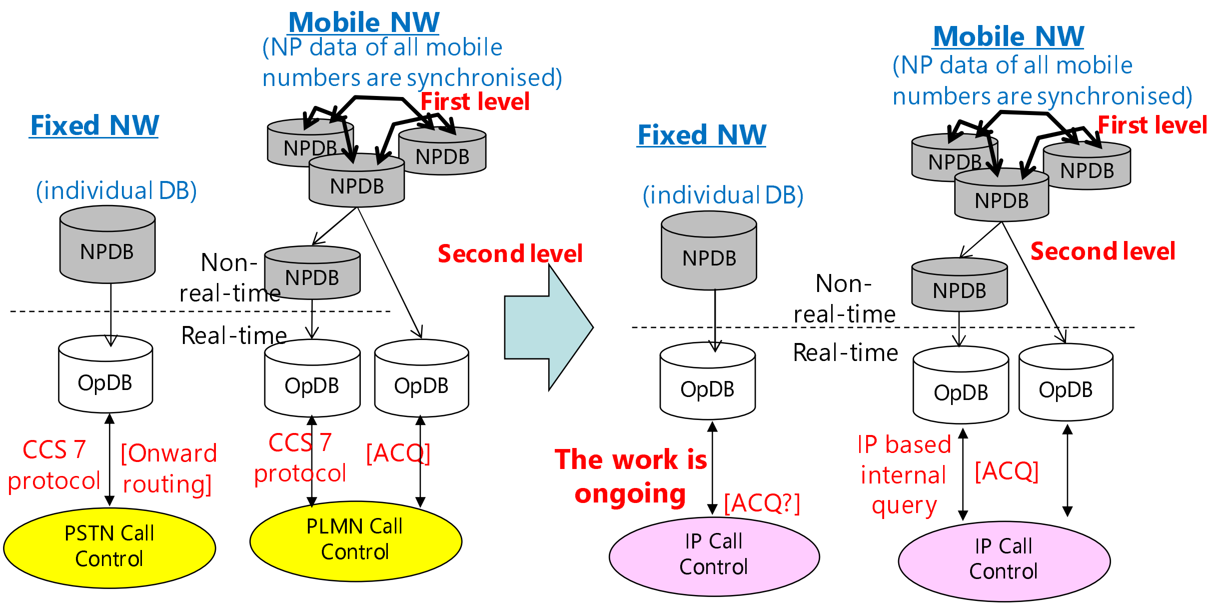


Figure B.4.1: Description of NP use case in Italy [non-ENUM like]

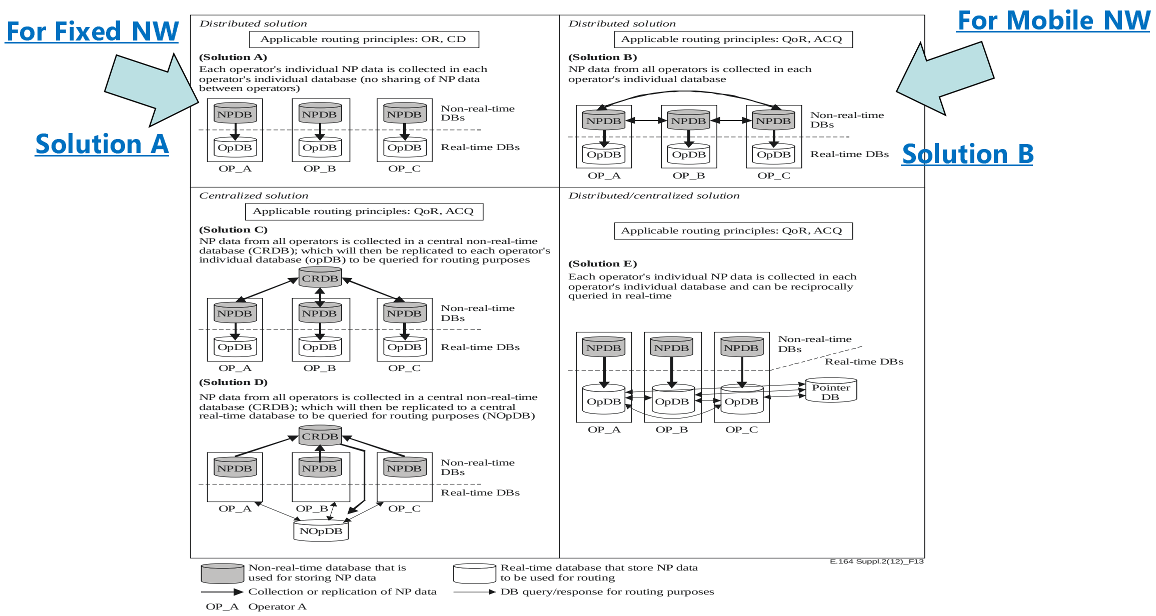


Figure B.4.2: Mapping to E.164 Supplement 2; NP use case in Italy [non-ENUM like] (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

