Infrastructure ENUM

´Implementation options for the Netherlands´

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Management Summary

This study is explorative in nature. A panel of selected stakeholders was first interviewed and afterwards they participated in an online questionnaire. For this study the following stakeholders have been identified as important: the government and regulatory authority, operators, vendors, interest groups and facilitators. All these stakeholders were involved in this study for investigating the possibilities for applying Infrastructure ENUM.
Infrastructure ENUM is the mapping of telephone numbers (E.164 numbers) to other identifiers which can be used by IP networks. Infrastructure ENUM fulfils a function within translation from naming into addressing. This is needed because a telephony number has no meaning within an IP network. The term Infrastructure ENUM is interchangeable with “carrier” and “operator ENUM”. Currently, Infrastructure ENUM receives a lot of attention.
An important precondition for Infrastructure ENUM to become successful is that E.164 numbers will remain the most important identifier for voice services in the long run. Without E.164 numbers is Infrastructure ENUM not necessary. However there are strong indicators that E.164 numbers will dominate voice services for a long time. These indicators are the universal comprehensibility of numbers, the large ‘installed’ base and the strong international standardized system.
Two application areas for Infrastructure ENUM have been identified: (1) facilitating VoIP interconnection and (2) facilitating number portability. Currently VoIP services are interconnected through the public switched telephony network. Trough IP networks this could be done much more efficiently. However, several ways exist to incorporate number information in these IP networks. The following organization structures for Infrastructure ENUM are formulated in this study: 1) The closed model, 2) Open Infrastructure ENUM: The email model, 3) The compromise model and 4) Next Generation COIN. These so called implementation models comprise VoIP interconnection and number portability as the two application areas for Infrastructure ENUM. The main difference between the implementation models is the degree of openness. Roughly there are two approaches for the organizational structure of Infrastructure ENUM: an open and a closed approach. Model 1 & 4 represent the closed approach and model 2 & 3 represent the open approach. The following conclusions are drawn:

- No seriously considered alternatives for Infrastructure ENUM technology exist.
- No overall consensus for a particular organizational structure exists.
- Facilitators, vendors and interest group clearly support the open models.
- DGET/OPTA have a neutral position with regard to Infrastructure ENUM and the other stakeholders confirm this position.
- Operators are seen by all stakeholders as initiators/locomotives of an Infrastructure ENUM initiative.
- It is most likely that in the short term the closed models will arise and in the long term these closed models will merge with other models.
- Introduction of Infrastructure ENUM does not require a change in business model except for the email model.

Overall, it can be concluded that when considering the results of this study, the closed model and the next generation COIN model are most likely to become the Dutch form for Infrastructure ENUM.

Preface

This report is the final step in completing my education career. Looking on the Internet for some nice quotes with regard to this matter I found the following one:

'Education is what survives when what has been learned has been forgotten'
B. F. Skinner (1904 - 1990), New Scientist, May 21, 1964

I think this is the essence of education. I learned a lot, but the thing that lasts is the way of thinking, the tools and approach of learning new things. I look back upon my study as a valuable time in my life.

I conducted this study for TNO ICT. I heard from my internship co-ordinator Ies Biemond that TNO ICT was looking for students like me. I applied and started in March 2006. I moved to Delft and had a nice time there. TNO ICT is an organisation that offers many students internships. Therefore a nice group of young enthusiastic people have welcomed me. With Lex, Frenkie, Rick, Maarten, Tirza, Bin, Frank, Pim, Tim, Chrystal, Geerten and Wendy, we formed a nice group. We supported each other with writing our final thesis and created a pleasant working atmosphere at TNO ICT. One of the illustrations of this is that Lex and Maarten posted the following instructions on a "post it" on my screen: "one picture tells more than thousands words ", "schrijven is schrappen", "stress is for the HTS" and "form follows function". Given in a humorous mood, these instructions are of course incorporated in this report. Furthermore, I enjoyed the football plays on Monday after work with TNO ICT colleagues.

With regard to my research project I want to thank my supervisors, Pieter Nooren, Rudi Bekkers and Erik Fledderus, for saving time in their agenda's to give me the necessary supervision. I am pleased with the cooperation with my supervisors. Another person I want to thank is TNO ICT colleague Oskar van Deventer for helping me with finding the right contacts and for being a pleasant sparring partner. Martijn Poel and Toon Norp were assisting me also with several questions. I also want to thank Tim de Koning and Gert Kremer, one of the respondents, for helping me with testing the questionnaire. Furthermore I want to thank Dick van Smirren for his useful advice for the presentation I did for the ISOC meeting about Infrastructure ENUM. With regard to the reviewing of my report I want to thank my colleague students Souli Nnafie, Claire Groosman and Marc de Rooij. Last but not least, I want to thank all the respondents for their effort and time. Conducting the study, I noticed that many people were interested in this study. That gave me energy. Currently, ENUM is the news with the re-delegation of the Dutch ENUM domain to SIDN. This new information is not incorporated in this study, indicating that developments in telecommunications are going fast. It is just a matter of time before things will be outdated. Nevertheless, I enjoyed doing this study.

Lennart Maris
Eindhoven, January 2007

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List of abbreviations

ARPA	Address and Routing Parameter Area
ATA	Analog telephone adapter
COIN	COmmunication INfrastructure
CPP	Calling party pays
DGET	Directoraat Generaal Energie en Telecommunications
DNS	Domain Name System
DUNDI	Distributed Universal Number Discovery
ENUM	E.164 numbering mapping
E.164	The International Public Telecommunications Numbering Plan according ITU-T Rec E.164
E.164 Number	a number taken from E164 and assigned to an end user
FWD	Free world dialup
IETF	Internet Engineering Task Force
IN	Intelligent Network
ISOC	Internet Society
ISP	Internet Service Provider
ITU	International Telecommunications Union
LNP	Local Number Portability
NMA	Nederlandse mededingingsautoriteit
NRA	National Regulatory Authority
OPTA	Onafhankelijke Post en Telecommunicatie Autoriteit
PSTN	Public Switched Telephone Network
QoS	Quality of Service
SIDN	Stichting Internet Domeinregistratie Nederland
SIP	Session Initiation Protocol
SKA	Sender keeps all
SS7	Signalling System 7 (C7 in Europe)
TDM	Time Division Multiplexing
URI	Uniform Resource Identifier
VoIP	Voice over IP

1 Introduction

Technologies in telecommunications are changing rapidly. Some of these changes offer the end user completely new opportunities, like GSM changed the way of communication between people tremendously. However a lot of changes in telecommunications are taking place without the end user noticing it. New protocols, transport layers, conversion to Session Initiation Protocol (SIP), the arrival of Next Generation Networks (NGNs) and E.164 Number Mapping (ENUM) are examples of changes not noticed by average users. Many users want to be able to reach everyone in the world simply by dialling one standardized number. So a universal naming / addressing system and interconnection of different networks are necessary to fulfil this need. Within the current public switched telephony network (PSTN) this is already realised, but new technologies are coming into play. Currently new voice services are entering the market, which have the same features as the traditional voice service. The only difference is that the new voice services are based on another technology: Voice over IP (VoIP). VoIP is a wide concept. But the important point to notice here is the fact that VoIP technology makes it possible that phone calls can be transported over IP networks. For example it is possible to make calls through the Internet and to bypass high international rates. Because operators are shifting more and more towards VoIP, the way they interconnect must change as well. Both the 'IP world' and the 'PSTN world' have their naming and addressing structure, these need to be combined. One of the possibilities is the use of E.164 Number Mapping (ENUM). ENUM[1] maps telephone numbers[2] to identifiers used within IP networks. It is a standard for exchanging information on where to find particular telephone number within different VoIP networks. ENUM has received considerable attention from operators. This report will focus on Infrastructure ENUM, a version of ENUM especially for operators. There are uncertainties and there is a lack of clarity around Infrastructure ENUM. Because Infrastructure ENUM requires collaboration and commitment of different parties, it is not easy to predict what will happen. This report will give an overview of Infrastructure ENUM, its possibilities and the attitude of different stakeholders towards Infrastructure ENUM. The content and structure of this report is presented in section 1.4. This first chapter will describe the problem definition, research questions, Delphi methodology, limitations and the added value for TNO ICT.

1.1 Problem definition and research questions

Voice over IP (VoIP) is entering the Dutch telecom market and many providers are offering communication services based on VoIP technology. Metcalfe's Law states that the value of a network is closely related to the number of users connected by the network (Gilder, 2000). So interconnection of VoIP based services to each other and to traditional voice services are very important. However all these voice providers have different strategies and interests. This creates interconnection challenges.

[1]Appendix B can be consulted for more information about ENUM.
[2]Telephone numbers are standardized according to the international public telecommunications numbering plan, ITU-T Rec E.164. Therefore telephone numbers are named E.164 numbers.

The Public Switched Telephone Network (PSTN) is working with the standardized E.164 numbering (governed by ITU) for identifying users on the network. This allows communication with users all around the globe. With the emergence of VoIP technology other sorts of addresses for identifying users are coming into play, like IP addresses and SIP addresses. Infrastructure ENUM can play a role in mapping these different identities to each other. Important to mention is that Infrastructure ENUM is intended for **inter** operator use. So the use of Infrastructure ENUM within the domain of one operator is out the scope of this report. Currently there is no (national) Infrastructure ENUM database operating in the Netherlands. This results in the following main research question:

Which organizational structure for the application of Infrastructure ENUM fits best the various stakeholders in the Netherlands?

The following sub questions have been formulated:

1. What is E.164 Number Mapping (ENUM), who are the stakeholders and what are the important policy, business and technology issues with regard to (VoIP) interconnection in the Netherlands?

2. What are the stakeholder's interests in the field of VoIP interconnection and Infrastructure ENUM?

3. Which implementation models can be drawn for Infrastructure E.164 Number Mapping (ENUM)?

4. What are the stakeholder's positions about the Infrastructure ENUM implementation models?

5. What is a likely adoption path for the Infrastructure ENUM implementation models?

The first question delivers an overview of already known information in literature about Infrastructure ENUM and VoIP interconnection. The second question delivers the results from the interviews with stakeholders. The third question results in implementation models for Infrastructure ENUM in the Netherlands. The fourth and the fifth question deliver the evaluation and the discussion of these models.

1.2 Scope of the report

This thesis will assess the possibilities of the application of ENUM for interconnection of VoIP based services and will develop different application scenarios from a technology, business and policy perspective.

1.3 Methodology

1.3.1 An exploratory method

This research will use an exploratory method to investigate possible implementations of ENUM for VoIP interconnection. Because ENUM is currently not used on a substantial scale, there is not much experience with it. From a technical point of view, quite some research has been undertaken. However

research which puts ENUM in a broader perspective is very scarce. The literature about the policy and business aspects of ENUM is rather limited. Therefore an exploratory research is more applicable in this case than a quantitative approach.

1.3.2 The Delphi method

The exploratory research method that will be used in this research is the Delphi method (Turoff & Linstone, 1975). The Delphi method is a systematic, multi round data gathering method based on independent inputs of selected experts from different fields. Gordon (1994) describes the Delphi method as a form of a controlled debate. It relies on the knowledge of experts from different fields and the researcher who controls the information between them. It is a good method for delineating the pros and cons associated with potential applications for ENUM. The most important property that discriminates the Delphi method from other methods is the use of multiple rounds. This report will conduct a two round Delphi. The first round consists of open interviews and the second round is a structured Internet questionnaire with the same respondents. This creates the possibility for a validation of the issues resulting from the interviews. The results from the respondents are presented anonymously in this report.

1.3.3 Delphi applied in this case

Within Delphi there are special variants and some important choices have to be made. Tapio (2002) describes a Delphi variant which does not have generating consensus as the prime objective. He applies Delphi in a disaggregative way, which means that the main goal is to cluster the main possibilities. This disaggregative variant[3] will be used in this report, because the goal here is not to create consensus. The aim is to create a helicopter view. An another important characteristic of this study that needs to be mentioned is that prediction of what can happen is more important than when it will happen exactly.

1.4 Report structure and research approach

Figure 5 shows the research approach and structure of this report. The first step is a literature analysis and sub question 1 (see section 1.1) will be answered. The important stakeholders are identified and the result is an overview about the current discussion topics around ENUM and (VoIP) interconnection. These topics will be discussed with the experts in the first Delphi round with open questions (sub question 2). Then this input will be used to develop implementation models for ENUM (sub question 3). These options will be validated in the second Delphi round by a structured interview, filled in over the Internet (sub question 4 and 5). This feedback on the models will be used to draw the final conclusions in chapter 7.

[3] Tapio uses this method with quantitative variables and uses cluster analysis. This is not the case in this report.

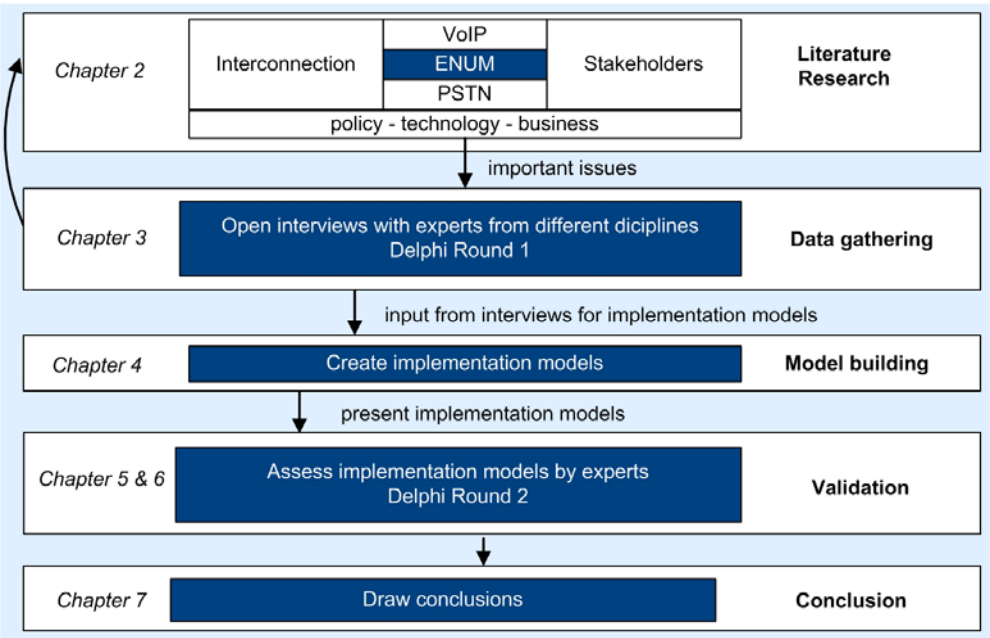

Figure 1 Research approach and report structure

1.5 Limitations

The constraints of this study which are already known beforehand are mentioned in this section. The following three constraints are mentioned:

National focus – This report has a national focus. Most of the people which are interviewed were located in the Netherlands. Maybe the international dimension of Infrastructure ENUM will be of more importance than assumed in this report.

Time limit -- A period of eight months is reserved for writing a master thesis. Delphi studies usually take much longer, even up to a couple of years. Due to the time restrictions this research has limited the Delphi study to two rounds and the expert panel to a number of nineteen. Most important characteristic of the expert panel therefore is that different disciplines are represented in this panel. Furthermore some Delphi studies usually require the expert panel to "select itself". Experts are asked to appoint people to the expert panel. For this thesis, this approach would take too much time, therefore the expert panel has been chosen in a more direct fashion.

Limited number of respondents
Within this report is chosen for an explorative research method. As a consequence, only a selective group of interviewees can participate in this study. This group is expected to represent the environment in which Infrastructure ENUM has to operate. However it has to be taken into account that it was intended to do an market exploration and to come up with exact market desires. This study is exploring the possibilities regarding Infrastructure ENUM in the Netherlands. The expert panel only reflects a coarse sample of all stakeholders.

1.6 Expected value added for TNO ICT

This report has been carried out as a graduation project under the authority of TNO ICT. TNO ICT[4] has many existing and potential new customers (operators, vendors, government) with interests in VoIP interconnection. Infrastructure ENUM can play an important role in VoIP interconnection in the future. An analysis of Infrastructure ENUM from a broad perspective is valuable for TNO as it extends TNO's knowledge in VoIP interconnection. As an added benefit, the Delphi method used in this study provides information on the views on Infrastructure ENUM inside a number of important Dutch operators.

[4] Appendix A can be consulted for more information about TNO.

2 ENUM and VoIP interconnection

2.1 Introduction

The aim of this chapter is to answer the first sub question:
'What is E.164 Number Mapping (ENUM), who are the stakeholders and what are the important policy, business and technology issues with regard to (VoIP) interconnection in the Netherlands?'
This chapter presents the results of the literature study. Relevant information from conferences, reports, books and Internet has been collected. For writing the section about interconnection and number portability some information collected from the interviewees has been used.
The first section explains the ENUM technology and the two application areas for so-called "Infrastructure ENUM" are presented. The second section gives a brief introduction on the types of VoIP services, because this is important for understanding the Infrastructure ENUM application areas. Section 2.4 and 2.5 explore the application areas of Infrastructure ENUM: (1) interconnection of voice services and (2) number portability. Section 2.6 summarizes this chapter.

2.2 E.164 Number Mapping (ENUM)

2.2.1 The emergence of ENUM: User ENUM

E.164 NUMber Mapping (ENUM) was first defined by Faltstrom (2000) in Internet Standard RFC 2916. The basic idea was to add the widely used E.164 telephone identity to the Internet. The domain "e164.arpa" was proposed for storing the E.164 number information within the Domain Name System (DNS). In short, the DNS translates domain names into IP addresses (addresses that make sense to the network). In 2004 this standard was succeeded by RFC 3761, which brought RFC 2916 in line with state of the art DNS technology. Later on in the discussion around ENUM, the RFC 3761 is labelled as User ENUM. This has been done to distinguish it from Infrastructure ENUM. Next section discusses Infrastructure ENUM in more detail.
According to standard RFC 3761, User ENUM is defined as:

> **User ENUM**: the mapping of telephone numbers (E.164 numbers) to Uniform Resource Identifiers (URIs) using the Domain Name System (DNS) in the e164.arpa domain

The following four concepts in the above definition need some explanation: (1) E.164 numbers, (2) Uniform Resource Identifiers (URIs), (3) the DNS and (4) e164.arpa domain. E.164 numbers are standardized in the International Public Telecommunications Numbering Plan[5] and compromise most numbers used for telephony services. A Uniform Resource Identifier (URI) is a unique pointer to an address on the Internet (Berners-Lee et al., 2005). Examples of URI's are

[5] ITU-T Rec E.164

http://www.tno.nl, mailto:l.maris@telecom.tno.nl[6] and sip:alice@60.123.23.52 URI's. The core functionality of ENUM is that it maps E.164 numbers to other identifiers (URIs). This mapping is done by means of the domain name system. The domain name system (DNS) stores and associates many types of information with domain names, but mainly, it translates domain names (computer hostnames) to IP addresses. The domain that is reserved for User ENUM is the 'e164.arpa' domain.

User ENUM allows the end user to use its E.164 number as a general identifier for Internet services. For example it would be possible (if mail clients are supporting it) to email a user by using its E.164 number. So with User ENUM an end user can centralize his contact information behind one number. Figure 2 shows the core functionality of User ENUM (see appendix B for more information about ENUM). The other end-users are provided with capability of looking up contact data.

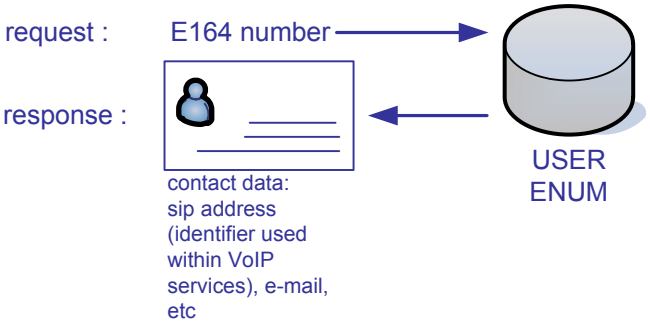

Figure 2 User ENUM, the electronic visiting card

Notwithstanding the fact that the User ENUM standard has already existed for a substantial time, the standard did not gain momentum. Reasons for this limited use of User ENUM can be found in:

- The market for ENUM services is small, because there is no real user need; it is not solving a user's problem: a user does not want to be emailed on a number for example.
- Service providers / Operators have no say in User ENUM (Stastny, 2006)
- Privacy: there is the risk that User ENUM will become the ideal SPAM database, because querying this User ENUM gives user's contact information. This information can be misused by malicious organisations/persons.

Because operators do not have any control over the destination of E.164 numbers, they are reluctant to use the information from the User ENUM database. What is the benefit of putting a E.164 number in the User ENUM database if none of the operators is using this database? Maybe other benefits will arise when new (successful) services become available for User ENUM. Currently there are no successful services for User ENUM[7].

This lack of services for User ENUM is the reason for the small scale in which User ENUM is operating now and it is quite likely (because of the reasons above) that

[6] One could remark that mailto is not a protocol in stead of http and sip. However the operation for resolving a URI scheme is not mandated by the URI specifications [RFC2368]. The mailto scheme provides a standard scheme for an Internet email address with several headers, which can be used by an email client. Therefore it is an URI.

[7] This turned out in a meeting of the ISOC SIP SIG (special interest group) meeting on 26th September 2006 in the Hague

User ENUM will not gain momentum. This has resulted in initiatives to use the ENUM technology by operators: Infrastructure ENUM. Next section discusses Infrastructure ENUM and the difference with User ENUM.

2.2.2 The difference between User & Infrastructure ENUM

As mentioned above, ENUM is a database based on DNS technology. Important with every database is who has access/change rights to the database. The DNS database on the Internet is publicly available. So everyone can retrieve information from the DNS. However, only domain name holders are able to change this information. This is a clear concept. With ENUM these issues are not as clear as with the current DNS. The two main important issues are:

1. Who is able to use the information from the ENUM records?
2. Who is able to alter the ENUM records? (Who fills the ENUM database?)

Figure 3 shows these two important dimensions on the axes. The second dimension forms the basis for splitting up ENUM into two basic types: User ENUM and Infrastructure ENUM. The record use dimension shows who is able to use the ENUM database. If operators fill the ENUM database then it is labelled Infrastructure ENUM, in the situation in which users are filling the ENUM database it is labelled User ENUM. User ENUM can be used by operators, which is shown by the option in the left corner. However this option is only likely when USER ENUM is successful.

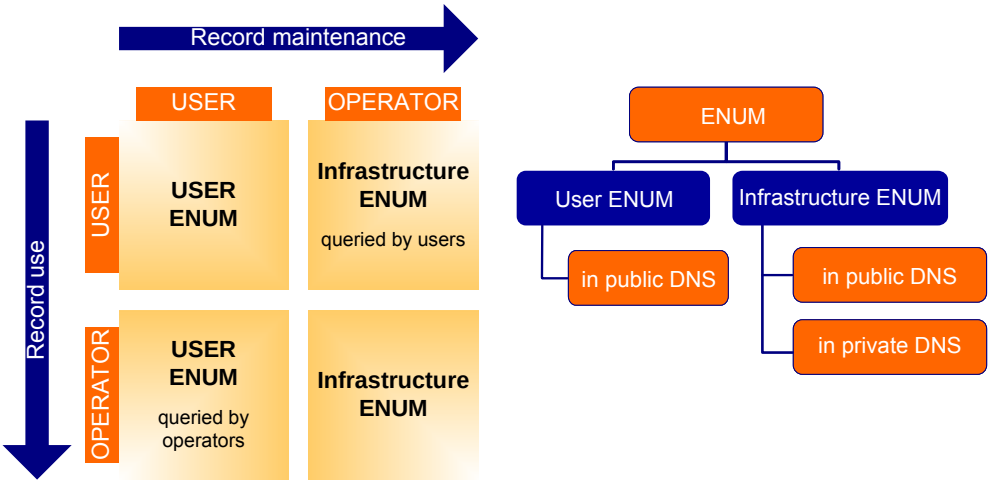

Figure 3 Difference User and Infrastructure ENUM and ENUM breakdown

In this report Infrastructure ENUM is defined as the type of ENUM in which only an operator is able to alter the information in the ENUM records. The term operator plays a crucial role in this definition and therefore requires some clarification. The definition of an operator used in this report is: a telecom service provider which provides a voice service with E.164 numbers to customers. For the Dutch situation, this means that an operator is an organisation having an OPTA registration and having (E.164) numbers assigned by OPTA[8]. This definition does include operators which do not have their own network or network equipment. However, a voice service provider which does not provide E.164 numbers with its voice service is not considered as being an operator.

[8] OPTA is the abbreviation for 'Onafhankelijke Post en Telecommunicatie Autoriteit'. This organization is the Dutch national regulatory agency (NRA).

The question who is going to use the records is still in discussion and depends on the form of Infrastructure ENUM the operators chose for. If they want to keep most of the intelligence in the network, then they want to exclude users from using the database. However, a more open approach allows users to use directly information from the Infrastructure ENUM database. This choice which has to be made by operators, also appears in the breakdown of Infrastructure ENUM in the right side of figure 3. Within Infrastructure ENUM there are two options:

1. Infrastructure ENUM in a private DNS

This is the closed form of Infrastructure ENUM. Only operators are able to query the Infrastructure ENUM database which is placed in a private DNS.