B.5 Use Case in Switzerland [non-ENUM like]

In Switzerland, the existing number portability infrastructure can be categorized as solution C (NP data from operators is collected in a central non-real-time database (CRDB), which will then be replicated to each operator's individual database (OpDB)).

However, while migrating towards an All-IP environment each operator is free to choose and implement the preferred technology of the NPDB/OPDB.

As far as numbering administrators are aware operators are not preferring ENUM-like solutions.

The details are given in figure B.5.1 and figure B.5.2.

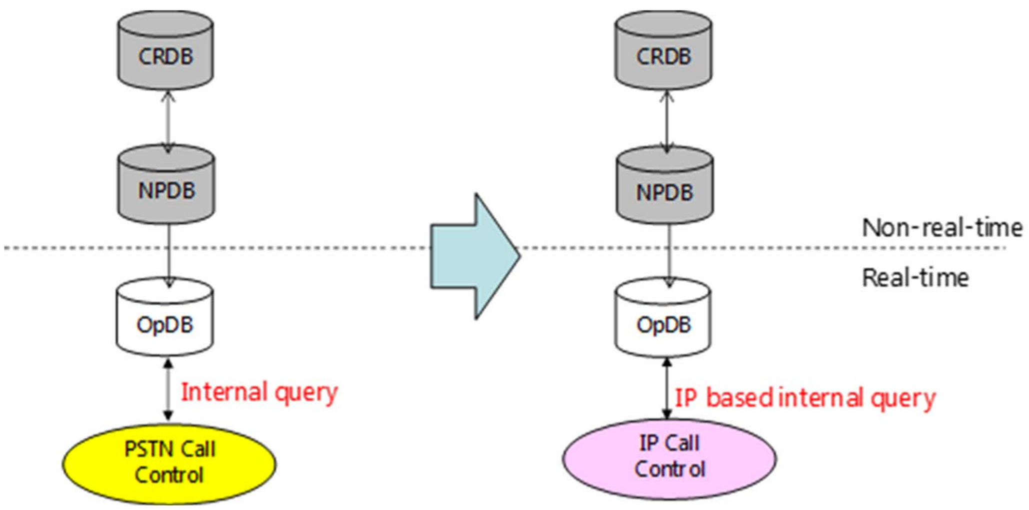


Figure B.5.1: Description of NP use case in Switzerland [non-ENUM like]

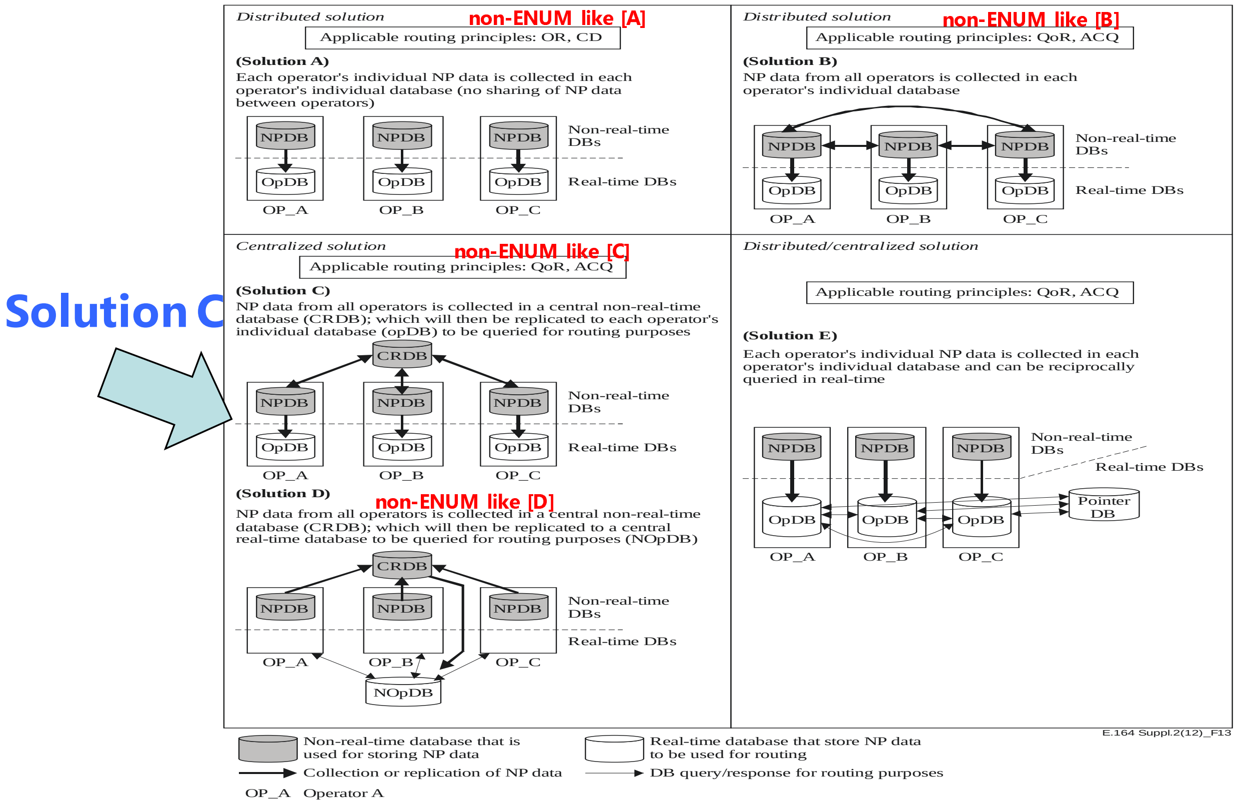


Figure B.5.2: Mapping to E.164 Supplement 2; NP use case in Swiss [non-ENUM like] (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

B.6 Use Case in Sweden [non-ENUM like]

In Sweden SNPAC the administrative reference database CRDB is used. The Telecom Operators manages the AdmDBs (NPDBs) and operational databases (OpDBs) themselves.

The porting information is completed with routing information by the network operator. Therefore it is not 100 % sure to know if the network operators recently have done some work to create a NOpDB from the porting information delivered by CRDB. However no such work is done at present.

The details are given in figure B.6.1 and figure B.6.2.

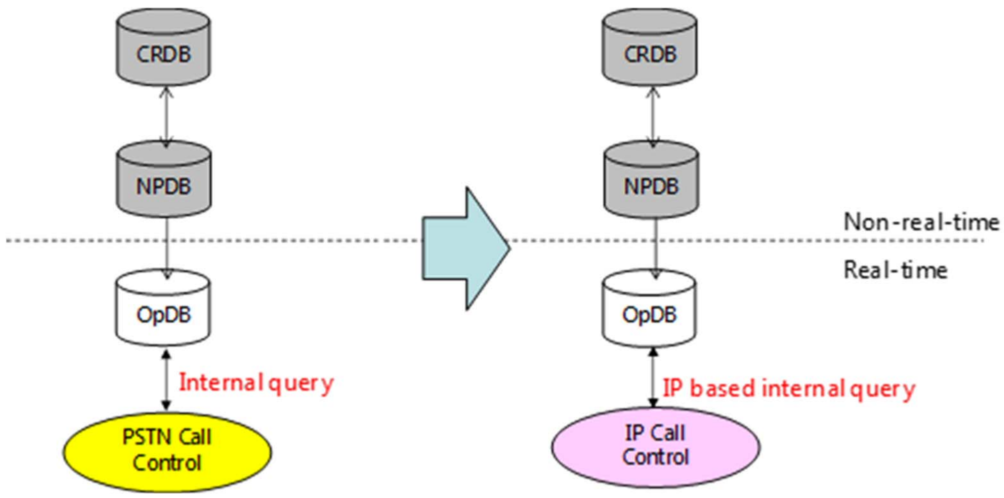


Figure B.6.1: Description of NP use case in Sweden [non-ENUM like]