2. Infrastructure ENUM in the public DNS

This is the open form of Infrastructure ENUM. Everyone with access to the Internet is able to query the Infrastructure ENUM database which is placed within the DNS.
If Infrastructure ENUM is part of the public DNS then there are two options for using the identifier returning from the Infrastructure ENUM database:

1. *The DNS is also used to resolve the final destination*
   This means that the information which is resolved from the Infrastructure ENUM database can also be further resolved in the DNS to recover the final destination. So all traffic can be routed to the right destination by means of the Infrastructure ENUM database and the DNS.

2. *The DNS is not used to resolve the final destination*
   The Infrastructure ENUM database is just providing an identifier which points toward the right network. This means that only operators are able to use the information provided by the Infrastructure ENUM database for actually delivering a call. The Infrastructure ENUM database is the starting point for resolving where to find a particular E.164 number. The second stage, the delivering of a call can only be done by operators.

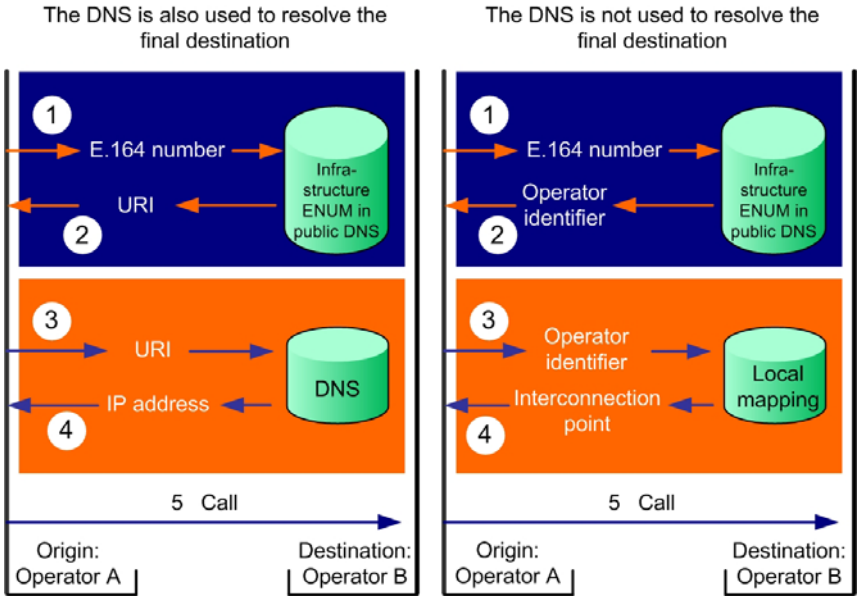

Figure 4 The two options for Infrastructure ENUM in the public DNS

The difference between the two options for using the identifier returning from Infrastructure ENUM in the public DNS is illustrated by figure 4. For example, a look up in the Infrastructure ENUM database gives URI gateway1@operatorB.nl. According to the first option, this URI can be resolved with the DNS to the right IP address. The second option shows that a local mapping is required to resolve the destination. This local mapping is set up according to agreements with other operators. The operator identifier, which returns from the Infrastructure ENUM database has the form of a URI. However, the specific form of this URI needs to be standardized.

This section has discussed the difference between User ENUM and Infrastructure ENUM. Furthermore, the possibilities within Infrastructure ENUM have been discussed. Summarized:

User ENUM: the mapping of telephone numbers (e.164 numbers) to Uniform Resource Identifiers (URIs) using the Domain Name System (DNS) in the domain e164.arpa, having the restriction that both record maintenance and record use, are within the user's authority.

Infrastructure ENUM: the mapping of telephone numbers (E.164 numbers) to Uniform Resource Identifiers (URIs) using a (public or private) Domain Name System (DNS), having the restriction that record maintenance is done by the operator. The term Infrastructure ENUM is interchangeable with "carrier ENUM" or "Operator ENUM"

Generally, User ENUM can be seen as the electronic visiting card and Infrastructure ENUM as a way of supporting operators for routing their calls. In theory these two ENUMs can co-exist.

2.2.3 Infrastructure ENUM's status of standardization

ENUM is an initiative coming from the Internet world. The main ENUM developments are done in an international environment: the Internet Engineering Task Force (IETF). This organization has a special ENUM working group en has published the standard (RFC 3761, User ENUM). For User ENUM there is a standard, for Infrastructure ENUM this is not the case. The discussions within the IETF ENUM working group around a standard for Infrastructure ENUM are in full swing (Pfauz, 2006). The main point of discussion is whether there has to be a special domain where operators can store their numbers. The standard for Infrastructure ENUM will take some time, because there are too many differences in opinion, stated by P. Falstrom[9] in a personal interview by telephone.

2.2.4 ENUM in the Netherlands

The first Dutch initiative to examine the possibilities for User ENUM in the Netherlands was a report carried out by an industry workgroup named "Nederlandse ENUM Groep" (NLEG). This industry workgroup was formed by

[9] P. Falstrom is one of the authors of ENUM RFC 3761.

DGET[10]. DGET is part of the Dutch ministry of economic affairs. The focus of this report was to come up with recommendations for implementing User ENUM in the Netherlands.

After this report of NLEG[11] (2002) there was too little interest from the market for performing an ENUM field trial. Since 2002 it has been quiet around ENUM in the Netherlands. In 2005 with the "Future of VoIP" conference, the attention for ENUM was rising again. On this conference, Infrastructure ENUM came into picture. Association COIN[12] and Amsterdam Internet eXchange (AMS-IX) commissioned ICT Management & Consultancy B.V. for investigating the current situation around ENUM in the Netherlands. This has been done parallel to this study. The report (Pannekoek, 2006) is considering Infrastructure ENUM as serious form of ENUM. The most important conclusion is the relatively low priority of operators for establishing Infrastructure ENUM. Nevertheless, most of the parties are curious about what Infrastructure ENUM can offer. Currently, there is only one serious Dutch Infrastructure ENUM initiative, which is in the development stage. This initiative from several cable operators uses Infrastructure ENUM in a closed environment (see section 2.4.5 for more information).

Currently there is no User ENUM operational in the Netherlands. However SIDN[13] has serious plans to launch a User ENUM platform in the Netherlands[7] and with high probability it can be said that they will become the registry[14] of the 1.3.e164.arpa domain. Their motivation is to force a break-through in the lack of services around User ENUM by establishing the platform. They are not intending to develop the services themselves, but they expect that other parties will come up with services which need an E.164 number as identifier.

2.2.5 Application of Infrastructure ENUM

In contrast with User ENUM, Infrastructure ENUM has two clear services. This creates opportunities for Infrastructure ENUM. The two services that can be distinguished are:

1. *facilitating number portability;*
2. *facilitating VoIP interconnection.*

The functionality of Infrastructure ENUM is basically the mapping of telephony numbers to URIs. This means that Infrastructure ENUM is only applicable in areas where mapping of identifiers is useful and necessary. If we take a look at the current PSTN interconnection, currently operators collect information where to route calls to, from the OPTA registrations[15] and from the COIN platform. This information is kept in their local mapping database. The COIN platform (see section

[10] DGET is the abbreviation for Directoraat Generaal Energie & Telecommunicatie. DGET is the successor of DGTP (Directoraat Generaal Telecom en Post).
[11] Partners of the "Nederlandse ENUM Groep" (NLEG) were: KPN, ISOC, DGTP, NLIP, Nominum and SIDN. Stratix was secretary.
[12] Association COIN is the organization which is founded to facilitate number portability in the Netherlands.
[13] SIDN is the abbreviation for 'Stichting Internet Domeinregistratie Nederland'. This organization runs the domain registration for the .nl domain.
[14] The hierarchy is registry, then registrar (administrator acting in behalf of registrants) and the end user in the registrant.
[15] E.164 numbers are granted by OPTA. OPTA maintains a database in which the organizations / persons are stored to which numbers are granted.

2.5.3 for more information), is the only platform on which operators are exchanging routing information on a substantial scale. Therefore the first application area for Infrastructure ENUM is number portability. Number portability is the feature of switching to another operator without having to change your number, which is required by law. Infrastructure ENUM can be used as technology for the next generation COIN platform.

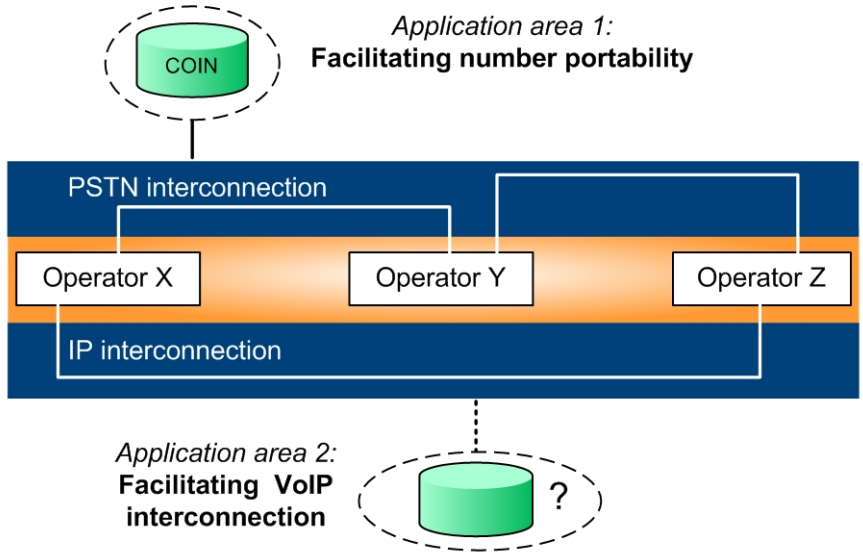

Figure 5 Application areas Infrastructure ENUM

Next to this application of Infrastructure in the 'old world', Infrastructure ENUM can also be applied in the field of VoIP interconnection. VoIP interconnection is defined in this report as the linking of two networks of two operators by means of IP. As shown in figure 5, currently there is no information platform that contains information about where numbers are hosted and which numbers are reachable by IP. In order to deliver VoIP telephony services, VoIP operators are currently interconnected through TDM. Infrastructure ENUM could support the choice between PSTN and IP (option 1 and option 2 in). It is important to notice that within

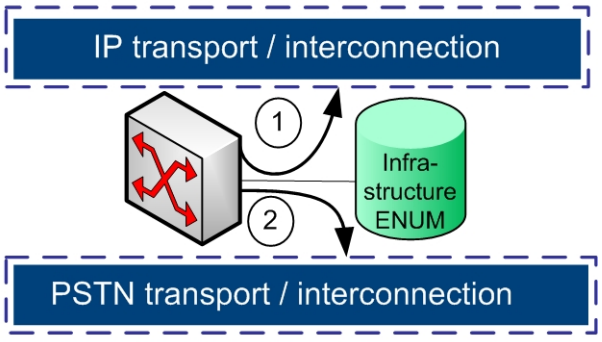

Figure 6 Infrastructure ENUM supports choice between IP and PSTN

VoIP interconnection, Infrastructure ENUM will only facilitate the mapping of an E.164 number to an URI. Establishing a successful VoIP interconnection requires more issues to be clearly arranged. Issues, like the use of the resulting URI data, as well as non-ENUM-derived URI data, for use in signalling and routing of real-time sessions, are out the scope of this report. The Session PEERing for

Multimedia INTerconnect (Speermint) working group of IETF is focussing on this part of VoIP interconnection[16].

It may be stated that if we take the “All-IP” paradigm seriously, any real-time communication originating on IP and terminating on IP must stay on IP end-to-end (Stastny, 2006). Infrastructure ENUM is a good candidate for facilitating the identifier part of it.

2.2.6 Alternatives for Infrastructure ENUM

Infrastructure ENUM is a solution for numbering mapping, which has a particular hierarchy, such as with DNS. Some others are supposing a fully decentralized solution which has the advantage of the absence of central hierarchy of authorities running the database. Distributed Universal Number Discovery (DUNDi) is a peer to peer system for locating gateways to telephony services developed by Mark Spencer (Spencer, 2004). Spencer claims that this approach with no central hierarchy will work better. However this decentralism can also hinder the rise of this technology, because of the lack of coordination.

DUNDI is the closest alternative for ENUM with regard to functionality. Infrastructure ENUM is not the only way to solve the mapping problems. One could also choose to incorporate the E.164 numbers directly into SIP addresses, so no mapping is needed. However this creates difficulties when transition to another signalling protocol becomes desirable.

2.2.7 Situation in other countries

For many countries the User ENUM domains are delegated in the e.164.arpa domain. However only in a very small number of countries User ENUM databases are actually operational, and they are operating on a small scale.

Regarding Infrastructure ENUM, there are already several Infrastructure ENUM initiatives (in private DNS) in operation in many countries. Generally on a small scale, but they do exist. Currently, Infrastructure ENUM in the public DNS is only operational in Austria (see text box below). People from the ENUM registry in Austria are also heavily involved in developing the Infrastructure ENUM standard.

Within the United States, there is also a trial with regard to Infrastructure ENUM, however, this is in an early phase (Neustar, 2006).

Infrastructure ENUM in Austria

The front runners of Infrastructure ENUM can be found in Austria. The Austrian forerunners chose, considering a fast implementation, for a public tree for Infrastructure ENUM within their country domain (+43 or in ENUM .3.4.).

In short:

- They use the i.3.4.e164.arpa tree ;
- The ENUM records are kept in the Registry itself, so there are operators which do not act as Registrar for their own numbers;
- The number database from the Austrian National Regulatory Authority is preloaded;
- Registering to the Infrastructure ENUM is limited to operators which provide services with E.164 numbers;
- No number holder information is kept in the registry.

[16] http://www.ietf.org/html.charters/speermint-charter.html can be consulted for more information about Speermint.

2.2.8 Infrastructure ENUM: Open issues

From the literature and presentations about ENUM three open issues are identified. Around these issues uncertainty and discussion exists about how to design the Infrastructure ENUM system. The three open issues are: (1) the content of the Infrastructure ENUM database, (2) the place of Infrastructure ENUM in the DNS and (3) the organisation / cooperation needed to establish / operate Infrastructure ENUM. A short description per point follows below.

1. The content of the Infrastructure ENUM database

It is clear that the infrastructure ENUM database must contain E.164 numbers. But what kind of Uniform Resource Indicator (URI) must be available in the Infrastructure ENUM database? The function of the Infrastructure ENUM database is routing a call to the correct destination network. The destination network itself knows how to deliver the call. Thus the most obvious option would be a gateway of a particular operator. The form of this URI depends on the kind of Infrastructure ENUM (private or public DNS). It will range from a direct address of the operator's serving SIP server to a more general form such as a Telco code (as used within COIN). The most important requirement is that it uniquely identifies a particular destination network.

2. Location of the Infrastructure ENUM database

The discussion around the location of Infrastructure ENUM within the DNS is dealing with the possibility of creating a 'golden' tree for Infrastructure ENUM or several 'private' trees, which are only accessible for participants. Such an international solution demands much more patience than a private solution. Currently, there is no standard for the 'golden' tree for Infrastructure ENUM. There are two options: a new sub tree within every countries' domain (for example for the Netherlands: **i**.1.3.e164.arpa[17]) or a totally new tree, such as. ie164.arpa. The first option can be implemented faster, because no new delegations have to be done. However the last one has a more proper separation between User and Infrastructure ENUM. No decision has been made yet within the IETF. Private trees, such as Xconnect are not subordinate to these standardization issues.

3. The Organisation / cooperation needed to establish / operate Infrastructure ENUM

Infrastructure ENUM in a public DNS or in a private DNS needs an organisation operating the Infrastructure ENUM database. Within both options trust is very important. Infrastructure ENUM in a private DNS is easier to arrange than Infrastructure ENUM in a public DNS, because no time is wasted for agreeing to a standard. This is the reason why some private ENUM initiatives are already operating. It is to a certain extend a bottom up approach for one Infrastructure ENUM system. The trust relation is easier to establish within a congenial group. However it is not clear how these different ENUM Islands can/will cooperate with each other.

[17] The country code of the Netherlands is 31. The domain that is currently standardized for ENUM is e164.arpa. Because of the hierarchy in domains from right to left, this country code is turned around to 1.3., so that country domains can be separately delegated to several national Registry organisations.

Within Infrastructure ENUM in a public DNS, it will be a central system with a clear hierarchy, with one central entity on top of each country. This entity must be trusted by all the operators. A difficult task because all parties are depending on how well this entity runs the service.

2.3 Voice over IP (VoIP)

Voice over IP (VoIP) technology is based on the conversion of voice signals into voice packets, which are transported using various IP-based protocols for transport and for call set up and control (Stratix, 2003). In this report a provider that provides VoIP based services is a provider that uses at least VoIP technology for transporting voice from the customer premises to the provider premises. Thus voice over DSL providers and the PSTN providers are not VoIP providers.
Figure 7 shows the several types of VoIP based services. This figure is based on the classification made by Van Berkel (2004). IP telephony refers to VoIP services which are provided by providers who have an own (access) network. What we see now in the Dutch market is that operators are mainly providing a VoIP implementation of the existing PSTN service. Many companies are using VoIP technology for internal use, for example to connect different branches. The other forms of VoIP based services are provided through the Internet. The Internet is used as means of access to the customer. This is mainly done by using an analogue telephone adapter (ATA) to connect regular phone hardware to an Internet access router or by using software phones (soft phones) on computers. There are services with E.164 numbers, such as those offered by Optibel. An example of a VoIP service that does not provide Dutch E.164 numbers is Skype.

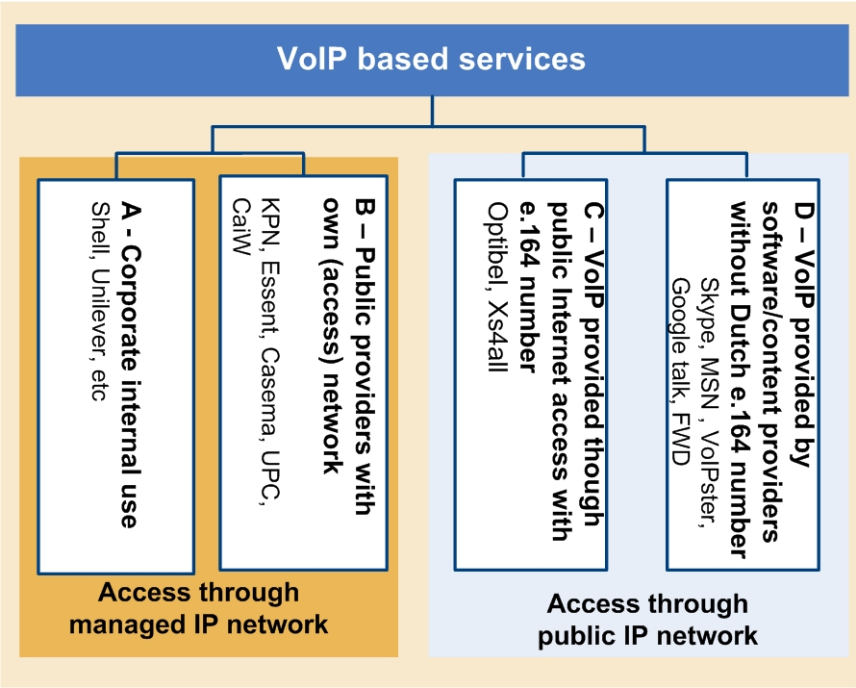

Figure 7 Breakdown of VoIP based services

2.4 Interconnection of voice services

2.4.1 Definition of interconnection & interoperability

As mentioned in section 2.2.5, facilitating VoIP interconnection is an important application area. To understand the role Infrastructure ENUM can play in this field, it is important to have a close look at how operators are interconnecting their services at the moment and the reasons for this current structure. The Dutch Telecommunications Act (Stb. 1998, 610) defines interconnection as a specific form of access between providers of public networks, which means a physical and logical connection of public communication networks. Interconnection is needed to establish interoperability between operators, which is regulated by law. Operators have to be interoperable with other operators, which means that end to end communication between two different operators has to be possible. Thus interconnection is laid down in laws and operators are obliged to be interoperable with other operators.

2.4.2 Short history of interconnection in the Netherlands

Interconnection of voice services came into play with the liberalisation of telecommunications in the late nineties. Telecommunications underwent major changes the last decade. Before 1997, the year when the liberalization of the telecom market was realized, only international interconnection existed. The incumbent, KPN, provided all the communication services within the Dutch borders, but for international traffic interconnection with other foreign networks was required. But after 1997 national interconnection became an important issue, because of the liberalization of the national market. KPN was not split up into a network and a service company (Bouwman et all, 2002). Thus KPN was a very powerful party and interconnection with KPN was crucial for other providers. Because of KPN's market power in telephony, the conditions for interconnection was subject to regulation and many disputes. The first regulatory efforts were mainly focused on regulating the conditions for interconnecting with KPN's network.

2.4.3 Interconnection through the PSTN

As mentioned in the previous section, new telecom parties entered the market in 1997. At that moment the only thing that mattered was interconnection with KPN, because KPN had by far the largest customer base and thus were all the new operators interconnected with KPN. So in the beginning KPN played an important central clearinghouse role. Every telecom operator had only interconnection agreements with KPN and not with each other (see figure 8). Operator A was communicating with operator B through the network of KPN. Currently this situation has changed and the large competing operators do have dedicated interconnections between them to deliver voice traffic to each other, and according to the interviews with the operators there is a trend towards more direct interconnections.

However, KPN is still the most important party in voice services in the Netherlands and interconnection with KPN's network is crucial for every operator. Therefore some explanation about interconnection with KPN's network will be given.

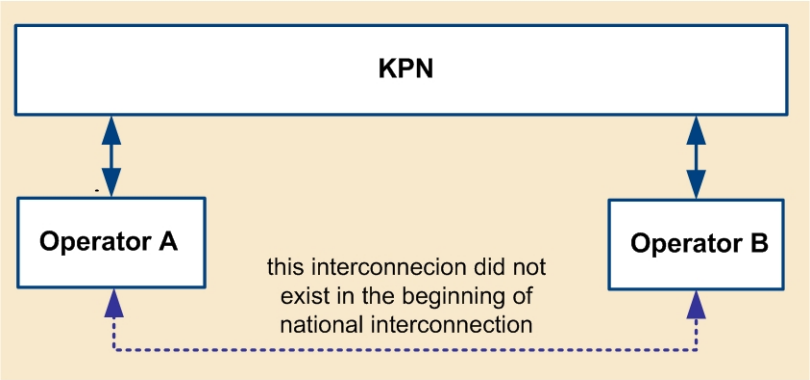

Figure 8 KPN: an important interconnection partner

KPN's PSTN network consists of 20 regional access points[18] (RAPs) and interconnection for voice services only takes place at this RAP level. If another operator wants to interconnect with KPN's network, it has two important choices:

1. interconnection with how many RAPs
2. which interconnection services are taken

The first choice is about the physical point of interconnection, so the place where calls are physically handed over. The second choice is about which interconnection services are delivered over this physical interconnection. These services are listed by the KPN reference offer for voice services. KPN offers 37 different services for voice interconnection (KPN, 2004). This large number of services[19] is caused by the many different needs from other operators. The most important services from this list are the transit and terminating services. This terminology is made clear in figure 9. The interconnection point is the physical point of interconnection, for voice services the RAP as mentioned above. It depends per operator what kind of services he will buy. Business considerations are the main factor in choosing the services. For example, an operator with enough volume between two interconnection points will perform its own transit and not order the appropriate KPN interconnection service.

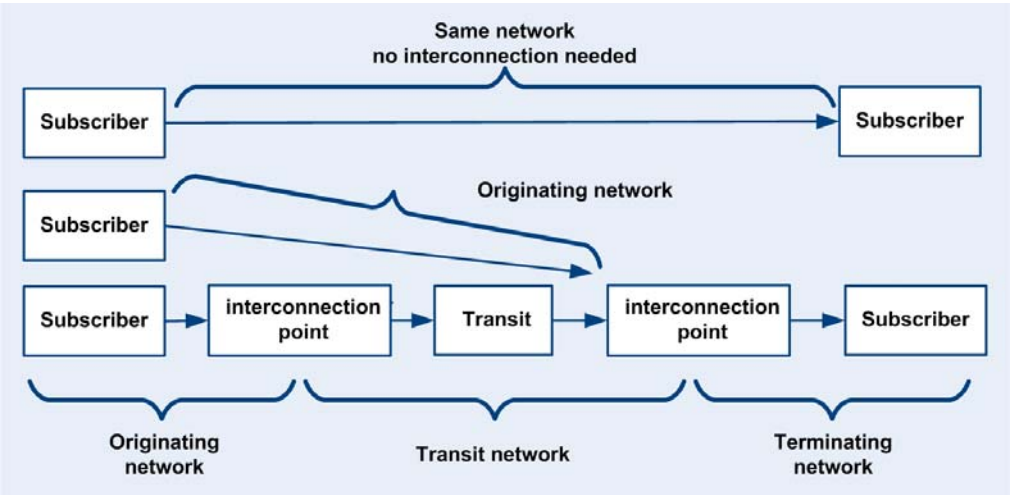

Figure 9 Interconnection terminology

[18] A regional access point is also called a "Eerste Orde Verkeers Centrale"(EVKC).
[19] Examples of services are: emergency service interconnect, 800/90x connect service, outgoing international interconnect, 06760 Internet connect service, etc.