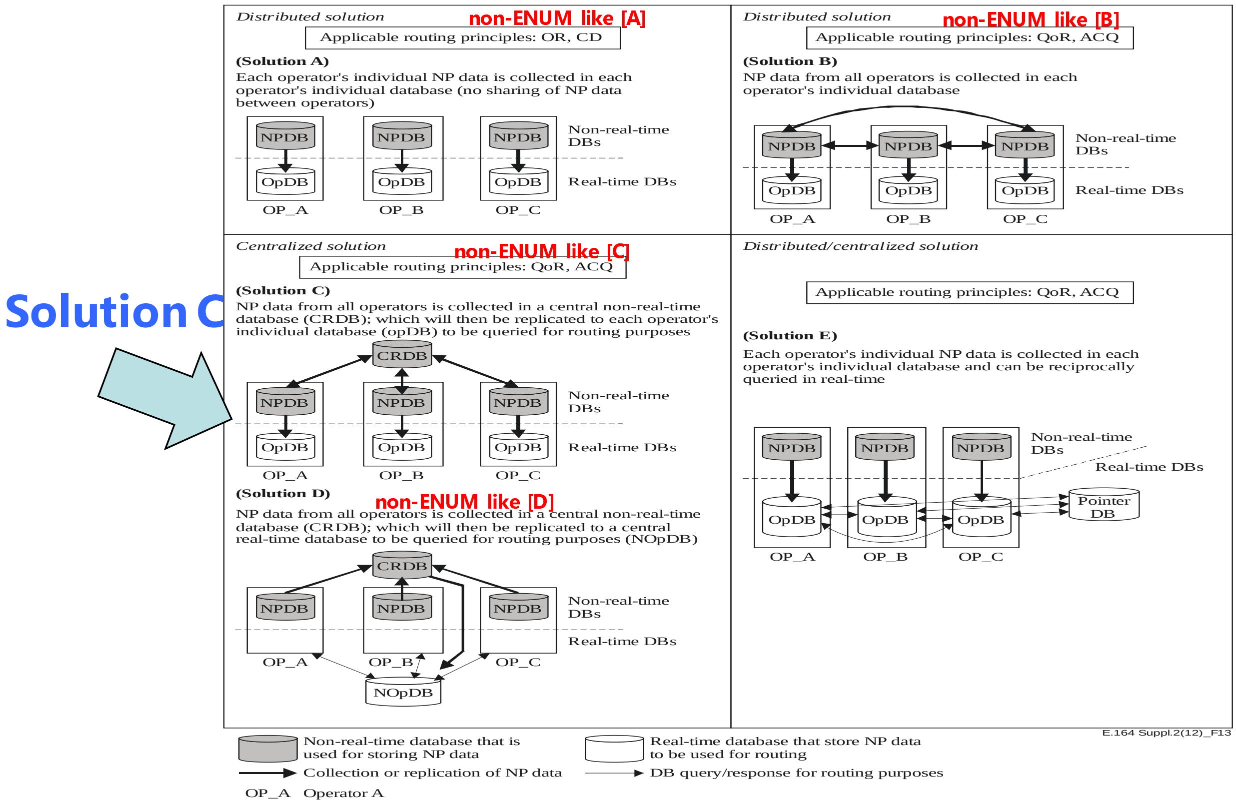


Figure B.6.2: Mapping to E.164 Supplement 2; NP use case in Sweden [non-ENUM like] (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

B.7 Use Case in Finland [ENUM-like is foreseen]

At the time of writing the work is ongoing and the Scenario based on ENUM-like technology is foreseen.

The details are given in figure B.7.1 and figure B.7.2.

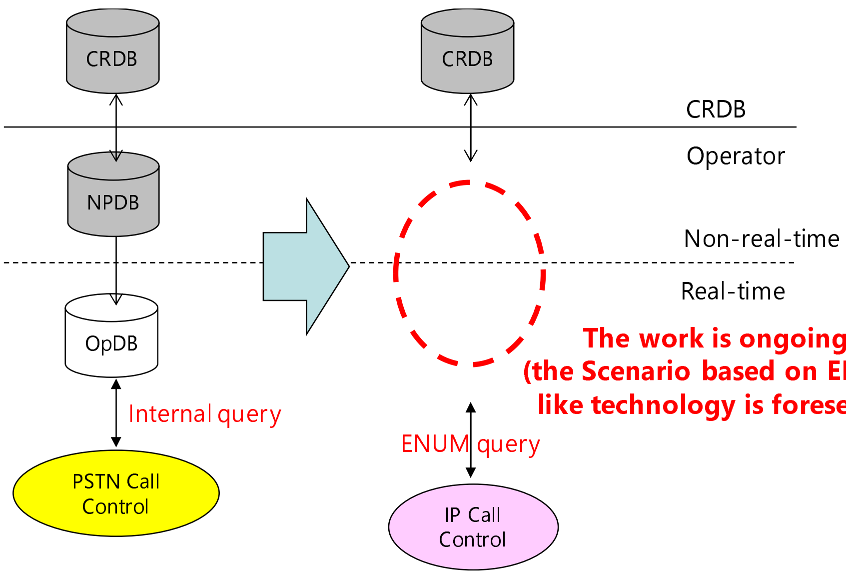


Figure B.7.1: Description of NP use case in Finland [ENUM-like is foreseen]