In summary, it can be said that KPN is still playing a very important role. Interconnection is established by physical interconnections with particular interconnection services.

The above description of interconnection and the concepts of transit, originating and terminating belong to the Public Switched Telephony Network (PSTN). The PSTN is defined in this report as the fixed network that works with C7 signalling[20]. So a network that is working with SIP[21] is not part of the PSTN. It may be surprising, but currently all the Dutch VoIP providers are connected with each other through the PSTN. Figure 10 shows the current situation of interconnection of VoIP services within the following two categories: (1) VoIP provided through public internet access with E.164 number (cat. C in figure 7) and (2) VoIP provided by public providers with own access network (cat. B in figure 7). So the VoIP services which are provided with an E.164 number are not interconnected by means of IP, but by means of the PSTN. VoIP traffic from operator A to operator B is first converted to the PSTN and after transport converted to VoIP again. The main reason for this situation is that the routing information is still mainly kept within the PSTN. This has to do with numbering and naming which is discussed in section 2.4.7. Interconnection of VoIP services in category D of figure 7 are interconnected by means of IP. This is explained in the section 2.4.6.

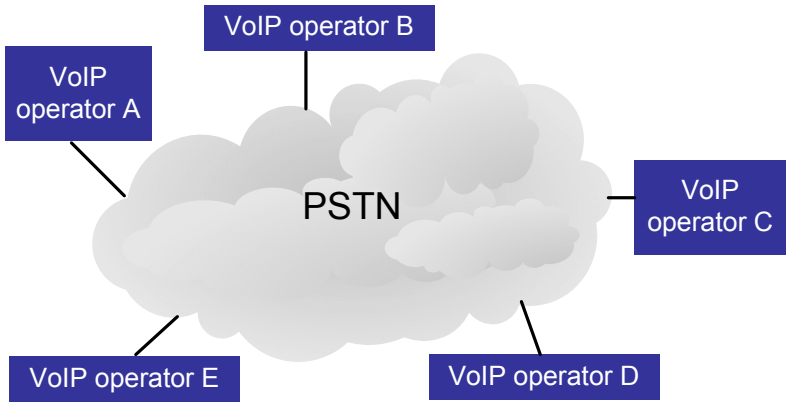

Figure 10 Current situation: VoIP services interconnected through the PSTN

2.4.4 Changes in the interconnection field

The emergence of VoIP services with E.164 numbers is creating possibilities for new services and finally interconnection through the PSTN is likely to be largely abandoned. This is because some major disadvantages exist with interconnecting VoIP services through the PSTN. From a technical point of view there is the following major disadvantage: a call must be converted two times as is depicted in figure 11. These converting steps hinder end-to-end IP connectivity, which hinders the possibility of extra functionality. Examples of extra functionality are video conferencing, and presence[22] (Stastny, 2006). Besides these technical arguments there are also commercial reasons. It would save investments when the expensive

[20] The concept signalling comprises the messages that are needed to set up a call. C7 is the international standard for signaling within the PSTN.
[21] SIP is also a signaling protocol.
[22] Presence is the information provided to a user, which indicates whether her/his buddies are online or not. For example the information which is available in chat programs like MSN messenger.

gateways, which do the converting work, could be removed. IP routing equipment is also much cheaper than the current PSTN routing. The realisation of a VoIP interconnect through IP would be more cost efficient and flexible compared to a traditional PSTN interconnect. These arguments make it according to the interviewed operators just a matter of time when VoIP services are interconnected with each other by means of IP. Another important driver is that many (new) operators want to by pass the regular PSTN interconnection business model.

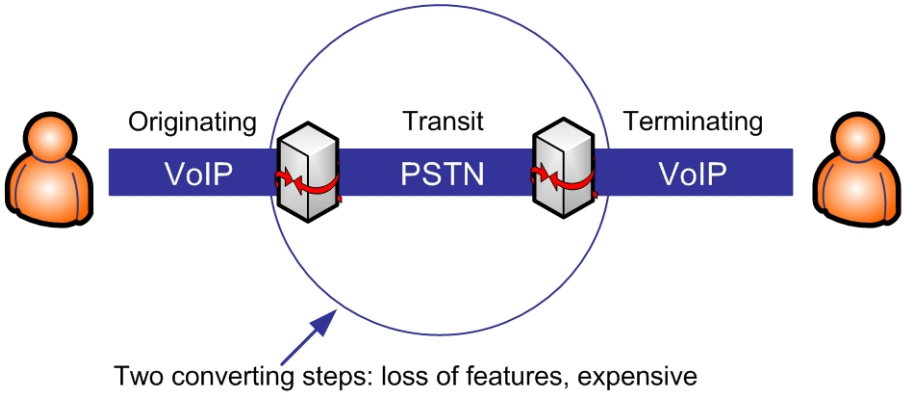

Figure 11 Disadvantages of VoIP interconnection through the PSTN

2.4.5 VoIP interconnection through IP: The Dutch cable initiative

As mentioned in the previous section, interconnection of VoIP services by means of IP, has serious benefits. This has been the motivation for CaIW, a relatively small Dutch cable operator, to initiate a project, which has to deliver a working VoIP interconnection platform for several Dutch cable operators. These operators are UPC, Casema, Multikabel, Essent and of course CaIW. The project entails a proof of concept that is planned to finish in Q4 of 2006[23].

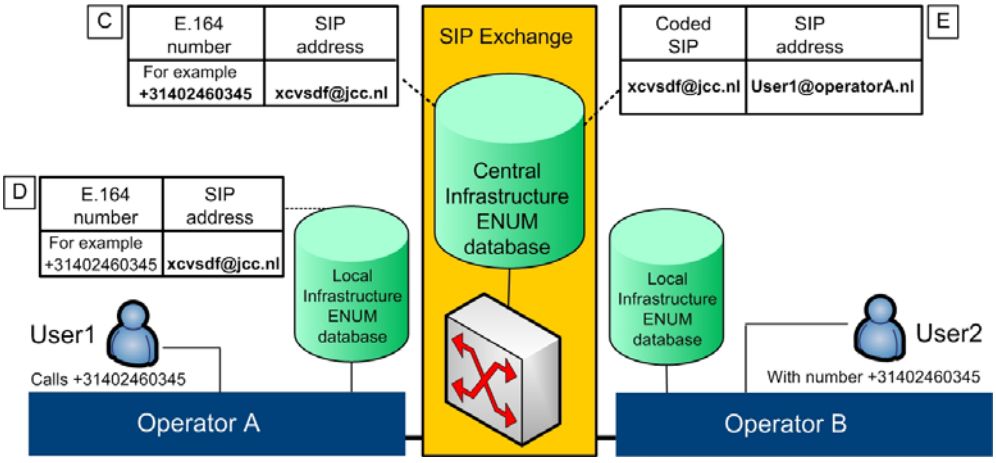

Figure 12 Structure of the cable initiative with Xconnect

Infrastructure ENUM is just a part of this concept. The concept is to create a peering place where several parties can peer with parties they choose. So a connection to the SIP exchange does not imply interconnection with all participating parties. Operators are free to have different peering relations with other operators. To establish this, there has been chosen for a concept of a central SIP exchange which relays signalling messages between the several participating

[23] The figure is based on information from the interviews.

operators. Signalling messages are the messages that are necessary to establish a call. To manage number information between the SIP exchange and the operators Infrastructure ENUM is used. So within this initiative, Infrastructure ENUM is just a component of this so called SIP exchange. Figure 12 shows the structure of the Infrastructure ENUM component of the SIP exchange[23]. The central Infrastructure ENUM database (C in figure 12) contains all the number information from the participants. The local Infrastructure ENUM databases (C in figure 12) are sub sets of this central database. When user 1 calls +31402460345, a local lookup is performed by operator A and results in a SIP address to points indirectly to user 2. The SIP exchange maps this SIP address to the final SIP address by means of a second mapping (C in figure 12). The final audio stream does not flow through the SIP exchange, but flows direct from operator to operator by means of IP.
The proof of concept of the SIP exchange is reported to be successful[24]. However it is important to mention that still some substantial hurdles have to be taken. The SIP exchange has only been tested on a small scale. To extend this to a large scale, most of the large cable companies have to prepare their soft switches[25] for the SIP exchange. Another challenge is the establishment of new business models within voice interconnection. Roughly there are two possibilities[26]: 1) copy the current situation around PSTN interconnect and 2) do it in a way common for the Internet. Resistance from parties which prefer the first option could seriously delay the development of the SIP exchange. Will it be flat fee for the cable companies and terminating for the rest? Section 2.4.9 discusses the tensions between these different ways of commercial agreements around interconnection.

2.4.6 VoIP services interconnected through 'The Internet'

This section describes interconnection within category D of figure 7: VoIP services provided by software/content providers without Dutch E.164 numbers. The well known VoIP services such as Skype, Googletalk and MSN are part of this category. The strategy of most of these parties is to gain a critical mass to their own service and calling with other providers is not possible. This implies that there is no interconnection between these services. They do not want a smooth interconnection with others. It is part of their strategy to be an island. They only have interconnection with the PSTN to enable users of their service to call PSTN users (for example Skype Out). Skype is not offering VoIP services with Dutch E.164 numbers, neither are Googletalk and MSN[27].
The strategy of the small VoIP providers on the Internet, like Free world dialup (FWD)[28] is totally different from the larges ones mentioned above. FWD is part of a global network of small VoIP providers. Every VoIP provider distributes numbers according to its own numbering scheme, and defines its own prefixes to other networks. This can be seen as a form of interconnection. All calls are routed by means of IP to each other. A FWD subscriber number must be dialled differently from other networks. This is illustrated in figure 13, which shows that for example a subscriber of Adiptel must dial **590 before the FWD number and a subscriber of

[24] Reported by Sikko de Graaf, CaIW, at the SIPSIG meeting about Infrastructure ENUM (30 nov 2006).
[25] A soft switch is equipment which is running on software and enables an operator to route calls to the right destination.
[26] This is mentioned by one of the interviewees.
[27] Skype offers the service "Skype In", which enables users to use Skype with an E.164 number. However this service is not available for Dutch E.164 numbers.
[28] http://www.freeworlddialup.com can be consulted for more information.

Sipgate must use 000393 as prefix. This is a clear example of the result of little coordination of the number space. It is not desirable for users that the exact number for dialling an FWD number depends on which network you are calling from. For the sake of clarity, the numbers used within these small VoIP providers are not E.164 numbers.

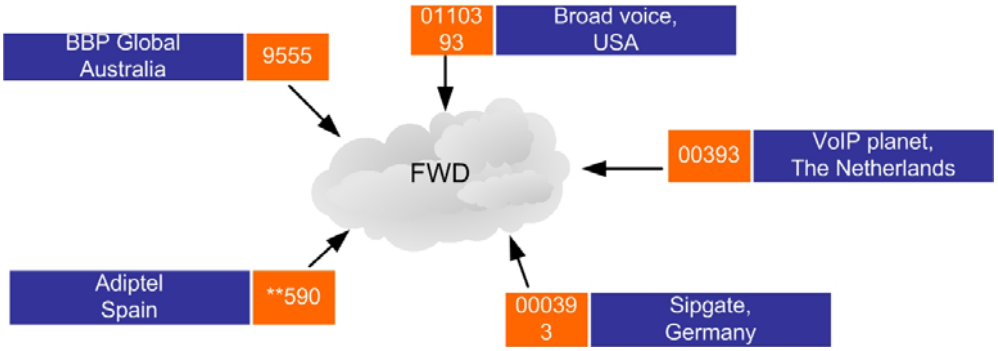

Figure 13 Different prefixes from other networks to the FWD network

In contrast with the bottom up model of FWD, a few small parties which offer interconnection broker services also exist. One example is the VoIP peering fabric (www.vpf.com) and Infiniroute (www.infiniroute.com). These companies offer a central place where VoIP providers can interconnect their services over IP.

From an Internet perspective, the most obvious option would be to organise VoIP traffic in the same way email is currently interconnected. Every domain has its own SIP server and the routing is performed on bases of the DNS records where the address information of the SIP server is saved. However, it is the question whether QoS requirements will allow such a structure.

Summarized it can be said that interconnection through the Internet is very small. The large VoIP providers on the Internet do not interconnect. Only some small sized peering points exist.

2.4.7 Voice service identifiers: naming and addressing

Two important concepts for identifiers within a network are naming and addressing. Naming concerns the identifiers used by customers (end users). The identifiers used by the network for routing are covered by the concept addressing. Addressing and naming are two separate fields, which is clearly illustrated by Internet domain names. Domain names like www.tno.nl are easy to remember, but the network is not able to route on such a domain name. Therefore the Domain name system (DNS) translates a domain name to an IP address, which makes sense to the network. This is depicted in the left side of figure 14.

Currently, operators are only translating numbers to destinations through steps 2 and 3 in figure 14. This means that the intelligent network of an operator comprises all information to map numbers to destinations. So the mapping between naming and addressing of E.164 numbers is currently handled by the PSTN.

There are strict regulations for the allocation of E.164 numbers. DGET[29] formulates this numbering plan (Ministry of Economic Affaires (2006)). The numbering plan determines which number (series) are used for particular services / applications[30].

[29] Directoraat-generaal voor Energie en Telecommunicatie is the official Dutch body concerned with policy making in the field of telecommunications and energy.

[30] The important categories are geographical numbers, mobile numbers, personal numbers (087), free service numbers (0800), paid service numbers (0900) and national company numbers (088).

OPTA[31] grants the Dutch E.164 numbers according to the Dutch numbering plan. The information where to route numbers to is based on information from the OPTA. The E.164 numbers for the Dutch domain (+31) are granted in blocks by OPTA to operators. So at first sight can be determined which numbers belong to a particular operator. Together with the information of ported numbers, an operator is able to address numbers. The COIN database only points towards the network of a particular ported number. How to route to that network has to be determined by the operator.

Regarding VoIP services, there is also a distinction between naming and addressing. Currently three naming identifiers for VoIP services can be distinguished:

- Private naming schemes, like Skype is using
- SIP addresses, similar layout as email addresses, but then used for voice services.
- E.164 numbers from the International Telecommunications Union (ITU) international numbering plan

Because the first category of naming identifiers is per definition not suitable for inter-operator use, it is not useful to discuss this type of identifier. The second option is much more interesting, because it is based on the way how email finds its destination. For example, entering a SIP address into a soft phone[32], causes the soft phone to query the public DNS (step 1a in figure 14). This results in the correct addressing information. No Infrastructure ENUM is needed, because the user is directly entering a SIP identifier. Infrastructure ENUM comes into play, when users are entering E.164 numbers for VoIP services. An additional mapping step is needed to map the E.164 number to the final correct address. This is depicted with 1 in figure 14. After the ENUM translation step, the given identifier will be further resolved by public DNS or either a private DNS. One of the open issues of Infrastructure ENUM which is mentioned in section 2.2.8.

[31] OPTA is the abbreviation for 'Onafhankelijke Post en Telecommunicatie Autoriteit'. This organization is the Dutch national regulatory agency (NRA).
[32] A soft phone is a computer application that enables your computer to make voice calls.

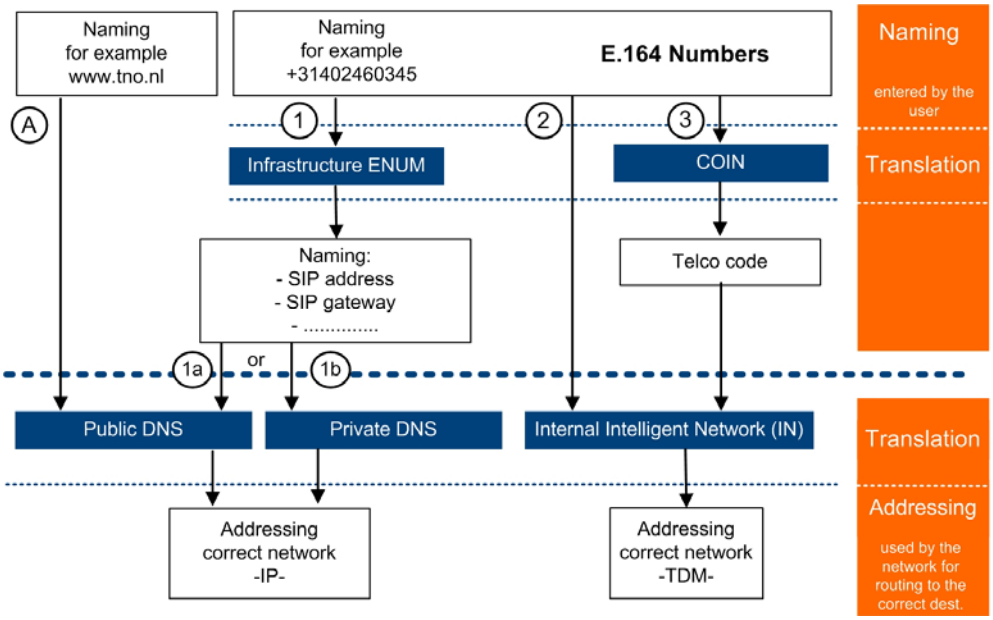

Figure 14 Identifiers: naming and addressing

2.4.8 Regulation and interconnection

Regulation and interconnection are strongly related. A few years ago a shift to a new regulatory framework was made (Dommering, 2004). The old rules, open network provision (ONP) rules, focused also on competition regulation. However the regulated markets were defined by law. Within the new regulatory framework the NRA regulates on the basis of market analyses. So the markets do not have to be defined in telecommunications law.

The telecommunications act (Stb. 1998, 610) is the main Dutch law in which al the rules are stated with regard to telecommunications. The obligation of interoperability, which is one of the most important obligations in this act, applies for every party providing public communication. The main drivers for this interconnection regulation are the creation of a level playing field for effective competition and the establishment of interoperability. (Bouwman et all, 2002). Without regulation the following market failures can occur (OPTA, dec 2005): (1) discriminatory use or withhold of information, (2) delaying tactics, (3) unfair conditions, (4) quality discrimination, (4) strategic product design, (5) illegitimate use of information, (6) price discrimination, (7) excessive pricing and (8) margin holling-out.

With its fixed network, KPN is labelled as having a significant market power[33] on all wholesale markets defined by OPTA[34]. With regard to the focus of this report, it is interesting to look at the wholesale market for call termination. Call termination is about the conditions around delivering calls to other networks. For KPN the following obligations hold for call termination on their fixed network (OPTA, dec 2005): access, transparency, having a reference offer, non-discrimination, tariff

[33] If a party is labelled as a significant market power on a certain market, OPTA can enforce the following obligations to that party (OPTA, dec 2005), from light to serious: (1) Transparency, (2) Non-discrimination, (3) Reference offer, (4) Cost orientation (tariff regulation: wholesale price cap or delayed reciprocity), (5) Separated accounting, (6) Access, and (7) Regulation of end user tariffs.

[34] These markets are: wholesale markets for call originating, wholesale markets for call transit, wholesale market for call termination, wholesale markets for wholesale-telephony connections (OPTA, dec 2005).

regulation: wholesale price cap and separated accounting. The obligations for other fixed operators are much lighter for call termination: access, transparency and delayed reciprocity (a light form of tariff regulation). Thus other fixed operators do not have the obligation of non discrimination and can charge their customers different rates for the same service.

The creation of this level playing field has led to many disputes. Tariffs are still the main topic of discussion and dispute. If two operators disagree with each other about interconnection conditions, OPTA[31] is the organisation that deals with the dispute. An operator with a significant market power is not allowed refuse interconnection because of a dispute. OPTA passes judgment over the dispute and determines what both parties have to do.

The emergence of VoIP has raised new questions and challenges with regard to regulation. An example of such a new question was the nomadic use of geographical numbers by VoIP services. From a technical perspective it is with VoIP quite easy to use the VoIP service nomadically. For example the VoIP service of Xs4all can be used from every computer connected to the Internet. It creates the possibility that geographical numbers can be used for example outside the Netherlands. The Dutch solution for this was to create two new number series for nomadic use[35]. This is a good example which illustrates that there is extensive regulation on the use of E.164 numbers. This is also the case with interconnection.

2.4.9 Interconnection business models

Traditionally, the most widely used method of charging calls in Europe and the Netherlands is the calling party pays (CPP) business model. This model determines that the calling party is forced to buy a so called terminating service from the network which needs to be accessed in order to make a call. Figure 15 shows that within the calling party pays cost structure, network A has to pay network B for delivering minutes to the users of network B.

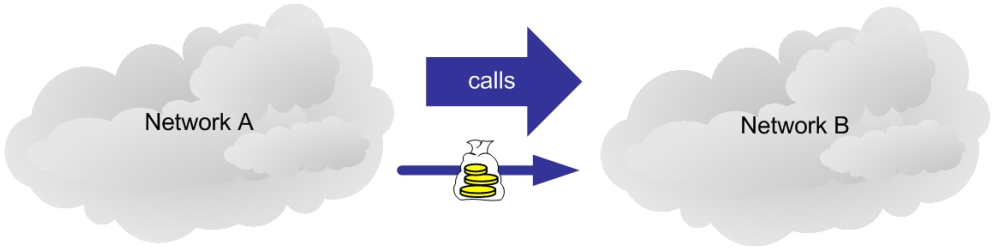

Figure 15 Calling party pays business model

This CPP business model is totally different from the charging model used within IP networks, like the Internet. Within IP networks two charging models are common: (1) the sender keeps all (SKA) model[36] and (2) the transit fee model.

The sender keeps all model is characterized by (see Figure 16):

- no financial flows between A and B
- A & B share the operational costs of the interconnection
- A & B recover their operating costs of their network only from access fees
- Less regulatory intervention needed because there are no interconnection fees that need to be regulated
- Traffic balance important

[35] These two new number series are the 085 and the 091 series.
[36] Peering and bill and keep are other names for the sender keeps all model.

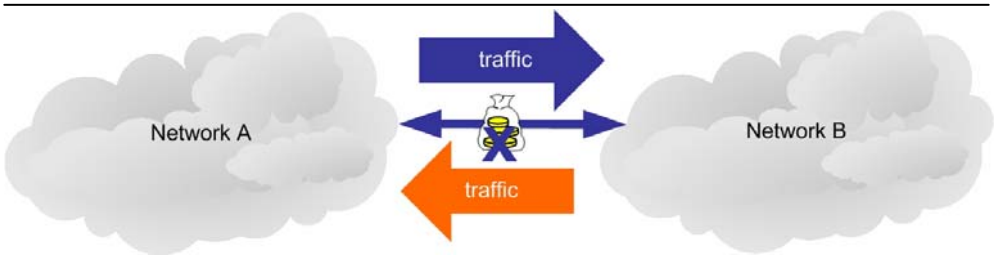

Figure 16 Sender keeps all business model

The SKA model only works with networks that transfer equal amounts of traffic. With the further development of IP networks the SKA model as only interconnection model did not satisfy anymore (Dalton, 2006). This is the reason for the rise of the transit fee model (see figure 17). Small IP networks have to buy bandwidth from a transit large IP network (network B). Typically, there is no use of traffic volume metrics (received or sent gigabytes), because of malicious traffic generation that can be done by network B. For example, if they trigger or capture computers connected to network to use as much as possible, this would introduce significant financial risks to network A (Huston, 2005). Therefore a fixed amount for a particular bandwidth is paid by network A. The role which the networks are playing is dynamic, because networks are not equally in size over time.

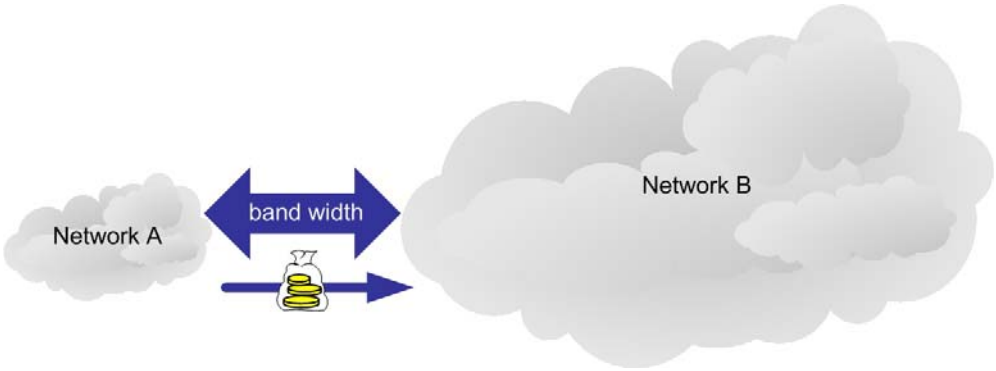

Figure 17 Transit fee model used with unbalanced traffic

Customers (like network A in figure 17) want to become peers and peers want to become suppliers (like network B in figure 17). Continuously, parties are striving to strengthen their position and therefore interconnection arrangements can change over time.

A (VoIP) call between the networks A and B causes equal traffic streams in both directions. So one could argue that interconnection between two VoIP networks can be done on the basis of the SKA model. The precondition for this is that the VoIP networks recover their own network costs from their own users. Like on the Internet, a transit fee model could be used to interconnect with transit (backbone) operators.

Arbitrage and the current interconnection regime are preventing a smooth transition from CPP to SKA. This is illustrated by the example mentioned below. Operator C will deliver all his traffic for operator A through operator B, which is not happy with this situation. So coexistence of CPP and SKA is not very likely and a situation with only SKA or only CPP is sustainable.

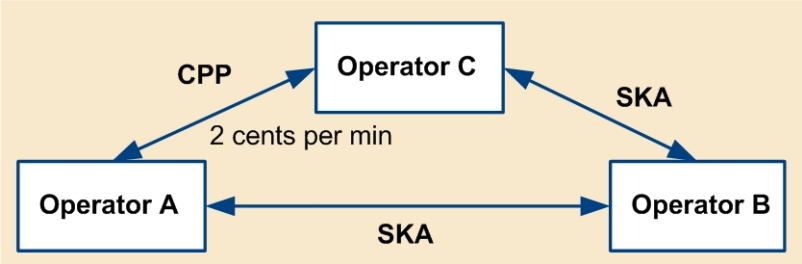

Figure 18 Example of arbitrage

A SKA model for voice interconnection will only work if operators will charge users within the retail domain with a flat fee[37] access tariff. The reason for this is that the 'willingness to pay' is not equal for the calling and the called party (Wright, 2002). Wright argues that the calling party has greater willingness to pay than the called party. This has been the basis for the occurrence of the calling party pays (CPP). People are reluctant to pay per call for incoming calls[38]. However if a flat fee for incoming and outgoing calls would be charged then this problem is eliminated.

The current trend in the retail domain towards flat fee calling will dictate the wholesale domain, and interconnection will move to SKA and transit models. However the providers will do everything to prevent voice to degrade to data and Arbitrage is preventing a smooth transition.

2.5 Number portability in the Netherlands

2.5.1 Motivation for number portability

The need for number portability is closely linked with the liberalisation of the telecom industry. Before the liberalisation, number portability was not an issue. However in a market with several operators, number portability became an important requirement for effective competition.

An E.164 number can have a large value for a customer or a business. It is not convenient to change number and in some cases, the number has a large business value. For example a company advertising its products for years with a particular sales number. Without number portability, moving to other operators means a new E.164 number. Customers and businesses are reluctant to move to another operator, because of the already mentioned (high) switching costs. Thus E.164 are key control points (Wennekers, 2003). The absence of number portability would create barriers for competition between operators.

So the most important reason for the government to legally enforce number portability was to support effective competition. This government reasoning was underpinned with an OVUM report (Hall et all, 1996). This report with the title "Number portability in the Netherlands", ordered by HDTP[39], showed with clear calculations that number portability would have large economic benefits that easily exceed the costs of introduction of number portability. Another positive aspect is that number portability will lead to a more efficient use of the number space. Every operator reserves number blocks and is incorporating some growth in reserving these number blocks. In a situation without number portability, operators have to

[37] Flat fee is a fixed amount paid per month irrespective of use (under faire use conditions).
[38] A good illustration are telemarketing calls.
[39] HDTP is the abbreviation for "Hoofddirectie Telecommunicatie en Post". This organization was responsible at that time for telecommunication policy.

reserve much more number blocks than in a situation without number blocks (HDTP, 1997).

The driver for number portability is the regulatory obligation. Without this regulatory obligation, number portability would not have been voluntarily established. The Dutch government chose for an approach that gave freedom to the operators how to comply with the number portability obligation. Next section discusses the considered options for number portability by Dutch operators.

2.5.2 Considered options for number portability in the Netherlands

The Dutch operators were free to a large extend, in their way of implementing number portability. From a technical perspective they could choose between the following options (Foster, 2003):

- Onward routing: all ported numbers are routed through the 'old' network
- Call drop back: all ported numbers are partly routed through the 'old' network
- Query on release: only when a call is reported not to be at the initial location, a look up is performed in the database
- All call query: all calls are queried before a connection is set up

These options are depicted in figure 19. The two options in the upper part are using a central database for number portability. The two lower options are only using local databases for number portability that are only locally filled.

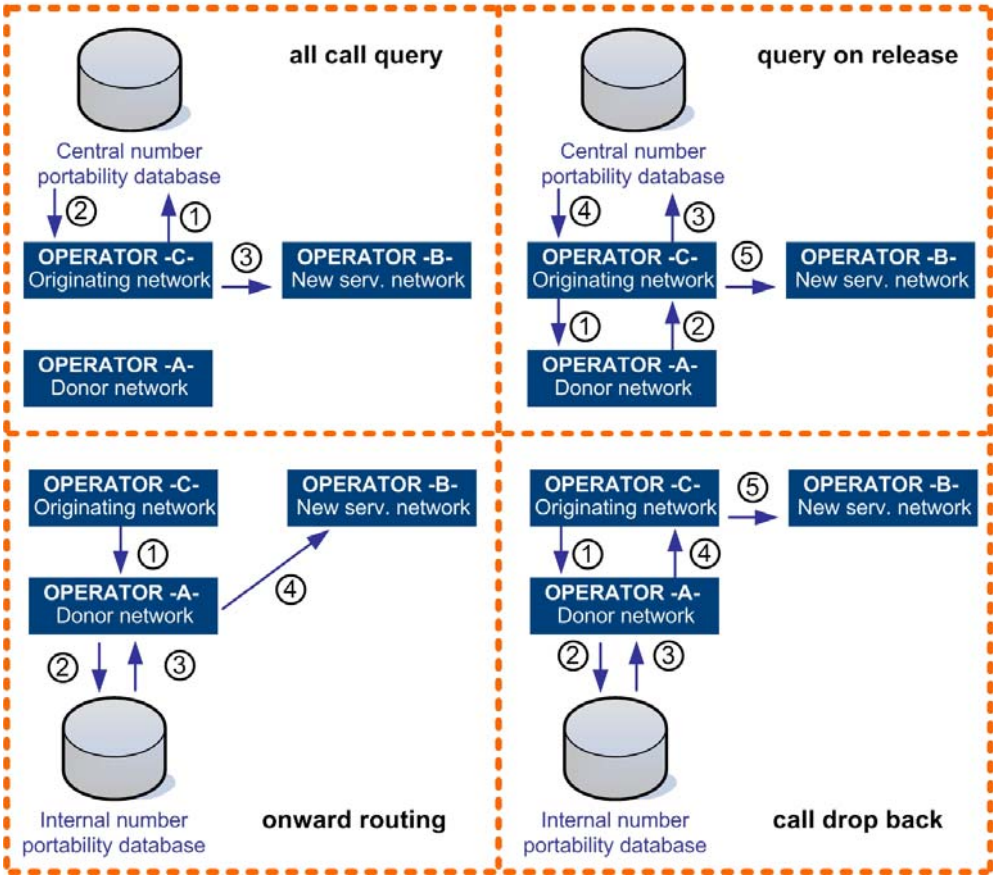

Figure 19 Methods for implementing number portability

All call query and query on release change the fundamental nature of a dialled E.164 number from a hierarchical physical routing address to a virtual address.

Extensive support of donor is necessary with onward routing and call drop back. This also means that those networks are able to gain traffic information that can be used for marketing of products and services and it gives those networks an unnecessary revenue earning capability. These topics were very sensitive in the beginning of interconnection. The new competing parties did not trust each other and therefore these disadvantages of onward routing were heavily weighted in the Netherlands. Besides these disadvantages, it holds that with a higher percentage of ported numbers, onward routing and call drop back are not efficient at all. Nevertheless, some countries, like the UK and Norway, are using onward routing and call drop back as way of implementing number portability

In the Netherlands, operators were in favour of all call query and query on release. This is because these two methods closely fit the position that operators should be able to remain in control of their own network call control process. Together with the other disadvantages of onward routing and call drop back, all operators preferred call query and query on release.

With number portability, it is all about cooperation. The important operators in the Netherlands chose for the options with a central number portability database. The precise organisation and set up of the Dutch approach is discussed in the next section.

2.5.3 The Dutch solution for number portability: COIN

One of the main conclusions of the OVUM report (Hall et all, 1996) was: “The main practical obstacle to the introduction of portability and the highest cost is the upgrading of administration and billing systems”. So as already mentioned in the previous section, number portability is all about cooperation. From a technical point it was quite easy to arrange, but the real challenge was to design a smooth process around number portability. With this in mind a steering committee chaired by HDTP[39] was established in November 1996. This committee was formed by KPN, Telfort, A2000, Libertel and Enertel. The objective was to investigate the possibilities for cooperation in more detail. In January 1997, consultancy firm OVUM, was asked by the five previous mentioned parties to come up with a serious plan for implementing number portability in the Netherlands. This has resulted in the signing of memorandum of understanding (MoU) in September 1997, in which the five parties clearly state that they want to come up with a joint system for arranging number portability in the Netherlands.

Finally, these efforts led to the set up of ‘Stichting nummerportabiliteit’, an organisation which was funded by the five initial operators and two new mobile operators, Ben and Dutchtone. This organisation was responsible for managing the joint so called COmmunication INfrastructture (COIN). This communication infrastructure platform COIN consists of three parts: the inter-operator communication infrastructure, the central reference database and the communication module (Como) for connecting to the (meshed) network. These elements are depicted in figure 20. Every operator has a (virtual) connection to all the other operators and a connection to the central reference database. This connection is an ADSL connection with TCP/IP protocol. So the COIN platform is a point to point system communication platform which is used to inform other operators from ported numbers.

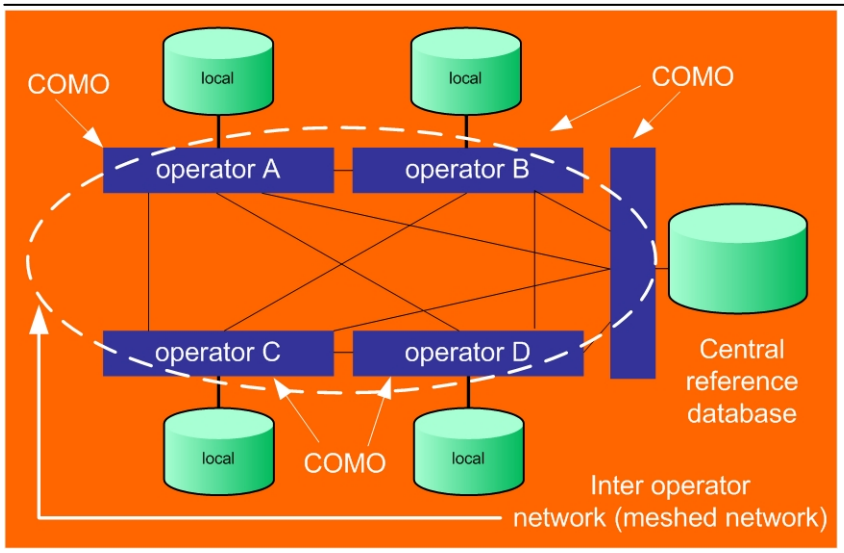

Figure 20 Number portability platform in the Netherlands (COIN platform)

The COIN platform started operating in April 1999, the date that number porting was available in the Netherlands. By that time the number of joining operators had grown to ten. The foundation was funded and governed by the initial 7 operators. To give all operators equal control, the organisation form changed to an association form in 2002. This association was named COIN and currently has 30 members. The services offered by COIN are extended with exchange of information required for changing ADSL provider, and with the provisioning of information of which numbers have to be covered on a specification of a customer's bill. Furthermore, COIN provides read rights of the central reference database for third parties (like OPTA).

2.5.4 Evaluation of COIN

As already mention before, communication and a clear number portability process are very important issues for number portability. The Dutch operators chose for a one stop shopping model for number portability. This means that if a user wants to change to another operator, he only has to arrange things with its current operator. After the introduction of number portability in 1999 there were many complaints about the slow process of many operators. OPTA has administered a few fines for operators which were to slow.

Currently, the porting process is working properly within the required time spans. Currently, around 200,000 numbers a month are ported (see figure 21). This means that around 2.8 million numbers a year are ported[40]. This large number can only be successfully handled with a proper working system. A company named PortingXS[41] is also contributing to an efficient handling of number portability. Several operators outsourced their number portability process to PortingXS. This indicates that number portability is a specific and a mainly administrative process[42].

[40] This number includes mobile numbers.
[41] PortingXS is pronounced as porting access.
[42] For example, the user has to prove that he/she is really using the number that has to be ported.

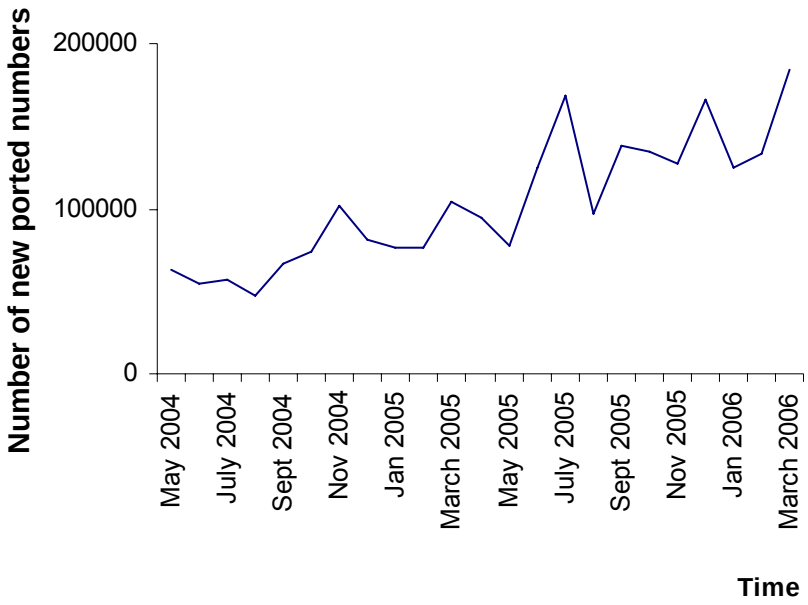

Figure 21 Number of ported numbers 2004, 2005 and 2006 in the Netherlands[43]

It is important to mention that the term COIN is used to refer to two things: namely COIN as organisation and COIN as inter operator communication platform. With regard to the COIN organisation there was one case of in which COIN was accused of being a cartel with to high entry costs for small providers. Therefore a small operator, Plex, did not want to become a member of COIN. Plex requested KPN directly to port numbers to the Plex network. KPN refused and OPTA decided (OPTA, 2002) that COIN had to change their access options for small operators. COIN lowered its entry costs. NMA[44] decided that COIN was not a cartel. Generally, it can be said that COIN as an organisation is functioning well.

From a technical point of view, a central message broker system, thus no meshed network, would be easier to implement some checks for compliance with number portability agreements between operators. It would make the system more error proof.

2.5.5 Infrastructure ENUM and number portability

The COIN communication platform was specifically developed for enabling number portability in the Netherlands. Infrastructure ENUM could be the technology of the next generation COIN. A system with central message broker combined with an Infrastructure ENUM database would be a good option for the next generation COIN. However, it is important to mention that transition to Infrastructure ENUM does not necessarily cause an easier number porting process. The Infrastructure ENUM database is just a part of the agreements that have to be made.

[43] The diagram is based on figures from association COIN.
[44] NMA is the abbreviation for “Nederlandse mededingingsautoriteit”, the Dutch antitrust agency.

2.6 Summary

The most important findings from this chapter are presented in the text box below.

ENUM

- Development of ENUM started with USER ENUM.
- There is a clear difference between User and Infrastructure ENUM. Generally, User ENUM can be seen as the electronic visiting card and Infrastructure ENUM as a way of supporting operators for routing their calls. In theory these two ENUMs can co-exist.
- Types of Infrastructure ENUM: Infrastructure ENUM in the public DNS and Infrastructure ENUM in the private DNS.
  Within the first one there are two options: 1)*The DNS is also used to resolve the final destination or 2) the DNS is not used to resolve the final destination.*
- Standardization of Infrastructure ENUM in the public DNS has started, but has not delivered an RFC yet.
- No Infrastructure ENUM in a public DNS is operational in the Netherlands.
- The three open issues are: (1) the content of the Infrastructure ENUM database, (2) place Infrastructure ENUM in the DNS (or not) and (3) the organisation / cooperation needed to establish / operate Infrastructure ENUM.
- Two application areas for Infrastructure ENUM have been identified: facilitating VoIP interconnection and facilitating number portability.

Interconnection

- Currently VoIP services are interconnected through the PSTN.
- It is just a matter of time when VoIP services are interconnected with each other by means of IP.
- UPC, Casema, Multikabel, Essent and CaIW established in cooperation with Xconnect a SIP exchange for interconnecting VoIP services. Number information is incorporated in the form of Infrastructure ENUM in a private DNS.
- The large VoIP providers on the Internet are not interconnecting with each other and there are only some small sized peering points for voice exist on the Internet.
- Regulation and interconnection are strongly related.
- Naming and addressing are important concepts within interconnection. Infrastructure ENUM fulfils a function within translation from naming into addressing.
- Two business models are competing with each other for being the model for interconnection of (VoIP) services. In short, the Internet model and the telecom model.

Number portability

- COmmunication Infrastructure (COIN) is the organisation and platform which runs number portability in the Netherlands. It is a point to point system with a central reference database.
- Infrastructure ENUM is a candidate technology for the next generation COIN platform.

3 Stakeholders' initial view on Infrastructure ENUM

3.1 Introduction

The aim of this chapter is to answer the second sub question:
'*What are the stakeholder's interests in the field of VoIP interconnection and Infrastructure ENUM?'*
This chapter describes the results from the first round interviews with Infrastructure ENUM stakeholders in the Netherlands. Open questions have been asked in face to face interviews. This chapter and chapter 2 form the base for the next chapter which describes the Infrastructure ENUM implementation models.
First the selection of the interviewed panellists is explained. After this, the most important issues, attitudes and interests from the interviews will be discussed per group of stakeholders. The final section summarizes this chapter.

3.2 Selection of panellists

Creating the list of desired experts for the panel has been quite straightforward in this report. The Delphi method requires different stakeholders to be present in a Delphi expert panel. For this research the following stakeholders have been identified as important for Infrastructure ENUM: government and the regulatory authority, operators, vendors, interest groups and facilitators. End users are missing in this list, because they are not direct stakeholders in Infrastructure ENUM. Infrastructure ENUM facilitates operators in delivering services to end users, but end users do not have to be aware that this service is using Infrastructure ENUM. So for example the Dutch consumers' organization, the "Consumentenbond", was not considered as relevant.
Within the selected categories the most relevant organizations were selected and the TNO network was used to contact experts within these organizations (see appendix C for the panellist). The selection within three groups (operators, interest groups and facilitators) needs some more explanation. As mentioned in section 2.2.2, an operator is defined as an organisation having an OPTA registration and having (E.164) numbers assigned by OPTA. From the overview of different kinds of VoIP services (see figure 7), the relevant operators were selected. Despite VoIP service providers in category D (in figure 7) are not marked as operator in this report, it would be relevant to have them involved. The reason for this is that they can switch to category C and they have impact on the voice market. Unfortunately, no experts from the service provider category D could be found willing to help.
Within interest groups, only the BTG is regarded as relevant, because its represents bulk consumers which can be that large that can be seen as sort of operators as well.
The term 'facilitators' requires some more clarity as well. Within the interconnection of networks there already exist some cooperation: association COIN for facilitating number portability, AMS-IX for IP peering and SIDN for managing the .nl domain. These last two have not been interviewed (due to practical reasons), but they filled

in the questionnaire. The information from the interview with association COIN is used in section 2.5 and not in this chapter.

3.3 First round question development

Section 2.2.8 identified three open issues around Infrastructure ENUM. These open issues have been used as starting point for making the questions. The interview was split up into two parts: (VoIP) interconnection and Infrastructure ENUM. These two parts have been split up into question about the technical, business and policy aspects of the topic. The interviews are recorded to digital audio files, which have been used to transcribe the interviews. The questions can be found in appendix E.

3.4 Positions expressed by the regulatory bodies: OPTA & DGET

OPTA, where two people are tracking the ENUM trends and developments, observes a great interest in ENUM. However little things are happening in practice. This is an indication that all the stakeholders are orientating themselves on the possibilities of ENUM and nobody wants to commit themselves to the technology.
Both OPTA and DGET do not have official positions about the application of Infrastructure ENUM. They consider it is as too early and are exploring the possibilities of Infrastructure ENUM. DGET is considering what and how active their role should be. The spectrum is ranging from monitoring and let the market do the work, to controlling and outlining a new ENUM policy. Besides this choice that has to be made by DGET, they are in the process of granting the license for the registry of the .1.3.e164.arpa domain. SIDN[45] has interest in becoming 'The Registry'. In the 4th quarter of 2006 there will be more clarity about who will become the Registry. The most important criterion for DGET is that consumers are able to switch from one operator to another. The organisation structure of Infrastructure ENUM may not block this. But it is not likely that Infrastructure ENUM will change the current strict coupling between an E.164 number and a service. Furthermore, it is important to maintain the high performance of the PSTN with regard to quality and reach ability.
Both organisations recognise that settled parties are more reluctant for Infrastructure ENUM than new entrants which are likely to be in favour of Infrastructure ENUM. New entrants want to be able to use number information which is currently only available for settled parties which put a lot of effort in building a 'local' database with number information. And they observe the fact that telco companies cannot afford it in the long run to set up a very closed system, because it is very likely that other companies will bypass them for example through the use of a flat fee business model.
Infrastructure ENUM can be put in the public domain. DGET has to take into account that 'The Registry' needs support from operators for being successful. It plays a crucial role for interconnection. The government should put strict supervision on 'The Registry'.

[45] SIDN is the abbreviation for 'Stichting Internet Domeinregistratie Nederland', freely translated into 'Foundation Internet Domain Registry Netherlands'. This organisation is responsible for issuing .nl domains.

Besides this passive role of supervision, all the stakeholders interviewed in this report are indicating that there is no direct active role for the government for Infrastructure ENUM. Their position is that support must come from the market and that no extra regulation is needed. This is in harmony with what DGET and OPTA are acting and saying.

Main findings:
- Both OPTA and DGET do not have official positions about the application of Infrastructure ENUM.
- DGET is only active in granting the ENUM Registry for the public domain
- The most important criterion for DGET is that consumers are able to switch from one operator to another. The organisation structure of Infrastructure ENUM may not block this.
- At this moment no active role is required for the government and no extra regulation regarding infrastructure ENUM is needed.

3.5 Positions expressed by operators

This section describes the main messages from the interviews with the operators. The following messages are identified:

The permanent importance of E.164 numbers
A necessary condition for Infrastructure ENUM is of course that E.164 numbers will continue to be the method for identifying subscribers. Only one operator had the belief that E.164 will disappear on the long term and other identifiers will take over its place. But generally there is consensus about the important role that E.164 number will play for a long time. This importance will not erode in the future.

Positive attitude of operators toward Infrastructure ENUM
The operators are positive towards Infrastructure ENUM and they consider it as a technology with potential. They mention the importance of E.164 number reliability and reach ability. Infrastructure ENUM incorporates measures to retain these properties. If services behind numbers are becoming unreachable, customers will contact the expensive service desks, which is conflicting with the operators' interests.

Little support of operators for User ENUM
The coupling between a customer and an E.164 number is currently created by a telephony service. There is the possibility for number porting, but a real implementation of the 'number for life' requires a stricter decoupling between service and number. However the interviewed operators indicate that this concept of flexible and easy switching of reach ability information behind a number is undesirable. This is the main reason for rejecting User ENUM.

The most important driver for Infrastructure ENUM: VoIP interconnection
Most operators are looking for reasons for introducing Infrastructure ENUM. One of the interviewees formulated it like this: 'Why using ENUM, because it is new,

because it is sexy or because it has really added value?' What are the reasons for using Infrastructure ENUM?

Currently the market moves towards triple play. The operators are doing this because they want to tap new sources of revenue. This is necessary because of the decline of their traditional revenues through the rise of mobile communications, the decline of international call revenues through free VoIP traffic over the Internet and the rise of new services with multimedia.

Many people are switching to other operators. The trend in the market is that people still want to use their regular phone and the operators are reacting with simple plug and play products. According to one of the interviewees, operators with an own access network, are having an advantage in establishing a reliable telephony service. They are managing the network and this gives them power over operators with no own access network. Future growth of operators without network will definitely lead to disputes.

Allowing multimedia transport for new services, IP to IP interconnection is a logical next step. However none of the operators is interconnecting with each other on IP. Some of the service providers are transporting their traffic on IP to the next operator which takes care for their traffic to all the other operators. This traffic is then going to TDM interconnections. One of the service providers indicated that automated legal tapping is not possible for IP interconnections in contrast to TDM interconnection. For large providers automation of tap commands is very important.

Another operator indicated that IP interconnection is not having priority at all. If Infrastructure ENUM is deployed for facilitating VoIP interconnection, then first a decent IP to IP interconnection must be defined. Only when this is the case Infrastructure ENUM can be considered. An appropriate remark.

New services, like video calling, are much easier to implement on IP network then in the regular PSTN network. IP interconnect will become important if deployment of these services is having priority. Up to that time TDM interconnection will play the head role. At some point of time there has to be a business case for VoIP interconnection and thus for Infrastructure ENUM.

The Emergence and immaturity of IP interconnection

KPN is developing a new wholesale service: IP interconnection. However this IP interconnection will only be for voice and not for data and no new business model will be used. This will not persist, like one of the non telco interviewees formulated: 'The same as with the first cars, they looked like a coach without horses'. New cost structures will drive the market into other pricing structures, which will save a complex and expensive billing machine. Nevertheless, current regulation is throwing up barriers for moving to other business models. The delayed reciprocity which holds for all the operators except KPN creates a tariff advantage to the other operators and they do not want to give up this advantage. This and the immaturity of IP-IP interconnection are clearly illustrated by some cable companies which are installing a lot of new TDM interconnection equipment to be able to serve their fast growing customer base.