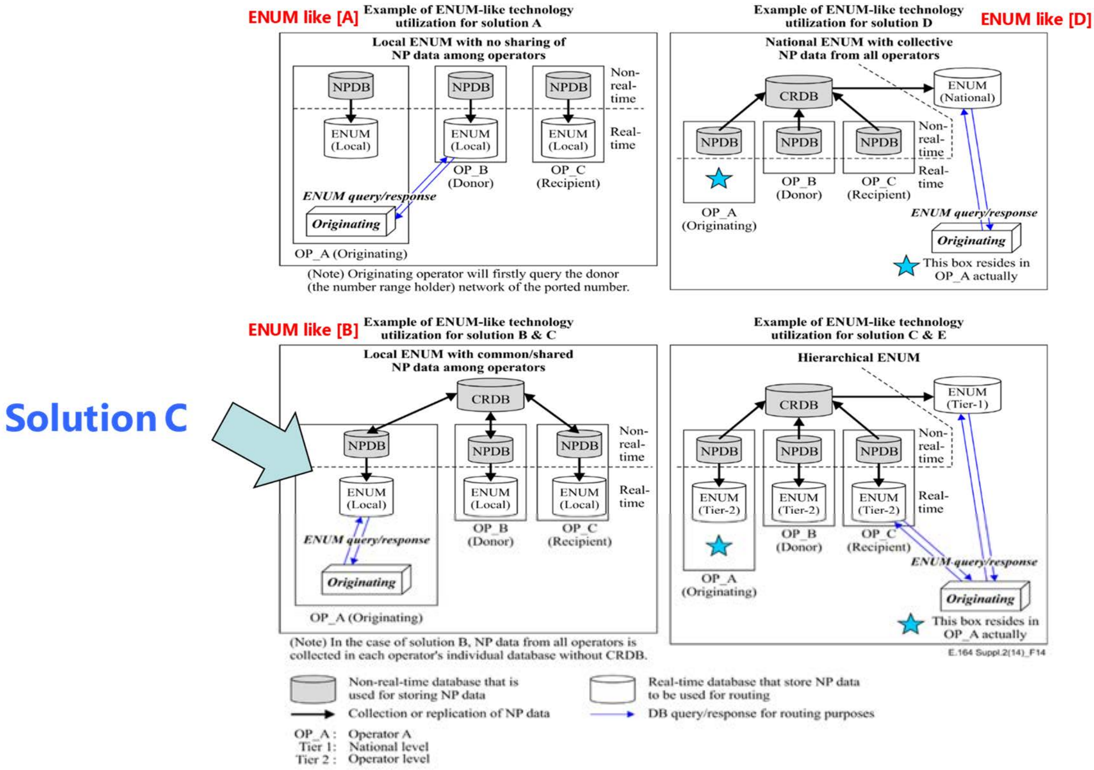


Figure B.7.2: Mapping to E.164 Supplement 2; NP use case in Finland (excerpted from Recommendation ITU-T E.164 Supplement 2: [i.2])

Annex C: Bibliography

ETSI TR 101 119 (V1.1.1): "Network Aspects (NA); High level description of number portability".

ETSI TR 101 118 (V1.1.1): "Network Aspects (NA); High level network architecture and solutions to support number portability".

ETSI TR 101 697 (V1.1.1): "Number Portability Task Force (NPTF); Guidance on choice of network solutions for service provider portability for geographic and non-geographic numbers".

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ETSI TS 123 228: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; IP Multimedia Subsystem (IMS); Stage 2 (3GPP TS 23.228)".

ETSI ES 282 002: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); PSTN/ISDN Emulation Sub-system (PES); Functional architecture".

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IETF RFC 5526: "The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application for Infrastructure ENUM".

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ETSI TR 184 007: "Naming/Numbering Address Resolution (NAR)"

ETSI TS 184 011: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Requirements and usage of E.164 numbers in NGN and NGCN".

ETSI TR 184 008: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Infrastructure ENUM Options for a TISPAN IPX".

History

Document history		
V1.1.1	July 2014	Publication
V2.1.1	May 2019	Publication