Despite this use of TDM equipment to counter the fast growing customer base, the cable companies are also experimenting with other forms of cooperation. Up to some extend the cable companies form a complementary group. They do not geographically overlap and they want to compete with KPN and other DSL based

providers. The trial they are now conducting in cooperation with Xconnect, is set up with central signalling. All the traffic is relayed by a central point which has to be trusted by all the parties. Maybe this concept will work with the cable companies which have the same mind set. But with real competitive operators a lot of political issues will come into play and it will be difficult to create a trusted interconnection hub. However it is also still the question if cable companies will use the central hub instead of establishing and using direct IP interconnections. No decisions have been made yet, according the cable operators.

Lack of an overall system with number information

The service providers differ in opinion about the term when IP to IP interconnection will be realized. Some think it will take some time, others think it will come soon. "Within VoIP is it all about signalling, transit will disappear", is how one of the last group formulated this matter. So transport over IP is not a problem at all, the problem is the lack of routing information about which E.164 numbers are reachable by means of IP. It is easy for a new operator to interconnect with another operator over IP. However it is difficult for the two operators to find out which numbers have to be routed to the other party. They miss a central system where to find which numbers are reachable on IP and on which net. Infrastructure ENUM can play a role here.

Infrastructure ENUM technology for COIN

Talking about infrastructure ENUM most of the service operators see a role for Infrastructure ENUM within number portability. From a COIN point of view (see section 2.5) it will be good to change the point to point system to a central message broker system. This creates the opportunity of a better control of the number portability process. Infrastructure ENUM is a serious candidate technology, also because it is not a proprietary solution. Although one of the interviewees noticed that the administrative processes around number portability are the most obstructing for an efficiency improvement. Just introducing Infrastructure ENUM in this field will not tackle these problems. Another factor which has to be taken into account is that COIN is performing well and one of the service providers warned: 'Do not underestimate the heavy demands on an IT system like COIN'.

The majority of the operators are indicating that for number portability COIN will continue to be the organisation. Whether COIN would be the right organisation for hosting the Infrastructure ENUM registry is input for discussion. COIN is seen by new operators as a bastion of telecom operators, which do not have knowledge and expertise for facilitating VoIP interconnection.

The importance of the International dimension

How important is the international dimension for the current Dutch situation? Most of the telephony traffic is flowing within the country. Number portability is also arranged nationally and the most important stakeholder on the Dutch market, KPN has also a national focus. So compliance with International standards for Infrastructure ENUM is not predominant in the Dutch situation, according to one of the operators.

Main findings:

- Operators agree about the remaining importance of E.164 numbers in the long term.
- User ENUM is rejected by operators for its decoupling between E.164 numbers and services. An operator wants to keep control over routing information behind numbers.
- Business interests are dictating the developments in the field of Infrastructure ENUM.
- The most important driver for Infrastructure ENUM is VoIP interconnection.
- Not clear whether the current Xconnect set up will work in a real competitive environment.
- Current interconnection regulation in the form of 'delayed reciprocity' is preventing the market to move to a new business model.
- Infrastructure ENUM is considered by operators as a technology with potential.
- Infrastructure ENUM can only be considered when a decent IP to IP interconnection is defined.
- The current problem is the lack of routing information about which E.164 numbers are reachable by means of IP→ Infrastructure ENUM could play a role here.
- Association COIN is seen by new operators as a bastion of telecom operators, which do not have knowledge and expertise for facilitating VoIP interconnection.
- The international dimension of Infrastructure ENUM is limited in the Dutch situation.

3.6 Positions expressed by vendors

According to one of the interviewed vendors, six years ago there were all kind of technical problems with VoIP: speech quality, speech encoding and low band width. These problems are solved and now business is dictating the properties and requirements. However there are still many different SIP versions. Furthermore, the ENUM vendor market is not transparent. With regard to ENUM equipment it is fussy to find out which parties exactly have working ENUM equipment. Vendors themselves do not know exactly who is able to build ENUM enabled equipment and who planning to do so. There are a lot of small vendors, which are saying that they are able to build ENUM equipment, but only a few have working ENUM equipment on shelf. Vendors, like AG projects and Nominum have some working ENUM equipment, but no Infrastructure ENUM is realised by any vendor. According to a personal interview by telephone with Michael Haberler, the pioneers in Austria have developed there own Infrastructure ENUM software. Siemens equipment is not (yet) Infrastructure ENUM enabled. Reason for this is that Infrastructure ENUM is not yet a standard and operators are not yet demanding it.

Main findings:
- Despite DNS is proven technology, there are no cut-and-dried Infrastructure ENUM solutions
- Vendors have to acquire experience with Infrastructure ENUM.
- Operators are not demanding Infrastructure ENUM support yet.

3.7 Positions expressed by the Interest group

The Dutch Association of Major Business Telecommunications Users (BTG[46]) promotes the interests of major businesses. They have an independent position towards operators and the government.
In their opinion KPN is still having a very dominant position and it will be difficult for cable operators to form a real counterpart. The divided management of the cable operators is causing this.
With regard to interconnection the message is: "Commerce is running the show with interconnection", indicating that business interests will also be very important with regard to VoIP interconnection. Currently all the cross company traffic flows over the PSTN. Some companies use VoIP for internal calls, but interconnection to other companies is always through TDM interconnects. The BTG is sceptical about the VoIP technology. In most of the cases it is a semi finished product and it is a treat for the reliable PSTN service. Its low cost image has to prove itself.
Things only change when the government is pushing operators by law. Number portability is a good example. From the BTG's point of view operators are not (yet) interested in Infrastructure ENUM. Maybe it is too early yet. Nevertheless, according to the BTG, Infrastructure ENUM should be international. "If Infrastructure ENUM becomes an official RFC, then it should be alright".

Main findings:
- BTG is sceptical about the VoIP technology
- Commerce is running the show with interconnection
- Infrastructure ENUM has to become an RFC, only when this is the case, it can become an success

3.8 Summary

The following stakeholders have been identified in this chapter as important for Infrastructure ENUM: government and the regulatory authority, operators, vendors, interest groups and facilitators. The panellists are selected from these groups and are interviewed face to face.
Both OPTA and DGET do not have official positions about the application of Infrastructure ENUM and they observe that no active role is required for the government and no extra regulation regarding infrastructure ENUM is needed at the moment. This is confirmed by the other stakeholders.
Operators agree about the remaining importance of E.164 numbers in the long term. This is in favour of infrastructure ENUM and VoIP interconnection is identified as the most important driver. A standard IP to IP interconnection is not defined yet

[46] BTG is the abbreviation for "BedrijfsTelecommunicatie Grootgebruikers".

and the market has to determine whether there is a business case for IP to IP interconnection. This will determine whether Infrastructure ENUM will be successful. Operators have a positive attitude towards Infrastructure ENUM in contrast with little support for the current User ENUM initiative. So business interests are dictating the developments in the field of Infrastructure ENUM.
Current interconnection regulation in the form of 'delayed reciprocity' is preventing the market to move to a new business model and this means no acceleration of the need for VoIP interconnection. It is also not clear whether the current Xconnect set up will work in a real competitive environment.
The vendors are indicating that despite DNS is proven technology, there are no cut-and-dried Infrastructure ENUM solutions. They have to acquire experience with Infrastructure ENUM and none of the operators is demanding Infrastructure ENUM support yet.
The interest group, BTG, is sceptical about the VoIP technology and are indicating that Infrastructure ENUM has only a chance when it becomes an RFC.

4 Implementation models for Infrastructure ENUM

4.1 Introduction

The aim of this chapter is to answer the third sub question:
'*Which implementation models can be drawn for E.164 Number Mapping (ENUM)?'*
This chapter presents the implementation models which have been developed from the first round interviews and the literature study. The issues mentioned in the previous section serve as input for the creation process of the models. Considering this input four models are created, which differ fundamentally. These four models are enough to reflect the possibilities and more models would be unpractical.
The first section presents how the models are constructed. Then the models are explained one by one. The final section will summarize this chapter. A table with the model properties can be found in appendix F.

4.2 Constructing the models

The visualizations of the models presented in this chapter show two imaginary operators A and B. Between them several options exist for the network connecting them and the properties of the Infrastructure ENUM used. Within all models the presence of a local cache is assumed to increase the performance at the infrastructure's side. The exact updating techniques of this cache are beyond the scope of this report.
The two main dimensions in which the models differ from each other are: application area and the degree of openness of the Infrastructure ENUM database. These are explained below.

Application area
According to section 2.2.5 there are two application areas for Infrastructure ENUM: facilitating VoIP interconnection and number portability. Model 1, 2 and 3 are facilitating VoIP interconnection and model 4 is basically for number portability. The first three models represent a new move into interconnection. Model 4 is a more conservative model. It considers Infrastructure ENUM next to PSTN interconnection, whereas the other models require VoIP interconnection.

Degree of openness
The models differ in their degree of openness. The openness is specified in three areas: querying, media and signalling. Querying is the process of retrieving information from the Infrastructure ENUM database. Altering the Infrastructure ENUM database can only be done by operators and only to the numbers to which they are number holder. That is straightforward, because otherwise parties can harm each other by changing number information. This is the case for all the models and is thus not a variable across the models. With signalling, call setup messages (SIP messages) are mentioned. The term media points to the actual audio stream. These properties are mentioned in the lower left corner of the model's visualisation. Query, media and signalling can be done over the Internet or

over a closed network. Closed networks are characterized by restricted access for particular parties. A closed network can be an island, completely isolated from other networks or it can be interconnected with other networks under a strict regime. For example the COIN network is a closed network and is not interconnected with other networks. Only COIN members can join the network and have direct information about which numbers are ported. On the other hand, the GSMA Exchange backbone is also a closed network (only used by mobile operators), but this network is interconnected with other networks under strict conditions. Dedicated lines between two operators are also considered as closed network.

Originally the Internet has an open character with open standards and deregulated regime. This holds only for the network, the applications that run on the network are not necessarily 'open' (Sallet, 2003). For example virtual private networks (VPNs) that run over the Internet, or paid services. For this report it is important to notice that the Internet is considered as an open network. So within the models, which use the Internet, 'open' means that operators use the Internet infrastructure for providing querying, media and/or signalling. Closed means that operators use closed networks. A closed network is characterized by the fact that only a (small) group of operators is having access to the network, and a new operator can only join when certain conditions are met. The main aim of using closed networks is that operators try to support and manage high QoS requirements. The COIN platform is an example of a closed network.

Figure 22 shows all the different combinations for querying, media and signalling. The two extremes of this spectrum are chosen for obtaining really distinctive models. Model 2, the open model, and model 1, the closed model, are opposites of each other. Model 3 is located between them and is chosen because this is the way it is organised in Austria. The other combinations were marked as less relevant.

	QUERYING	SIGNALLING	MEDIA
MODEL 2	Internet	Internet	Internet
	Internet	Internet	Closed
	Internet	Closed	Internet
MODEL 3	Internet	Closed	Closed
	Closed	Internet	Internet
	Closed	Internet	Closed
Xconnect	Closed	Closed	Internet
MODEL 1 / MODEL 4	Closed	Closed	Closed

Figure 22 Positioning of the models regarding querying, signalling and media

A full overview of the properties of the models presented in the coming sections can be found in appendix F.

4.3 Model 1 Closed Infrastructure ENUM

The Infrastructure ENUM database in this model (see figure 23) is not located in the public DNS, but in a private DNS established by a particular federation of operators. This means that 'requesting' is only possible for parties which are member of the particular federation. For setting up such a federation roughly there are two options for the task of that federation:

1. Run the Infrastructure ENUM database and provision only E.164 number routing information
2. Function as central hub for SIP traffic supported by an Infrastructure ENUM database

No choice is been made between these possibilities. It is a variable within model 1. The second option is the way Xconnect is organised (see section 2.4.5).

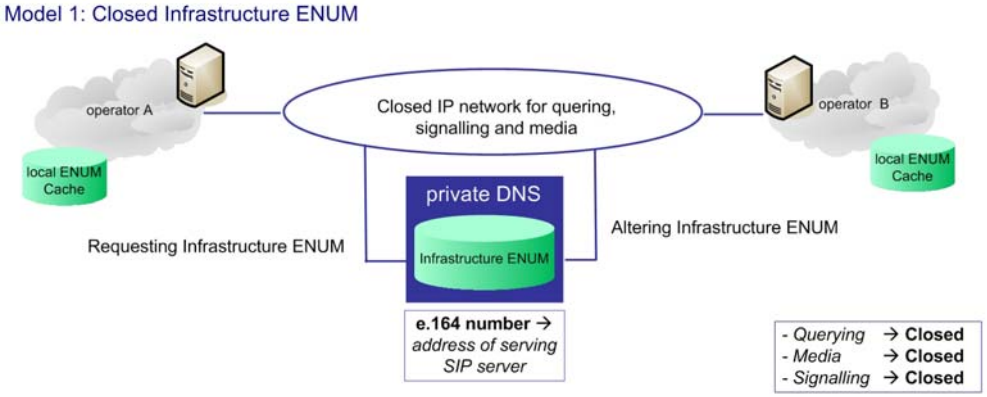

Figure 23 Model 1 Closed Infrastructure ENUM

4.4 Model 2 Open Infrastructure ENUM: The email model

This model (see figure 24) is the most open model and draws an analogy with the email system. Most important characteristic of the email system is that the routing of messages is entirely supported by the DNS and that there are no business agreements in advance between two email providers. Applying this principle to the domain of voice services, this would imply that it is possible for customers of operator A to call customers of operator B without the existence of an agreement between the two operators. If a customer of operator A wants to call a customer of operator B, he will look up the serving sip server of operator B, by querying the Infrastructure ENUM database. The result of this action can be transformed by the DNS to an actual routing address. Then signalling and media run over the Internet.
The Infrastructure ENUM database has been located in the public DNS. According to section 2.2.8, there are discussions going on within the IETF to standardize a domain for Infrastructure ENUM.

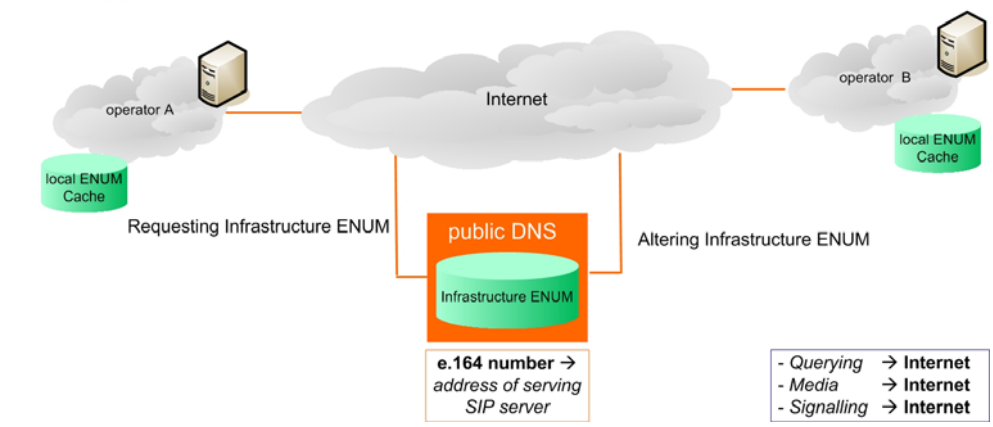

Figure 24 Model 2 Open infrastructure ENUM: The email model

4.5 Model 3 The compromise model

The significant difference with model 2 is that settlements have to be made in advance between the operators. Otherwise it is not possible to deliver calls to each other. Similar to model 2, the Infrastructure ENUM database is located in the public DNS. However in this model, successfully querying the Infrastructure ENUM is not implicating whether the operator is capable of delivering the call. Only when further settlements and interconnections have been made with the other party, the call can be successfully delivered. This is the way it is organised in Austria: Infrastructure ENUM in the public DNS and interconnection can be done in closed environment similar to how it is done now.

Model 3: The compromise model

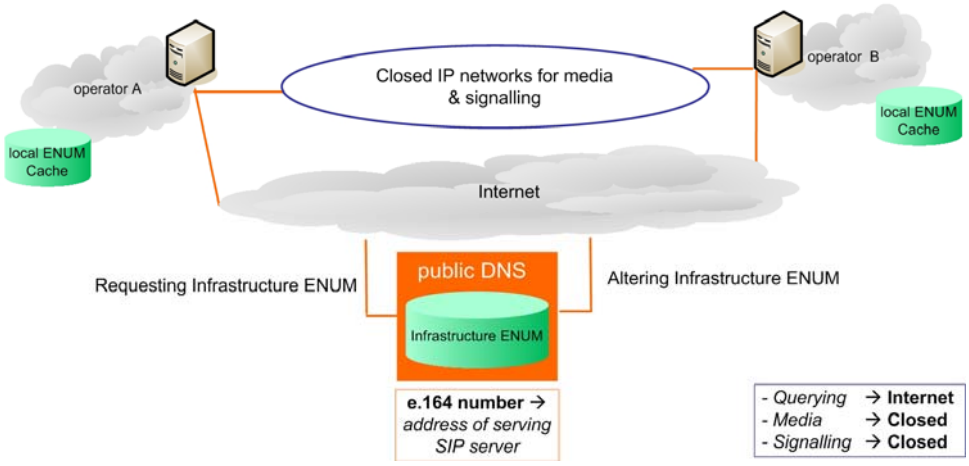

Figure 25 Model 3 The compromise model

It is important that there is one international standard over how to interpret the URI coming from the Infrastructure ENUM database.

4.6 Model 4 Next generation COIN

As the name already indicates, Infrastructure ENUM is used here as technological successor for the current technology of COIN. The current proprietary COIN technology is becoming obsolete and is not fulfilling current desires of a cheaper and more centralised system. Therefore COIN needs a new technology Infrastructure ENUM.

The function of Infrastructure ENUM within this model is facilitating number portability. This clearly differs from the first three models, which facilitate VoIP interconnection. The main difference between facilitating VoIP interconnection and facilitating number portability is the part of the number space which is supported. With regard to facilitating number portability, only ported numbers are qualified for being part of the database. Taking a look on facilitating VoIP interconnection, only VoIP numbers can be in. So within this model, the Infrastructure ENUM database contains only ported numbers.

From an organisational point of view this model is more specific. Association COIN is the organisation that operates the Infrastructure ENUM database.

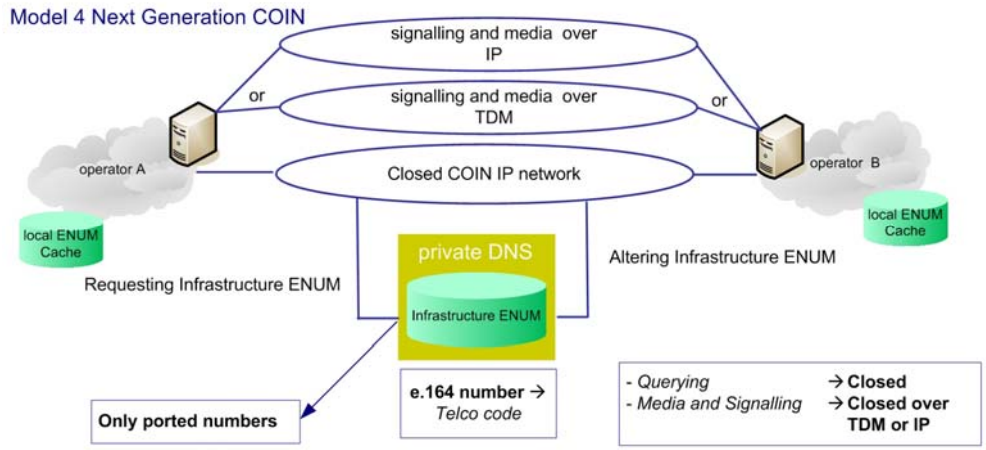

Figure 26 Model 4 Next generation COIN

In the other models interconnection is over IP. In model 4 this is not necessarily the case, because the Infrastructure ENUM gives (like the current COIN platform) only an identifier of the destination network. This identifier is locally translated to a correct network address. This can be an IP or PSTN destination.
In a nutshell this model leaves number portability as it is and replaces the current COIN technology by ENUM technology.

4.7 Summary

The application area and the degree of openness are the two main dimensions in which the models differ. The four models presented by this chapter for implementing Infrastructure ENUM in the Netherlands are:

- **Model 1: The closed model**

Facilitating: VoIP interconnection; *Degree of openness*: private DNS
This model describes the use of Infrastructure ENUM within a small group of operators. The participants within such federations are determining the exact specifications and only the participants are able to query the infrastructure ENUM database. The current Xconnect initiative is a form of this model.

- **Model 2: The email model**

Facilitating: VoIP interconnection; *Degree of openness*: public DNS
For the use of Infrastructure ENUM, an analogy is drawn with the current email system. Querying, signalling and media all run over the Internet. This implicates that operators can deliver calls to each other without having business agreements. Within this model Infrastructure ENUM is used for translating a number into a URI and the DNS is also used for translating this URI to the correct destination.

- **Model 3: The compromise model**

Facilitating: VoIP interconnection ; *Degree of openness:* public DNS
This model combines the easy accessibility of the public DNS with the operator's requirements with regard to business agreements and QoS requirements. Interconnection business can continue without no structural change.

- **Model 4: Next Generation COIN**

Facilitating: number portability; *Degree of openness:* private DNS

This model leaves number portability as it is and replaces the current COIN technology by ENUM technology. This means that only ported numbers can looked up by means of ENUM technology.

Roughly can be said, that model 1 and model 4 are the closed models and that model 2 and model 3 are the open models. The main difference between model 1 and model 4 is that model 4 is only supporting ported numbers and that model 1 only supports VoIP numbers.
The main difference between model 2 and 3 is that within model 2 the DNS is also used for routing to the correct destination. This is not the case within model 3. Here the URI obtained from the Infrastructure ENUM database is locally (at the operator's side) translated to the correct destination.

5 Implementation models: questionnaire results

5.1 Introduction

The aim of this chapter is to answer the fourth sub question:
'What are the stakeholders' positions about the implementation options?'
This chapter presents the results of the second round questionnaire. All questions and results can be found in this chapter. Next chapter will discuss and analyse these results. This chapter strives for a compact and complete overview of the results.
The first section presents how the second round questionnaire is developed. The second section discusses the response to the questionnaire. Hereafter, the results are classified in the following topics which are presented in the following order: alternatives for Infrastructure ENUM, business aspects, organisation and accessibility of Infrastructure ENUM, roles of actors, reasons for support/ no support, desirability / likelihood and the respondents' judgement about the models. The final section will summarize this chapter.

5.2 Second round question development

The models presented in the previous chapter, form the core of the second round questionnaire. The questionnaire can be found in appendix D. The total questionnaire consists of 63 questions, around sixteen questions per model. Nine questions were the same for each model. Because these questions are presented for each model, indirect comparison of the models is possible. Both open and closed questions have been used.
The dimensions mentioned in section 4.2 (application area and degree of openness) are already incorporated in the models. The other (open) issues from section 2.2.8 have been the basis for the questions. These issues are: (1) the content of the Infrastructure ENUM database, (2) location of the Infrastructure ENUM database, (3) the organisation/cooperation needed to establish/ operate Infrastructure ENUM. The main findings from chapter 3 have been incorporated into the questionnaire as well. One of the conclusions was that business aspects are dictating changes. Therefore the fit of the models to different business models has also been part of the questionnaire.

5.3 Response to the questionnaire

A list of people who have been interviewed and who filled in the questionnaire can be found in appendix C. The first round sixteen interviews were done with eighteen people. In the second round three new organisations, SIDN, AMS-IX and former Rits Telecom joined for filling in the questionnaire. Due to practical reasons it did not work out to interview them in the first round as well. So there were 21 people who could do the questionnaire. Seventeen people filled in the questionnaire, which resulted in a response rate of 81%. Unfortunately, three out of four people

who did not fill in the questionnaire were operators without own access network[47]. Thus no conclusions can be drawn for this group.
The respondents are not equally distributed over the different groups. Appendix C presents the various groups. The operator group is by far the largest group with nine people. The other groups (vendors, facilitators, government / NRA and interest groups) consist of four or less respondents. The reason for the relatively large operator group is that they will have to use and fund it. In the case of Infrastructure ENUM the operators have a large influence on what will happen with Infrastructure ENUM in the Netherlands.

5.4 Alternatives for Infrastructure ENUM

It is important to know whether other technologies exist which can fulfil Infrastructure ENUM's function. Within every model, one question has been asked about the alternatives for Infrastructure ENUM or the appropriateness of Infrastructure ENUM.
Regarding the email model (model 2), Infrastructure ENUM is the only reasonable technology. Infrastructure ENUM is an extension of the current DNS technology. The email model is the most open / Internet minded model and ENUM is developed within the Internet standardization body, IETF. Thus it is quite obvious that there are no serious alternatives for Infrastructure ENUM within the Internet context. Despite the absence of serious alternatives for Infrastructure ENUM in the context of the email model, it remains unanswered whether DNS is considered as appropriate for VoIP interconnection. Therefore the following question has been asked:

Model 2: Do you think DNS technology is suitable within VoIP interconnection?

Figure 27 Suitability of DNS technology for VoIP interconnection

Figure 27 shows that a clear majority considers DNS technology as suitable for VoIP interconnection. Thus there is no discussion about the suitability of DNS for the interconnection of VoIP services.
Less clear is whether Infrastructure ENUM is the only reasonable technology with respect to the closed model and the compromise model. Therefore the question mentioned below has been asked twice. First in the context of the closed model, secondly in the context of the comprise model.

Are there alternative technologies that can be used in stead of Infrastructure ENUM?

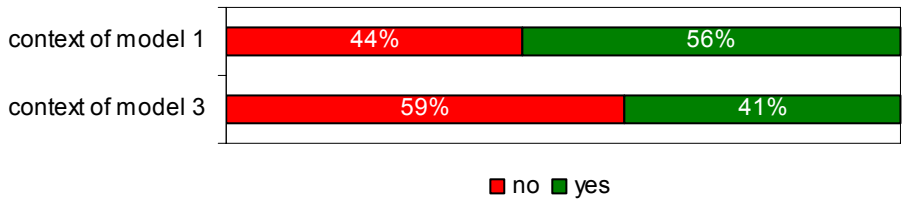

Figure 28 Existence of alternatives for Infrastructure ENUM

[47] The mentioned reasons for not participating are a lack of available time and a perceived lack of knowledge.

Remarkable is the difference in response between the two environments in which the question has been asked. With respect to the closed model (model 1), a small majority of the respondents answered 'yes' to the question above. Concerning the compromise model (model 3), a small majority answered 'no'. So with regard to open models the respondents state that they are expecting less other technologies which can do the Infrastructure ENUM task then with regard to closed models.
When the respondents answered 'yes', an open question followed, providing an opportunity for giving alternatives. The respondents who filled in a 'yes' gave in the case of model 3, only alternatives such as Xconnect and COIN, which can not be seen as competitive. Thus ENUM technology is the only serious option for the compromise model.
Stated alternatives for ENUM in the context of the closed model are: plain SIP routing, intelligent network (IN) routing and DUNDI. In fact, one of the respondents mentioned that every general agreed database technology is possible. Thus there are theoretically many alternatives. However as one of the other respondents formulated: "there are many others but none is worthwhile investigating; as ENUM provides a more scalable and interoperable solution". This remark together with the high percentage (44%) of respondents who answered 'no' and the not 'shocking' alternatives indicated that there are no 'real' alternatives for ENUM as technology in a closed environment.
The next generation COIN model is more specific than the other models and therefore a more specific question with regard to alternatives could be asked.

Earlier attempts have been undertaken for new COIN system, the so-called COIN 2. The COIN 2 project is cancelled.
Do you think Infrastructure ENUM will be the technology of the next generation COIN or do you consider another technology as more privileged?

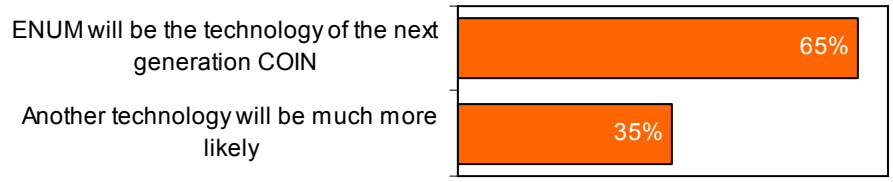

Figure 29 The technology of the next generation COIN

Figure 29 shows that if COIN is ready for using another technology, ENUM will have serious chance to be chosen as technology. One of the operators who chose for 'another technology' will be much more likely holds the view that the next generation COIN will use a similar technology, similarly to the technology intended for the COIN 2 project and only after that ENUM will be used.

5.5 Positioning Infrastructure ENUM in the business environment

The environment in which Infrastructure ENUM has to operate is dominated by business considerations. The fit with current and future business practices is mainly determining the success of a particular Infrastructure ENUM implementation.
Figure 31 presents the results from the question about the following business aspects : fit with the current business, accessibility for new operators, fit with the 'sender keeps all' business model (peering model) and the fit with the 'calling party

pays' business model. Figure 30 gives extra information about these business aspects.

Business aspect	Explanation
Fit with current business	This item measures the fit of the Infrastructure ENUM implementation model with the current way of doing business by the voice providers in the Netherlands.
Accessibility for new operators	This item measures the openness of the Infrastructure ENUM implementation model for entry of new voice providers.
Fit with 'Sender keeps all (SKA)' business model	This item measures the fit of the Infrastructure ENUM implementation model with the SKA business model. Within this interconnection business model, networks that transfer equal amounts of traffic do not pay each other and unequal traffic flows are paid by a fixed amount per month (or an other agreed time span) per bandwidth (see section 2.4.9 for more information about business models).
Firt with 'Calling party pays (CPP)' business model	This item measures the fit of the Infrastructure ENUM implementation model with the CPP business model. Within this interconnection business model, networks pay each other per delivered voice session. Thus an accurate administration of sessions is very important and the amount that has to be paid, depends on the number of session and their direction. (see section 2.4.9 for more information about business models).

Figure 30 Explanation of business aspects

If an implementation model would not fit the one of those two business models than it would down grade it possibilities on actual occurrence.
To investigate the fit with above mentioned business aspects, the following question has been asked.

How do the following business aspects fit with model x?

The left column of figure 31 shows these business aspects followed by the responses per model. The 'overall' column presents the total assessment of all the respondents per business aspect and the 'overall assessment' at the bottom of figure 31 presents the overall position of a particular actor group for all the business aspects per model.

	Operators	DGET / OPTA	Ven	Facil	Interest gr.	Overall	
Fit with current business	+	+ / -	+ / -	-	--	+ / -	Model 1
	-	+ / -	+	+	--	+ / -	Model 2
	+	+ / -	+ / -	+	++	+	Model 3
	+	+	+ / -	+	+ / -	+	Model 4
Accessibility for new operators	+	+	-	--	--	+ / -	Model 1
	+	+	+	++	--	+	Model 2
	+	+	-	-	++	+ / -	Model 3
	+	+	+ / -	-	+ / -	+ / -	Model 4
Fit with 'Sender keeps all' business model (peering model)	+	+ / -	-	+	--	+ / -	Model 1
	+	+ / -	+	+	--	+ / -	Model 2
	+ / -	+ / -	+ / -	+	+ / -	+ / -	Model 3
	+	+ / -	-	+ / -	+ / -	+ / -	Model 4
Fit with 'Calling party pays' business model (caller pays)	+ / -	+ / -	++	+	+ / -	+	Model 1
	+ / -	+ / -	-	-	+	+/-	Model 2
	+ / -	+	+	+	++	+	Model 3
	+ / -	+	++	+	+ / -	+	Model 4
Overall assessment	+	+ / -	+ / -	+ / -	-	N/A	Model 1
	+/-	+ / -	+ / -	+	-	N/A	Model 2
	+ / -	+ / -	+ / -	+	++	N/A	Model 3
	+	+ / -	+ / -	+ / -	+ / -	N/A	Model 4

-- bad - poor + / - neutral + moderate ++ good

Figure 31 Assessment of the business aspects

The most important findings resulting from figure 31 per business aspect:

- Fit with current business

With regard to this business aspect it is most interesting to look at the operators, because they are running the business.

Main finding:
- According to the operators: all models fit with current business except for the email model.

- Accessibility

The accessibility is best evaluated if all respondents are taken into account, because the others have a more unrestricted view.

Main finding:
- The email models scores as only model, positively at accessibility for new operators.

- Fit with 'sender keeps all (SKA)' business model

Main findins:
- Overall: SKA fits all models equally
- Operators: All models fit well with SKA except for the compromise model.

- Fit with 'calling party pays' (CPP) business model

Main findings:
- CPP fits all model except the email model
- Operators: CPP equally fits all models

Comparing the fit of the models with CPP and the fit with SKA, it can be concluded that :

Operators associate the Infrastructure ENUM models more with SKA than with CPP. The other stakeholders associate the Infrastructure ENUM models more with CPP than with SKA

Thus the others, which are more Internet minded, consider Infrastructure ENUM as something that will become incorporated in telecommunication business, while the operators see Infrastructure ENUM as something that will be ruled by the Internet interconnection business models. An interesting difference in view. The other stakeholders expect that operators are trying to keep the CPP model for interconnection supported by Infrastructure ENUM. While the operators themselves associate Infrastructure ENUM with the SKA business model. If business considerations determine that moving towards a SKA business model is not desirable, then it is likely that Infrastructure ENUM will not be applied. Because of the association of Infrastructure ENUM with the SKA business model.

Looking at the overall assessment in the bottom of figure 31, the following can be concluded.

Main findings with regard to the business aspects:
- Overall operators evaluate the business aspects most positively for the closed model and next generation COIN
- Facilitators prefer the 'open' models (model 2 and 3).
- The interest group disfavours the closed model and the email model. And favours the compromise model.
- DGET/OPTA and vendors have a neutral position

Besides the business environment in which Infrastructure ENUM has to operate, the costs of the Infrastructure ENUM database have to be recovered. In Austria they are already running a Infrastructure ENUM database (in the form of model 3 the compromise model) with a detailed plan how to finance and operate Infrastructure ENUM. This cost structure is presented to the respondents.

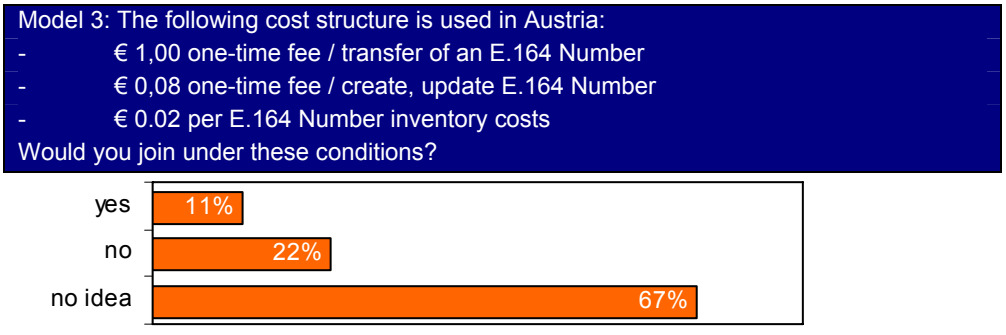

Figure 32 Operators' opinion about the cost structure in Austria

The question in figure 32 is only relevant for operators and therefore only their results are presented. The large percentage of operators who have no idea is indicating that this level of precision is a bridge to far in this stadium. One of the operators is also mentioning “why no query tariff?”. Such a query tariff would indeed be an option as well, however the reason for choosing the current Austrian cost structure had to do with a more predictable income stream for the organisation running the Infrastructure ENUM database.

5.6 Organisation and accessibility of Infrastructure ENUM

One of the important issues in which the implementation models differ from each other, is whether Infrastructure ENUM is placed in the public or a private DNS. With regard to the ‘open’ models (the email model and the compromise model) a question about the desirability of the public accessibility has been asked.

How do you evaluate the public accessibility of the Infrastructure ENUM database?

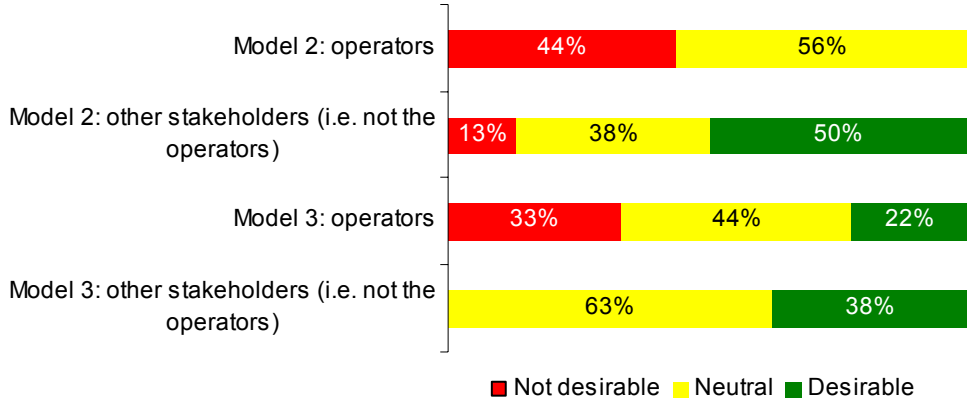

Figure 33 Desirability of public accessibility of Infrastructure ENUM

Figure 33 clearly shows a large difference in desirability between operators and the other stakeholders within the email model (model 2). No operators evaluate public accessibility as desirable and a reasonable percentage (44%) considers it as undesirable. This sharply contrast with 50% support of the other stakeholders. Taking a look to the desirability of public accessibility within the compromise model (mentioned in figure 33 as model 3), two things need to be mentioned: (1) again the contrast between the operators and the other stakeholders, however less strong than with regard to the email model, (2) within both groups the largest part of the respondents is neutral. The first observation indicates that the door is not totally closed for the compromise model. In spite of a reasonable percentage of operators who evaluates it as undesirable. The second observation points to an undetermined attitude, respondents do not exactly know how to assess this model.

The undesirability of public accessibility for operators is confirmed by the question about the desirability of limited accessibility in the closed model. Limited accessibility is one of the characteristics of the closed model. Therefore the following question is asked:

How do you evaluate the limited accessibility of the Infrastructure ENUM database?

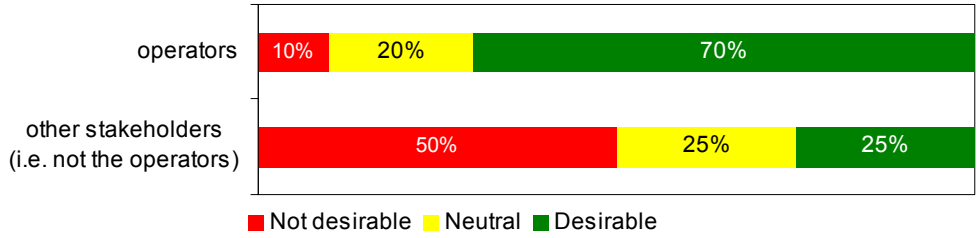

Figure 34 Desirability of limited accessibility of Infrastructure ENUM

From figure 34, it can be concluded that operators are pleased with the limited accessibility. This is not surprisingly and indicates that they prefer to operate in a closed environment. The other stakeholders are less pleased with the closed approach. 50 % considers it as not desirable. The same contrast which is seen in figure 33. Parties with other interests/views are not pleased with the closed preference of the operators. Appendix G presents the full results with the original five point scale which has been used.

Overall can be concluded that 70% of operators consider limited accessibility as desirable and public accessibility is evaluated neutral to negative. The other stakeholders prefer public accessibility.

The operators prefer a closed approach, so it is interesting to look in some more detail to the results of some other question asked in the context of the closed model (model 1). The 'closed' organisation and limited accessibility can lead to different 'islands' or initiatives. These federations of parties may exist next to each other.

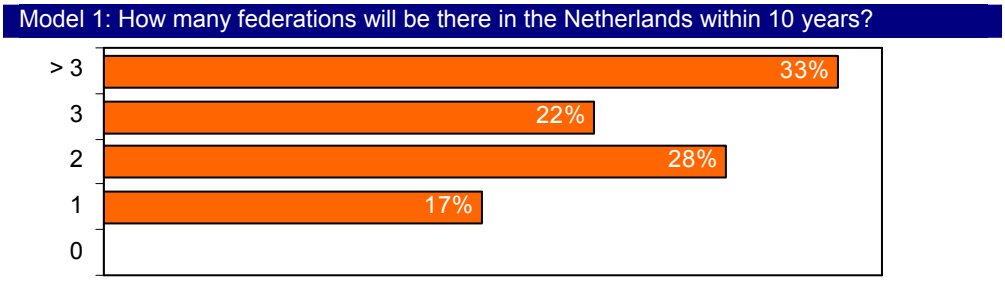

Figure 35 Expected number of federations

Figure 35 shows the number of federations that is expected by the respondents. It can be concluded that 83% of the respondents think other initiatives will appear, next the to the cable initiative with Xconnect. What catches the eye is the fact that 33% think that there will be four or more federations in the Netherlands. Of course the specific composition of these federations is unknown, but the high number of expected federations points to some commitment in the market for the closed model.

In addition to the number of federations it is also interesting to look at orientation of the federations. The majority of the respondents thinks that the federations will have an international orientation. Around one third thinks that the federations will only be national oriented. It is interesting to see that in globalising world, still one third of the respondents thinks that the federations will be national orientated. This indicates that the national component of interconnection cannot be neglected.

Model 1: Will the federations be mainly national or internationally oriented?

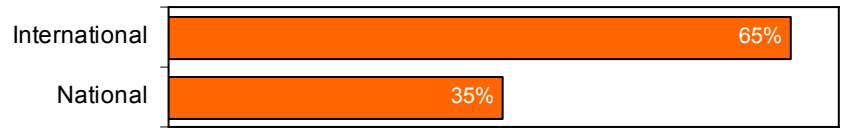

Figure 36 Orientation of the federations

A possible problem of spread number information, could be that if operators join more than one of these federations, then the uniqueness of number information can be assaulted. A situation in which two 'islands' give different information over the same number is not inconceivable. So possibly government measures would be one of the options. This option has been presented to the respondents.

Model 1: Do you agree with the following position: 'The government has to regulate that operators can only join one federation with their numbers, this to prevent querying a particular number will result in conflicting information.'

Figure 37 Position about: Necessity of regulation for entering federations

The result is very clear: it is not desirable at all that the government prevents operators from joining more than one federation. An overwhelming majority (83%) of the respondents is against government interference. So the existence of more than one federation does not need regulation.

In spite of the expectations of more federations coming up, currently there is only one attempt for creating such a federation in the Netherlands: the cable initiative with Xconnect. Xconnect manages a central SIP exchange. This means that calls are set up along a central authority. It is not clear if this set up will be the set up for the next generation interconnection. Figure 38 shows that 50% of the respondents regard the situation with a central authority handling SIP messages as undesirable. This overall percentage does not differ for the subgroups operators and others (see appendix G). It is clear that a central SIP exchange is only supported by one third of the respondents and operators. Thus the technical solution of the current Xconnect initiative is not supported strongly.

Model 1: How important is it that the organisation which manages the closed Infrastructure ENUM database also is the central place where SIP Messages are exchanged?

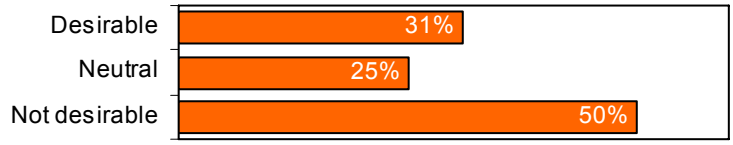

Figure 38 Desirability of a central SIP exchange

Besides the current cable initiative with Xconnect, the COIN organisation (see section 2.5.3 for more information about COIN) is another organisation that could play a role in establishing an Infrastructure ENUM database within a closed environment.

Model 4: Do you agree with the following position: 'Number portability has to remain a responsibility of COIN.'

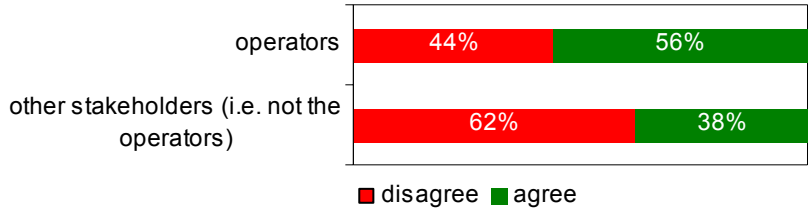

Figure 39 Number portability has to remain a responsibility of COIN

Figure 39 shows that the COIN organisation has a substantial support base for their current operations within the operator group.

Currently, the COIN number portability platform only contains 'ported' numbers. However if the COIN platform wants to be able to facilitate VoIP interconnection in the Netherlands, it has to contain all Dutch E.164 numbers. A small majority of operators consider the extension of the current COIN platform with all numbers as desirable. The other stakeholders share this position. The 'not desirable' group of 33 percent take the view that COIN only has to contain ported numbers and more functionality is undesirable. Overall can be said that there is a slight preference that COIN's functionality must be extended (see figure 40).

Model 4: Currently, COIN only contains 'ported' numbers. How desirable is it that COIN contains all numbers?

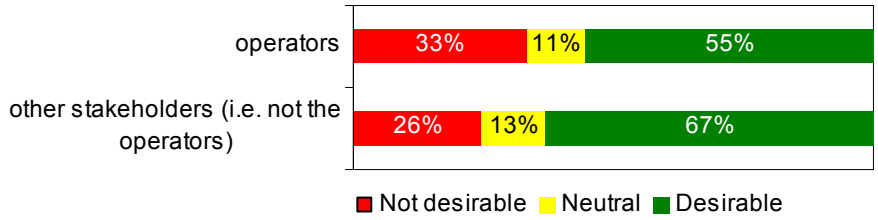

Figure 40 Desirability of COIN containing all numbers

The organisation COIN has a substantial support base for their operations and a slight preference exists that COIN's functionality must be extended. Thus the organisation COIN is considered as important and has an important role. To fulfil this role, COIN may use Infrastructure ENUM in the future.

Organisation COIN and the cable initiative with Xconnect are two organisations that can be important in the future for Infrastructure ENUM with a closed approach. Another organisation that could play a role with regard to open Infrastructure ENUM, is SIDN[45]. Currently SIDN is trying to get permission to be the Dutch registry for the .1.3.e164.arpa domain. Their current proposal (SIDN, 2006) is only focussing on User ENUM. However, it could be the case that 'open' Infrastructure ENUM could be placed under the .1.3.e164.arpa domain. SIDN can decide to delegate this sub domain, but they are still responsible for the whole domain. So it is important to know from an Infrastructure ENUM perspective what their basis of support is.

Model 2: Do you agree with the following position: "Stichting Internet Domeinregistratie Nederland (SIDN) is the proper organization for managing the Dutch 'Registry'?

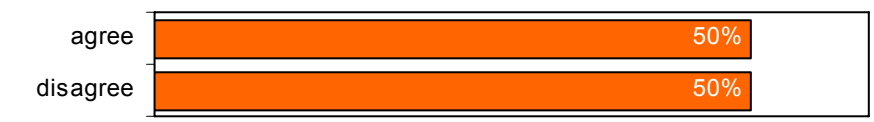

Figure 41 SIDN is the 'proper' organisation for the Dutch Registry

Figure 41 shows that SIDN does not have a majority supporting them. 50% is supporting them, but also 50% disagree with SIDN as registry for Infrastructure ENUM. Thus the opinions about this are divided. If the Infrastructure ENUM domain will be placed within the .1.3.e.164.arpa domain then SIDN has to create a larger support base, will it be successful.

5.7 Roles of actors

To determine which role the stakeholders are likely to play, all respondents were asked to give their view about the role of the stakeholders mentioned in figure 42: operators with own access network, operators without own access network, OPTA, DGET and vendors. The second column of figure 42 shows how these stakeholders see their role. The other columns show the expected role by all respondents. Only one of the following option could be filled in: initiator/locomotive, neutral or uninterested.

Which role do you think that the following actors will play?

	See themselves as	All respondents see them as			With respect to model
		Initiator, locomotive	Neutral	Uninterested	
Operators with own access network	Initiator, locomotive	82%	12%	6%	Model 1
	Neutral	24%	35%	41%	Model 2
	Neutral	53%	41%	6%	Model 3
	Initiator, locomotive	71%	24%	6%	Model 4
Operators without own access network	No data available	41%	41%	18%	Model 1
	No data available	71%	41%	18%	Model 2
	No data available	35%	47%	18%	Model 3
	No data available	35%	41%	24%	Model 4
OPTA	Neutral	12%	59%	29%	Model 1
	Neutral	18%	71%	12%	Model 2
	Neutral	18%	76%	6%	Model 3
	Neutral	24%	76%	0%	Model 4
DGET	Neutral	6%	65%	29%	Model 1
	Neutral	24%	59%	18%	Model 2
	Neutral	18%	71%	12%	Model 3
	Neutral	18%	76%	6%	Model 4
Vendors	Neutral	35%	59%	6%	Model 1
	Neutral	35%	53%	12%	Model 2
	Neutral	35%	53%	12%	Model 3
	Uninteressed	35%	47%	18%	Model 4

Figure 42 Role of the stakeholders regarding Infrastructure ENUM

The first thing that attracts attention is that operators are seen and see themselves as initiators/locomotives. The other actors are mainly neutral and cannot be marked as initiator/locomotive. The second and most important conclusion from figure 42 is that the compromise model (model 3), lacks an initiator/locomotive. The closed model (model 1) and next generation COIN have a clear initiator/locomotive, namely operators with own access network. The email model (model 2) has a clear

initiator/locomotive, namely operators without own access network. Regarding the compromise model the operators with own access network have only a small majority of the respondents seeing them as initiator/locomotive and they see themselves as neutral. This will say more about the role they will play, then the small majority seeing them as initiator/locomotive. Therefore it can be concluded that there is no initiator/locomotive for the compromise model. The lack of an initiator/locomotive for this model can entail difficulties with realising this model.
With regard to next generation COIN (model 4), a remark about the vendor's role has to be made. The vendors see themselves as uninterested, but 82% of the respondents see them differently. An explanation for this could be the wide range of products that are sold by vendors. The vendors participating in the survey are apparently not directly involved in supplying COIN's technology.

5.8 Reasons for support / no support of the implementation models

What are the reasons for actors, for supporting or not supporting a particular implementation model? This is the main question in this section. All the quotes of the reasons for support / no support can be found in appendix H.

5.8.1 Model 1 The closed model

Within this model there are dissimilarities between the operators' reasons and the other stakeholders' reasons. There are much more reasons for no support among the other stakeholders than among the operators. On average, operators see this model as a model with good properties such as a high degree of control and high security. One of the operators mentioned that if the federation is based on the "sender keeps all" business model, it would be a reason for joining that federation. Only one of the operators mentioned security as one of the reasons for not supporting this model. An important remark made by an operator is that one federation and that a 'sender keeps all' business model is preferable.
The others' reasons for not supporting this model are opposing the supportive reasons from the operators. They criticize the control and scalability in a multi-actor environment of this model. They mention also the risk of a too powerful position of the organisation that runs the closed Infrastructure ENUM.

5.8.2 Model 2 : The email model

The reasons for support / no support of model 2 Open Infrastructure ENUM: The email model is characterized by the fact that the operator group has little supportive reasons in contrast with the many supportive reasons from the others. Operators agree about the fact that this is the model for best effort services. This is regarded as a reason for no support, because of the insufficient monitoring of security and QoS. The other important operator's reason for not supporting this model is that this model requires a 'sender keeps all' business model. As long as the current interconnection regime of OPTA applies, this model 2 is undesirable. The current interconnection regime defines obligations to some strong market players, like non discrimination. Thus if this operator agrees a sender keeps all interconnection to one of its partners, it is obliged to offer this to all its business partners. This is a

barrier for moving from the calling party pays, to the sender keeps all business model.

5.8.3 Model 3: The compromise model

Operators' reason for supporting this model is mainly because it fits their current practices. As one of the operators expresses it: "open standards without the disadvantages of model 2". Thus more supportive reasons exist than with regard to the other open model (model 2). The operators' not supportive reasons underline that the number of bilateral agreements would be too high, security is still a problem and the reason for putting the ENUM in the public field is not seen. "If the interconnection is private, why not also putting the Infrastructure ENUM database in a private environment", is stated by an operator. One of the reasons for this is that international standardization and accessibility is much easier to establish within this model.

One of the others mentioned that this model is the compromise between the advantages of the open model and the disadvantages of the closed model. On the other hand others are worried about the access of new operators without own access network in contrast with the easy access of the email model. One of the vendors mentioned that many operators are dependant on classic vendors which do not have Internet ready software and thus do not support open models. This creates a tendency for these operators to choose for closed models.

5.8.4 Model 4: Next generation COIN

Like within model 1 there are some dissimilarities between the operators and the others. Operators have more supportive reasons. However others are less negative than with regard to model 1.

Advantages of this model mentioned by operators with respect to the current COIN are real-time availability of number information and lower costs because of ENUM technology. A different view comes from some other operators. They suggest not changing COIN and establishing another platform with ENUM for facilitating VoIP interconnection. This platform has no direct connection with the COIN database and organisation. This view does not match the remark of another operator that an extension of the current COIN is needed to support VoIP interconnection. If this is meant by this model then it would be a reason for support. This respondent considers COIN as the organisation which has to facilitate VoIP interconnection, which is actually a vote against this model, because this model is just focussing on replacing current COIN technology with ENUM for number portability.

5.9 Desirability / Likelihood of the implementation models: scatter plots

The desirability and likelihood are two important concepts which are obviously part of the questionnaire for every model. The question to measure desirability is:

How desirable is the use of model x for your company / organisation?

The question for the likelihood is:

What are the chances that model x is implemented on a large scale within 10 years?

The outcomes to these two questions are first presented in tables and secondly in scatter plots. Figure 43 shows the desirability of the models according to the different actor groups. Operators consider only the closed model as desirable and

do not have negative attitudes towards the other models. The vendors and facilitators see the email model as most desirable.

	Model 1: Closed Infrastructure ENUM	Model 2: Open Infrastructure ENUM: The email model	Model 3: Open Infrastructure ENUM: With interconnection agreement	Model 4: Next Generation COIN
Operators	Desirable	Neutral	Neutral	Neutral
DGET / OPTA	Neutal	Neutral	Neutral	Neutral
Facilitators	Not desirable	Desirable	Neutral	Neutral
Vendors	Not desirable	Desirable	Neutral	Not desirable
Interest Group	Not desirable	Not desirable	Desirable	Desirable
Overall	Neutral	Neutral	Neutral	Neutral

Figure 43 Desirability of the implementation models

Figure 44 presents the chances whether the models will become reality according to the respondents. Operators evaluate only next generation COIN as having a large chance to occur. Remarkable because they considered only model 1 as most desirable. However this points to a conservative development with regard to ENUM and it is uncertain whether the Xconnect initiative of cable operators (a form of closed model) will become successful. The facilitators have faith in the open models and think these models will become reality. The interest group thinks that none of models will become reality. Overall none of the models has a high chance to occur. This is an indication that it will take some time before an Infrastructure ENUM will become reality.

What are the chances that model x is implemented on a large scale within 10 years?	Model 1: Closed Infrastructure ENUM	Model 2: Open Infrastructure ENUM: The email model	Model 3: Open Infrastructure ENUM: With interconnection agreement	Model 4: Next Generation COIN
Operators	•••	•••	•••	••••
DGET / OPTA	••••	•••	•••	•••
Facilitators	•••	••••	••••	•••
Vendors	•••	••••	•••	••
Interest Group	••	••	••	••
Overall	•••	•••	•••	•••

•not likely at all •• not likely •••neutral ••••likely •••••very likely

Figure 44 Likelihood of the implementation models

As mentioned above, the desirability and likelihood are also depicted in scatter plots. These scatter plots provide insight to the position of the different actors. The respondents' scores on desirability and likelihood are plotted with desirability on the horizontal axis and likelihood on the vertical axis. Four quadrants can be distinguished: quadrant I (desirable and happening), quadrant II (undesirable and happening), quadrant III (undesirable and not happening) and quadrant IV (desirable and not happening). The quadrants I and III contain most respondents.

Evidently respondents are inclined to evaluate models that are undesirable for their organisation as less likely to occur.

Let us start with the scatter plot of the closed model. Members of group C in figure 45 can be considered as the supporters of this model: they think it is desirable and that the model is reality within 10 years. Only operators are found in this group. Group A represents the opponents, only one operator is in this group. Group B is neutral with regard to desirability and they are neutral to positive with regard to likelihood. It is remarkable that one of the cable operators is finding itself on the spot around D. Apparently, one of the cable operators is not a great supporter of the Xconnect initiative.

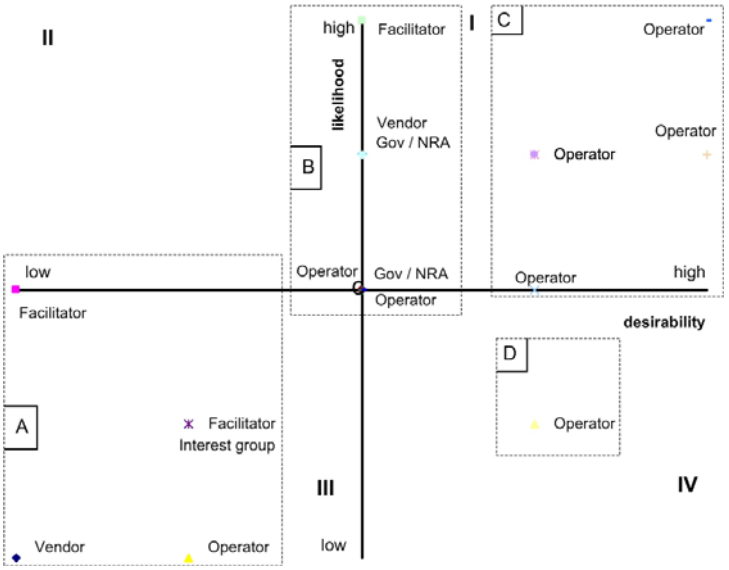

Figure 45 Scatter plot Model 1 Closed Infrastructure ENUM

The scatter plot of the email model (figure 46) shows a different situation. Within this model not the operators, but the facilitators (in group C) are the supporters of this model. Group B represents the group which is neutral with regard to desirability. Finally quite some operators are found in group A, the opponents of this model.

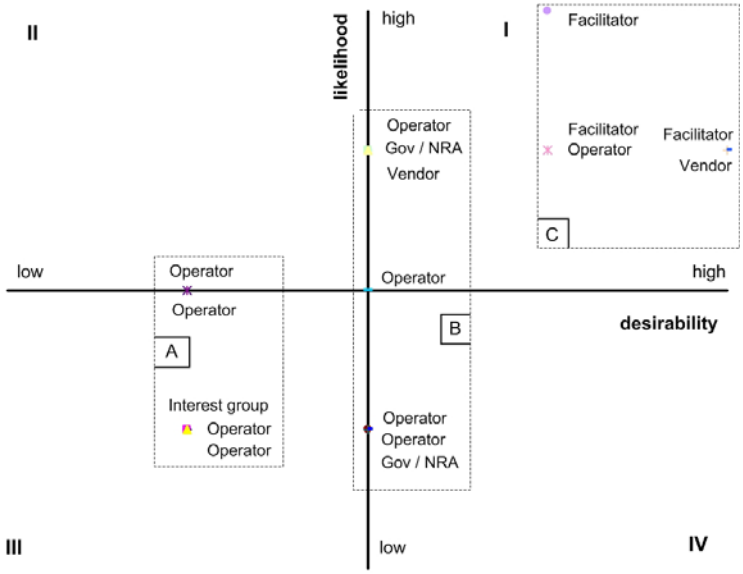

Figure 46 Scatter plot Model 2 Open Infrastructure ENUM: The email model

Figure 47, the scatter plot of the compromise model, shows very scattered respondents. Operators are spread out over figure 47 and there are two operators which are located within the desirable and happening quadrant (I), but also two in the not desirable and not happing quadrant (III). The facilitators are also scattered. So the opinions for this model are widely spread. The interest group is located in quadrant IV, which means a positive attitude towards the model, but a pessimistic view on the actual realisation.

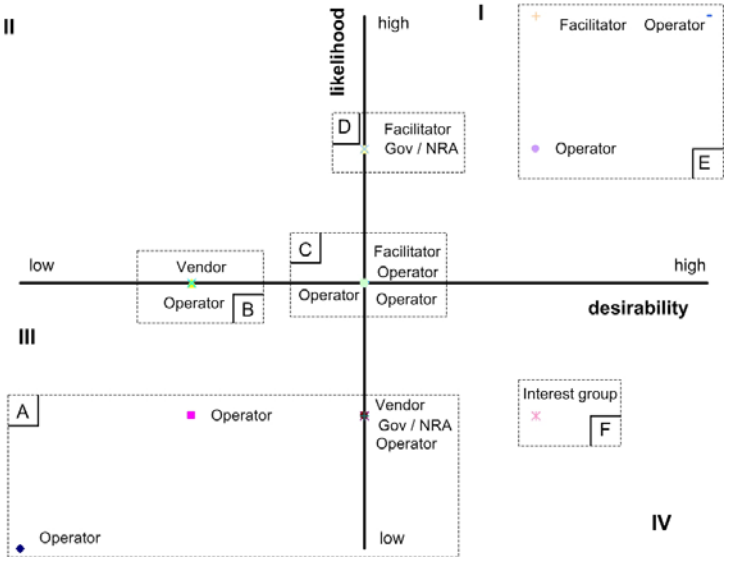

Figure 47 Scatter plot Model 3 The compromise model

The last scatter plot is presented in figure 48. The first thing that catches the eye in the scatter plot of next generation COIN model is the large group of respondents in the middle. This indicates that no quick action will be undertaken. However if one of the actors is initiating this model, there is a reasonable chance that they will try to influence this group for support. In group C no operators can be found. Thus no operators exist who think this model will not happen in the long run.

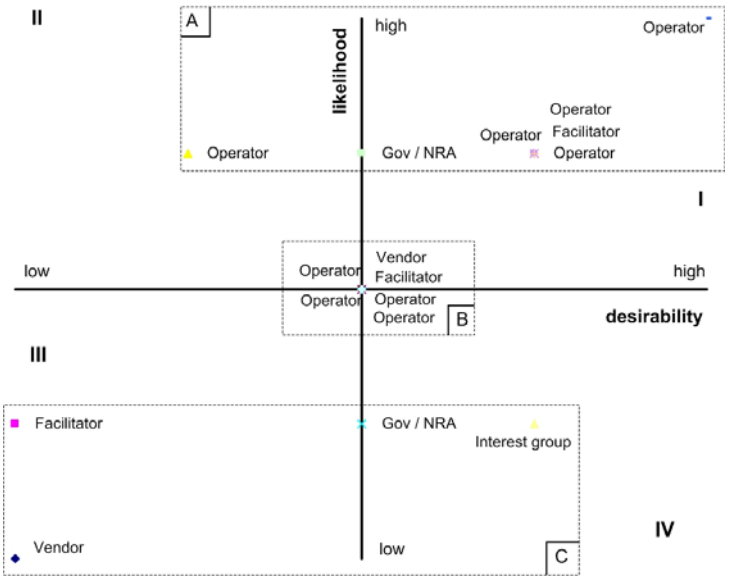

Figure 48 Scatter plot model 4 Next generation COIN

5.10 Respondents' judgement

At the end of the questionnaire all the respondents were asked to give their judgement over the models in a few words. These judgements can be found in appendix I and are summarized in this section.

5.10.1 Model 1 The closed model

All positive judgements designate this model explicitly as the fastest and most feasible solution (in the short term). So there is consensus about this among the supporters of this model. Maybe it will function as a leg up to other models. It is deployed all over the world and no regulation and standardization is needed and this is attractive for operators. However, these advantages are particularly opposed by facilitators who mention: (1) little difference to the current situation, (2) no compliance with RFC's, (3) too restricted, (4) resembles too much current interconnection models and (5) a proprietary system is not desirable.

5.10.2 Model 2 : The email model

The judgements are equally distributed over the categories positive, negative and neutral. Among the positive judgements no common denominator can be found. One of the operators mentioned that this will be the model when over five years SIP URIs are provided by Internet service providers (ISP's).
The neutral judgements mentioned that this model is most suitable for newcomers and for best effort services. This last observation is supported by the negative judgements which mentioned a lack of control as major disadvantage of this model. One of respondents thinks this model has more chance in the form of User ENUM. However this requires an active attitude of the user. The major difference between User ENUM and Infrastructure ENUM is that with Infrastructure ENUM (end) users are not direct stakeholders. With User ENUM (end) users are in complete control of the services behind the E.164 number.

5.10.3 Model 3: The compromise model

What catches the eye is that there are little negative judgements and most judgements are neutral. This points to an undetermined opinion concerning this model 3 The compromise model.
From a business perspective this model matches the current operator's situation and it offers from a functional perspective large advantages. One of the positive judgements points out that this model can also co-exist with model 2. This model would then be used for services which need QoS guarantees and model 2 for best effort services.

5.10.4 Model 4 Next generation COIN

The operators' judgements are mainly positive or neutral. Only one operator had a negative attitude towards this model. It fits with the current operators practices and ENUM is able to solve the problems with the COIN database. Another operator labelled this model as "better control in a safer environment". Several operators were expressing in their judgements a view on how this model should relate to the other models. One mentioned that this model will not exist, but will be part of model 2 and 3. So no apart number portability anymore. Another thinks that this model will not happen, but in the long run, model 1 will be under the authority of COIN. An

important requirement is that there must be one source for number information. Other actors mentioned that this model is not open and that it is a 'dead end'.

5.10.5 Judgements categorised into negative, neutral and positive

Figure 49 shows the categorisation of the judgements.

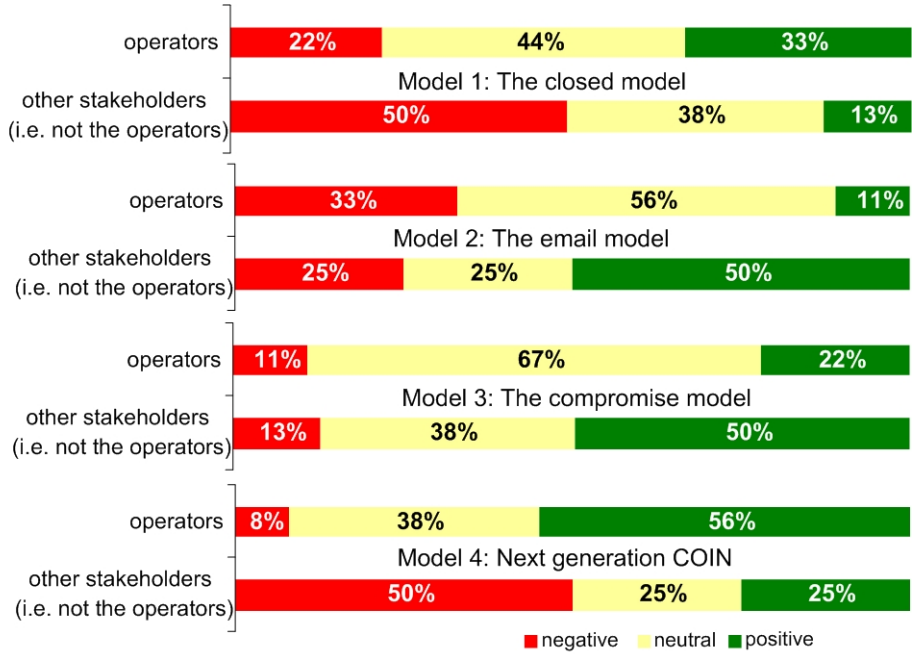

Figure 49 Categorisation of respondent judgements

The judgements contrasts between the two groups are largest within the closed model and the next generation COIN model. The others are opposing these models while the operators are neutral or in favour of the model. Operators are most positive over model 4 and the others favour the 'open' models 2 and 3. The compromise model is the model with most respondents having a neutral judgement, which indicates that the respondents need more information and discussion about the opportunities of the model to form an opinion. Operators disfavour the email model most.

In short, it can be said that operators assess the 'closed' models as most favourable, while the rest favours the 'open' models.

5.11 Summary

This chapter has presented the results of the questionnaire that has been filled in by 18 respondents and resulting in a response rate of 81%. Half of the respondents are operators. The most important results are presented in the text box below.

Main findings:

Alternatives for Infrastructure ENUM

- There are no serious considered alternatives for Infrastructure ENUM.

Positioning Infrastructure ENUM in the business environment

- Operators evaluate the business aspects most positively for the closed model and next generation COIN.

- Facilitators prefer the 'open' models (model 2 and 3).
- The email model does not fit the 'calling party pays' business model and is considered as the most accessible model.
- The 'sender keeps all' business model fits all models equally.
- The exact way of recovering the costs of the Infrastructure ENUM database, it to specific for the current stage of discussion in the Netherlands.

Organisation and accessibility of Infrastructure ENUM

- Operators prefer the closed model and next generation COIN, because of their closed characterization.
- 83% of the respondents thinks that other initiatives will appear, next the to the cable initiative with Xconnect.
- Large part of respondents sees current setup of Xconnect, with central SIP routing, as undesirable.
- One third of the respondents thinks that the federations based on the closed model (model 1) will have national focus.
- If the Infrastructure ENUM domain will be placed within the .1.3.e.164.arpa domain then SIDN has to create a larger support base.
- COIN as organisation has a moderate support base for being the organisation that carries responsibility for number portability.
- There is a slight preference that COIN's functionality must be extended to VoIP interconnection.

Roles of actors

- All models have a clear initiator/locomotive, except the compromise model (model 3). This moves the (possible) realisation of model 3 to the long run.

Reasons for support / no support

- Reasons for supporting the closed model are: high degree of control and high security. Not supportive reasons are: limited scalability and a powerful position for the organisation running the Infrastructure database.
- The email model has little supportive reasons from operators. Their not supportive reasons are that this model requires the 'sender keeps all' business model and that is only able to deliver best effort.
- The reason for supporting the compromise model is that it supports current practices and the most important reason for no support is that requires to many bilateral agreements.
- Supportive reasons for Next generation COIN are: lower costs because no use of proprietary systems anymore and number portability must continue to be COIN's responsibility. Some respondents want to extend COIN's functionality with facilitating VoIP interconnection; a vote against this model.

Desirability / Likelihood

- Next generation COIN is characterized by a large number of neutral respondents; most of the operators are neutral with regard to desirability. and feasibility→ no high need for changing COIN.
- The closed model is considered desirable by operators.
- The email model is considered likely by facilitators .
- The respondents are very divided with regard to the compromise model. This is clearly shown by the compromise model scatter plot (figure 47).

Respondents' judgement

- The closed model is considered as the quickest to implement and will function as leg up to other models.
- The closed model can cause proprietary systems and that is not desirable.
- The email model is considered (only) applicable for best effort services and one of respondents predict that this will be the model when SIP URIs are provided by Internet service providers.
- The judgments regarding the compromise model are mainly neutral, pointing to an undetermined opinion about this model.
- The co-existence of the compromise model with the email model is seen as positive.
- Next generation COIN model fits with current operators practices and ENUM is able to solve the problems with the current COIN database.

6 Review of the implementation models

6.1 Introduction

The aim of this chapter is to answer the fifth sub question:
'What is a likely adoption path for the Infrastructure ENUM implementation models?'
This chapter presents a view on the future of the implementation models. The implementation models are placed in a broader perspective. The results from the previous chapter form the basis for this future perspective. The most pessimistic perspective is that none of the models will become reality. This position is according to the results least plausible. The transition to VoIP is irreversible. This transition requires new techniques to map numbers to destination addresses. The respondents indicate that there are no other serious considered technologies beyond Infrastructure ENUM. This is a strong argument, that at least one of the models may become reality. The only argument that can weaken this reasoning is to reject the important assumption that E.164 numbers will remain the preferred way of identifying users of voice services. This assumption underlies a successful implementation of Infrastructure ENUM. This chapter will not reject this assumption.
Section 6.2 will discuss the future paths of the implementation models. Section 6.3 will summarize this chapter.

6.2 Adoption of the implementation models

The results of the questionnaire provide enough information for building a view for the adoption of the Infrastructure ENUM implementation models. Figure 50 presents a likely adoption path of the models over time. The left side of figure 50 presents the situation in the short run and the right side the situation in the long run. The figure is discussed and explained from left to right. It can be noticed that in the first phase only closed models are realized.

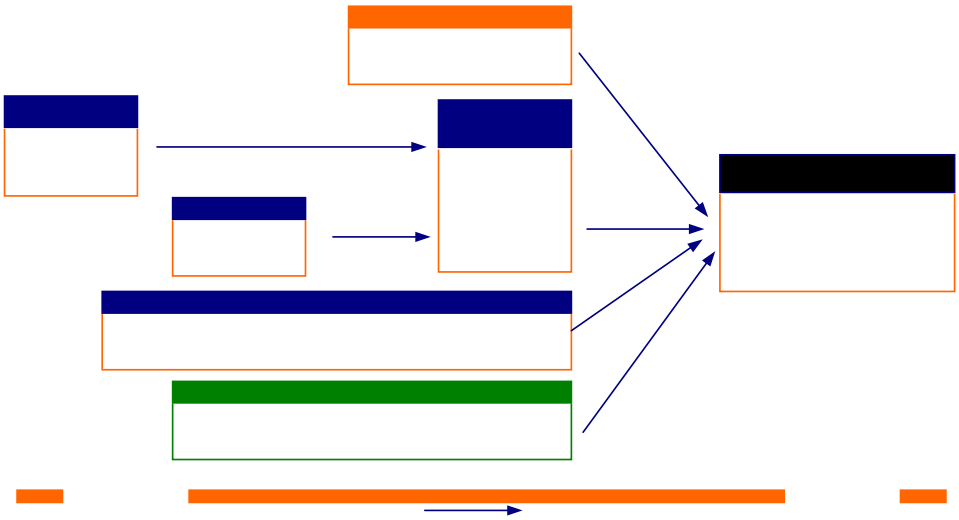

Figure 50 Adoption path of the Infrastructure ENUM implementation models

The questionnaire indicated that operators prefer a closed model and they consider the closed model as fastest deployable model. Currently, the cable initiative with Xconnect is piloting such a system. A closed environment is evaluated by the operators as more secure and it is easier to come to agreements. Next to this operator position, according to figure 35, 83% of the respondents expect that other initiatives besides the cable initiative will come up. Therefore several closed models are depicted in figure 50 in the short run.

Closed models are most likely to come up in the short run.

The respondents' judgements in section 5.10 show that many respondents share the opinion that it is quite likely that several implementation models will coexist. Therefore the emergence of the closed models is not preventing the development of open models. Somewhat later, in the medium term, parallel to the already existing closed models, it is likely that the email model will become reality. According to figure 42, operators without own access network are seen as initiators and are supporting the email model. The facilitators do have a positive attitude towards this model and it is according to the Internet minded parties the most preferable model.
These closed and open Infrastructure ENUM models are supporting VoIP interconnection, but number portability is still handled by COIN. The reason for this is that COIN is the only platform that provides an environment in which all number portations are reported. One could argue that within one federation (a closed model) number portability could be arranged. However not all the operators are member of that federation. Thus COIN is still needed. Operators evaluate next generation COIN as a model with a large chance to occur, the COIN organisation has a substantial support base and the fact that the current COIN technology will have to be upgraded once, make it reasonable that COIN will make the transition to Infrastructure ENUM technology.

It is likely that COIN will shift to Infrastructure ENUM technology in the medium term.

In the medium term all models are running parallel except the compromise model (model 3). The main reason for this is that according to figure 42 the compromise model lacks a clear initiator/locomotive in contrast with the other models. In spite of the lack of an initiator, the compromise model may play a convergent role in the long term. The other implementation models can be a leg up to this compromise model. Off course, it is disputable whether this integrating step will actual occur. Nevertheless, the need for integrating the several closed Infrastructure ENUM federations is driving new standardization processes in the long term. There are many examples within telecommunication business were such 'bottom up' way has worked out to come up with standards, like the current E.164 number standard. The compromise model will combine the advantages of the widely accessible DNS with the QoS requirements of the operators. Thus the compromise model will bring the 'best' of both open and closed worlds, because the control needed for QoS guarantees can be fully supported and operators have better easy access to E.164 number information. The open structure provides more international oriented

standards and more competition on the supply side of this technology. At the moment that all operators are using the compromise model, number portability can be handled by this Infrastructure ENUM database. The email model can be a part of the new compromise Infrastructure ENUM.

In the medium term, it is likely that all models are running in parallel and they may merge into the compromise model in the long run.

From a public interest point of view it would be most desirable if the Infrastructure ENUM database would be located in a public DNS, because of the better conditions for access and thus for more competition. Public accessibility in the compromise model has a positive effect on access for new operators to the voice market. A small operator is also able to know which party hosts a particular E.164 number. This information is important to be able to make agreements with other operators and to efficiently routing calls. This is different from the current situation in which only large operators actually know where E.164 numbers are hosted.

Up to this point, a general description of the adoption path of the Infrastructure ENUM models has been given. The results of the previous chapter do not provide a basis for making precise statements about the organisations which will run Infrastructure ENUM databases. However, a likely future scenario with (imaginary) names of organisations is outlined in the box below, to concretize the adoption path outlined above.

A likely future scenario

The cable initiative with Xconnect is the first closed model that appears. This first initiative combines an Infrastructure ENUM database with a central exchange of signalling information (SIP messages). The momentum of this initiative is moderate. After a short time, a new initiative is started, with the imaginary name NL ENUM fabric. This NL ENUM fabric has other members and does not operate a central signalling exchange. This is not preferable anymore because of two reasons.

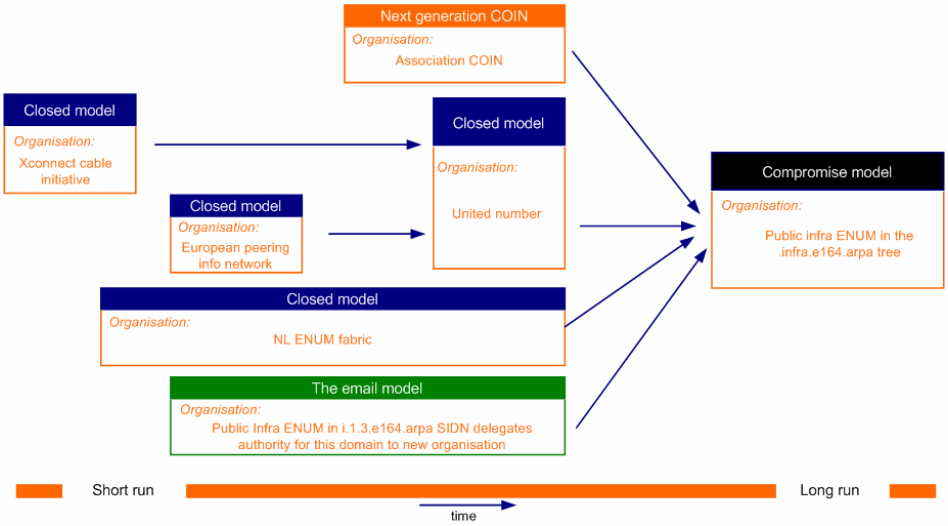

Figure 51 A likely Infrastructure ENUM future scenario

In the first place, improvements in standardization of SIP messages do not require a SIP exchange anymore. In the second place, forces within the Dutch market are not pleased with such a (powerful) authority which runs such a SIP

exchange. Its core business is just providing routing information for E.164 numbers. After this a European initiative, The European Peering Info Network, is also trying its chances for success. The government has a clear task in screening and securing that parties comply with their interoperability obligation.

In the medium term, the Infrastructure ENUM RFC is published by the IETF. SIDN delegates the responsibility for the i.1.3.e164.arpa domain to a new organisation with a large support base. The Infrastructure ENUM database is set up according to this IETF standard. This platform serves VoIP interconnection for best effort services. A 'sender keeps all' business model is used by a substantial part of the market. Somewhat later the European Peering Info Network combines forces with the Dutch Cable initiative and they form United number. COIN continues to be the platform for number portability and switches to Infrastructure ENUM technology.
The final step is a new Infrastructure ENUM sub domain: the infra.e164.arpa domain. This domain matches the new Infrastructure ENUM standard. This standard is widely accepted and all operators are using this platform for VoIP interconnection and number portability.

6.3 Summary

This section has pointed out that it is very likely that several models will co-exist. The exact proportion between the several models is difficult to predict. However, reasoning from a broader perspective, it can be concluded that closed models will be realized in the short term. After these first closed models, the email model is also likely to become reality and COIN will also transfer to ENUM technology. The desire to integrate the several closed models is putting pressure to the standardization process of the compromise model. It is a serious option that in the long run, the compromise model integrates all the models and one Infrastructure ENUM in the public DNS fulfils the two important services for infrastructure ENUM: VoIP interconnection and number portability.

7 Conclusions and recommendations

7.1 Conclusions

The goal of this study is to explore the application of E.164 Number Mapping (ENUM) in the field of voice over IP (VoIP) interconnection in the Netherlands. The accompanying main research question (presented in section 1.1) is:

Which organizational structure for the application of Infrastructure ENUM fits best the various stakeholders in the Netherlands?

The following organization structures for Infrastructure ENUM are formulated in this study: 1) The closed model, 2) Open Infrastructure ENUM: The email model, 3) The compromise model and 4) Next Generation COIN. These so called implementation models comprise VoIP interconnection and number portability as the two application areas for Infrastructure ENUM. The main difference between the implementation models is the degree of openness. Roughly there are two approaches for the organizational structure of Infrastructure ENUM: an open and a closed approach. Model 1 & 4 represent the closed approach and model 2 & 3 represent the open approach.
According to the respondents, for the application of Infrastructure ENUM, serious other alternatives for the Infrastructure ENUM technology do not exist. Infrastructure ENUM has a basis for support to be the method of incorporating E.164 numbers with VoIP interconnection

No seriously considered alternatives for Infrastructure ENUM technology exist.

However, the positions diverge how to set up Infrastructure ENUM. Generally, it can be said that none of the models is supported by all stakeholders. Thus regarding this study no overall consensus for a particular model exists.

No overall consensus for a particular organizational structure exists.

Despite the non-existence of an obvious choice for a particular organizational structure, the stakeholders (operators, DGET/OPTA, vendors, facilitators and interest groups) are favouring different models. The text boxes below show clearly the positions of the several stakeholders:

Facilitators, vendors and the interest group clearly support the open models.

DGET/OPTA have a neutral position with regard to Infrastructure ENUM and the other stakeholders confirm this position.

Operators with own access network prefer a closed approach. Thus no Infrastructure ENUM in a public accessibly DNS.

Regarding to the role of stakeholders, all stakeholders consider the operators as initiators/locomotives of an Infrastructure ENUM initiative.

Operators are seen by all stakeholders as initiators/locomotives of an Infrastructure ENUM initiative

Thus the contribution of the operators will determine the future of Infrastructure ENUM to a large extent.
Operators favour the closed model and they think that the next generation COIN model is most likely to occur. Because of the operators' preference for closed models and the current lack of an official standard for Infrastructure, it is most likely that in the short term closed models will rise in the Netherlands. However, these closed models do not stop the emergence of open models and the models will co-exist. Currently, the 'compromise' model which combines the open accessibility of E.164 number information with the current interconnection practices does not have a clear initiator/locomotive. However, this model could be the model in which all models will merge.

It is most likely that in the short term the closed models will arise and in the long term these closed models will merge with other models.

Operators mentioned in the interviews that business aspects were one the most important factors determining the future of Infrastructure ENUM in the Netherlands. Infrastructure ENUM is an 'enabler' not a driver. Only when business cases in which it is clear that certain (financial) benefits would occur, one would invest in Infrastructure ENUM. The question whether these business cases exist is not answered by this report. However, this report shows that the introduction of Infrastructure ENUM does not require a certain choice for a particular business model. Only the most open model, The email model requires a sender keeps all business model. The other Infrastructure ENUM options are equally suited for the sender keeps all model and the calling party pays model. Only the most open model (The email model) requires a change and is therefore considered by many respondents as an option for best effort voice services.

Introduction of Infrastructure ENUM does not require a change in business model except for the email model.

Overall it can be concluded that considering the results of this study, the closed model and the next generation COIN model are most likely to become the Dutch form for Infrastructure ENUM.

7.2 Discussion and reflection

The stadium in which Infrastructure ENUM is finding itself in the Netherlands requires a particular level of abstraction and a broad scope. Therefore the main objective of this study is to explore Infrastructure ENUM and its application in the Netherlands. This section discusses the limitations of this study.

The limitations mentioned in section 1.5, such as national focus, time limit and limited number of respondents, are limitations known beforehand. Nevertheless, they are limitations and for example the national focus is intrinsic to the choice that has been made in advance. The main reason for the national focus is the interest of TNO in the Dutch situation. However, this implies that little attention is paid to the international context of Infrastructure ENUM. In retrospect the results could be a little bit biased by this lack of international context. The limited number of respondents (n=21) is inherent to a Delphi research method.

Besides these limitations, other fields of discussion are identified and depicted in figure 52. Figure 52 shows the steps of this study with the identified fields of discussion. Starting on the left side of the second box, the first thing that needs to

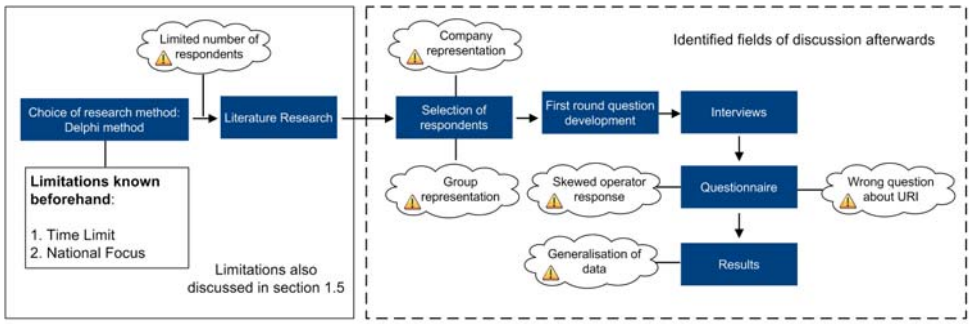

Figure 52 The fields of discussion and their place within this study

be discussed is the selection of panellists. Two 'warnings' are given here: 1) company representation and 2) group representation. Some companies within the operator group took part with two respondents. Both filled in the questionnaire and in some cases they gave different answers. Which raises the following question: To what extend is one respondent able to represent a company/organisation position? It is difficult to answer this question, but it is clear that the results are influenced by this bias. A same problem can be notice with creating a group representation. A small number of respondents limits the possibility of give a good representation of a plural group. For example within the vendor group it must be remarked that the outcome heavily depends on which vendors are chosen and what kind of products they produce. It is not possible to represent the whole vendor group in two respondents. This possibly explains the difference between vendors' self image and the role expected by others (see section 5.7). Thus the study is mainly explorative not representative.

The next discussion topics arise in the questionnaire step. The questionnaire contained a question about the suitability of a URI in the Infrastructure ENUM database. In retrospect this question was wrongly stated[48]. The intention was to answer the question whether there is a preference for a direct URI or an indirect URI, do operators need the DNS for resolving the URI. This indention become

[48] The high portion of respondents that did filled in 'no idea' is a good indication to this.

clear afterwards and the question: “Is an address of the serving SIP server as URI the most suitable choice within the context of model x?”, is too specific and does not answer the real issue.

The most important field of discussion is to what extend the results can be generalised. The choice for an explorative character of this study implies some limitations with the generalization of data. Figure 52 mentions this issue as a field of discussion connected with the results. Prior to the results, a skewed operator response raised in the questionnaire phase. Despite a successful response rate (83%), only one respondent of operators without own network filled in the questionnaire. This means that the operator group is skewed towards operators with own access network. The operators with own access network present a important portion of the market. However, the other operators can become much more important in the future and they are in this study underpresent. Of course they are interviewed within the first round, so their voice is heard. Within the phase selection of respondents, it was not possible, in spite of considerable effort, to aquire partication of Skype. Nevertheless, it can be concluded that operators without own access network are not equally represented. Thus when the term operators is used within this study, it is important to keep this in mind.

Finally, it must be remarked that new (potential) protocols and technologies are succeeding each other very fast in the telecom industry. These dynamics may hamper the value of the conclusions and recommendations of this thesis. What is true at this moment may be untrue the next moment. The rise of new protocols and technologies could happen tomorrow with unforeseeable impact.

7.3 Recommendations for further research

Infrastructure ENUM is in an early stage of discussion. There is no country in the world that has a large scale Infrastructure ENUM implementation. This study outlined several ways of how Infrastructure ENUM could be applied by operators. This study offers enough leads for further discussion. The recommendations for further research are twofold. First with regard to Infrastructure ENUM it is best to wait for progress of the standardization process and further development of trials in other countries. When Infrastructure ENUM is finding itself in a more advanced stadium, it is interesting to do a more specific study of a particular (international) case or Infrastructure ENUM variant.

Secondly, it is interesting to take another more specific approach for investigating one of the drivers of Infrastructure ENUM in more detail. This driver is VoIP interconnection. The majority of the respondents in this study indicate that business drivers are most important with regard to decisions around VoIP interconnection. This report focussed only partly on business aspects. However, they will determine what will happen with Infrastructure ENUM. A study with as main object, the important factors and limitations of structural change in the voice service market, would be an interesting study to carry out. What will happen when the voice market moves to the sender keeps all business model? What are the barriers for moving to sender keeps all? What is the relation between the ALL IP strategy of KPN and the possible emergence of Infrastructure ENUM?

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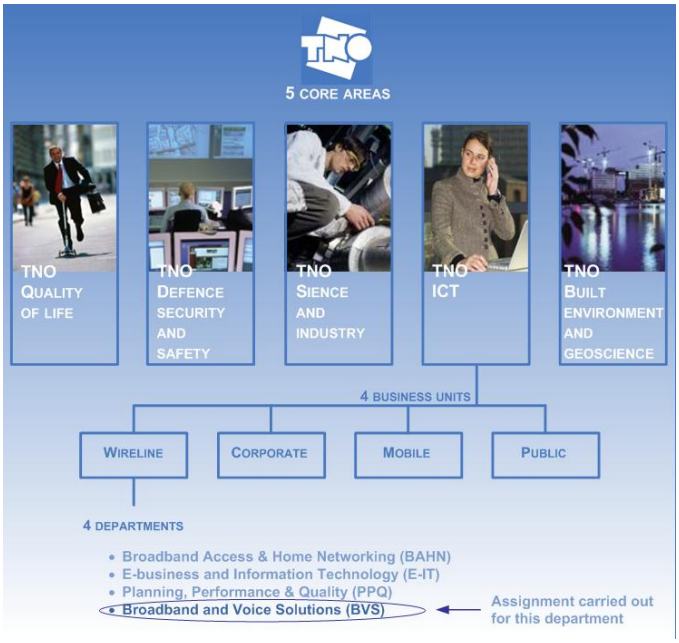
Appendix A About TNO

Mission statement:
"TNO makes scientific knowledge applicable in order to strengthen the innovative capacity of business and government"
TNO[49] is a knowledge organization for companies, government bodies and public organizations. The daily work of some 5,000 employees is to develop and apply knowledge. The company provides contract research and specialist consultancy as well as grant licenses for patents and specialist software. They test and certify products and services, and issue an independent evaluation of quality. TNO also sets up new companies to market innovations.

TNO Information and Communication Technology
TNO Information and Communication Technology is a unique center of innovation in the Netherlands that unites the ICT and Telecom disciplines of TNO. TNO ICT helps companies, government bodies and (semi-) public organizations to realize successful innovations in ICT. Value creation for clients is the priority, and the added value lies in the combination of innovative strength and in-depth knowledge. The approach to innovation is integrated and practical. Research involves more than the technologies themselves. Where necessary, TNO ICT also focuses on user-friendliness, financial aspects, and business processes. The implementation process is supported by carrying out technical and market trials. They are also specialists in innovation strategy and policy, and the extensive ICT expertise is a valuable resource that can be used to address issues in the wider community.



[49] TNO is the Dutch abbreviation for 'toegepast-natuurwetenschappelijk onderzoek', which means applied scientific research

Appendix B ENUM Basics

ENUM retrieving mechanism

To map a telephone number to an domain, the ENUM RFC 3761, defines the following algorithm to convert a E.164 number into a domain-name:

1. Remove all characters with the exception of the digits. For example, the First Well Known Rule produced the Key "+442079460148". This step would simply remove the leading "+", producing "442079460148".

2. Put dots (".") between each digit. Example: 4.4.2.0.7.9.4.6.0.1.4.8

3. Reverse the order of the digits. Example: 8.4.1.0.6.4.9.7.0.2.4.4

4. Append the string ".e164.arpa" to the end. Example: 8.4.1.0.6.4.9.7.0.2.4.4.e164.arpa

This domain-name is used to request NAPTR records which may contain the end result or, if the flags field is blank, produces new keys in the form of domain-names from the DNS. [RFC 3761]

NAPTR records

ENUM use a specific type of DNS records, namely "NAPTR" Resource Records. NAPTR stands for Naming Authority Pointer and is a newer type of DNS record that supports regular expressions. A regular expression is a standardized way of writing strings, especially used to search for particular text patterns.
For example the NAPTR records belonging to +31402460345 (an imaginary number) can be:

```
$ORIGIN 5.4.3.0.6.4.2.0.4.i.1.3.e164.arpa.
 IN NAPTR 100 10 "u" "sip+E2U" "!^.*$!sip:leendert@VoIPoperator.nl i" .
 IN NAPTR 102 10 "u" "smtp+E2U" "!^.*$!mailto:lennart@tno.nl i" .
```

The number 100 and 102 give a priority to the record. A lower number means a higher priority. In this case there are more services coupled to a single E.164 number. Therefore NAPTR records are required.

ENUM altering mechanism

To alter the ENUM database a provisioning protocol is needed. A recently standardized method for this is the Extensible Provisioning Protocol (RFC 4114). It provides the protocol for communication between the ENUM registry and the registrars (operators in the case of Infrastructure ENUM).

Appendix C Interviewees

Organisatie	Naam	Functie
Regulatory bodies		
DGET	Thomas de Haan	***Policy advisor***
OPTA	Herjan Barnard	***Senior technical officer***
Operators		
KPN	Niko Siljee	***Regulatory Affairs***
KPN	Maria van der Ploeg	***Product manager Interconnect Access***
Casema	Gert Kremer & Theo van den Berg	***Network architects***
Essent	Ronald Kleissen & Roel Mijnheer	***Network architects***
CaiW	Sikko de Graaf	***Technical Director***
Verizon	Steven Gerver	***Manager Switched Interconnect***
Priority Telecom	Otto Kern	***Manager interconnect***
Xs4all	Simon Hania	***Technical Director***
Optibel	Richard van Oorschot	***Project Manager***
VoIPster	Joost Beltman	***Manager***
Ritstele (now BBnet)	Ytsen Kooistra	***Founder***
Vendors		
AG projects	Adrian Georgescu	***Director***
Siemens	Mark Smorenburg	***Engineer***
Facilitators		
COIN	Lars Bosman	***COIN member***
SIDN	Frank Hondsmerk / Antoin Verschuren	***Project manager / Technical advisor***
AMS-IX	Geert Nijpels	***Network Engineer***
Interest groups		
BTG	Cees Tromp	***Director***

Appendix D Questionnaire

Beste deelnemer aan dit onderzoek,

De enquête duurt maximaal 40 min. Fijn dat u hier de tijd voor wilt nemen.
− Het is mogelijk om de enquête in gedeeltes te maken. Uw antwoorden worden continu opgeslagen en u kunt gewoon
de browser afsluiten als u wilt stoppen. Als u dan op een later tijdstip weer via de link die ik u gemaild heb verder gaat,
begint u automatisch op het punt waar u gebleven was.
− Links bovenaan vindt u de voortgangsindicator.

In de enquête worden 4 mogelijke implementatie modellen van Infrastructure ENUM voorgelegd. Het is de bedoeling om uiteindelijk uitspraken over de haalbaarheid en de belangen bij deze verschillende modellen te kunnen doen. Met de knoppen onder aan de pagina kunt u navigeren.
Succes!

Vul in de onderstaande box uw ***naam*** van uw ***organisatie*** in.
Vul in de onderstaande box uw ***eigen naam***.
Vul in de onderstaande box uw ***functie*** in.

Algemene toelichting 1: Infrastructure ENUM

Uit de interviews kwam naar voren dat er hier en daar nog wel wat verwarring bestaat over wat Infrastructure ENUM nu precies is. Voor mijn onderzoek gebruik ik de volgende afbakening: het gebruik van ENUM technologie met de beperking dat alleen ***operators*** hun ***eigen*** e.164 nummers kunnen toevoegen aan de infrastructure ENUM database. Daarnaast wil ik opmerken dat Infrastructure ENUM een technologie is die bedoeld is voor ***inter*** infrastructure gebruik. Een operator kan voor zijn eigen netwerk ook een soort infrastructure ENUM hebben, maar zo'n database is vaak heel nauw verweven met de architectuur van het netwerk / SIP servers en daarom wordt een dergelijke database in dit onderzoek geen Infrastructure ENUM genoemd.

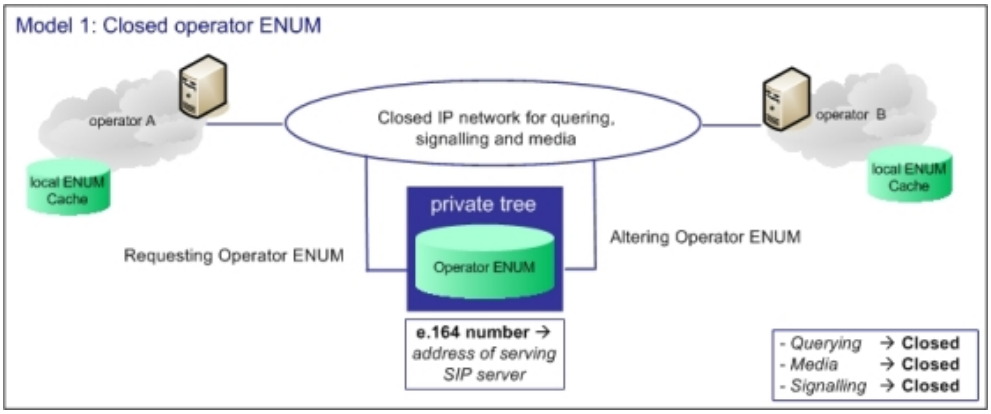
Instructie bij de komende vragen

Er worden nu achtereenvolgens vragen over 4 implementatie modellen voor infrastructure ENUM gesteld. De structuur van de
enquête is als volgt:
1. Toelichting ***Model 1 Closed Infrastructure ENUM +*** vragen m.b.t. model 1
2. Toelichting ***Model 2 Open infrastructure ENUM: The email model +*** vragen m.b.t. model 2
3. Toelichting ***Model 3 Open infrastructure ENUM: With interconnection agreement+*** vragen mbt model 3
4. Toelichting ***Model 4 Next Generation COIN +*** vragen m.b.t. model 4

Hieronder vindt u een overzicht van de modellen, zodat u weet over welke modellen het zal gaan in deze enquête. U krijgt
verderop in de enquête nog verdere toelichting tekstuele uitleg over de modellen. Lees de toelichtingen rustig door zodat u er zeker van bent dat u de strekking van het model begrepen heeft. U kunt altijd terug klikken om nog even het model te bekijken. De daarbij door u ingevulde antwoorden gaan daarbij ***niet*** verloren.

Algemene toelichting bij de modellen
In de modellen staan steeds twee operators afgebeeld A en B. Daar tussen staan verschillende opties voor het netwerk en de te gebruiken infrastructure ENUM. Rechts in de hoek staat een vakje met de termen querying, signalling en media. Met quering wordt het raadplegen van infrastructure ENUM database bedoeld, met signalling de weg die de SIP berichten afleggen en met de term media wordt de daadwerkelijk audio stream bedoeld. Er wordt in alle modellen de aanwezigheid van een locale cache verondersteld om de performance bij de desbetreffende operator te vergroten.

Model 1 Closed Infrastructure ENUM



Toelichting model 1 Closed Infrastructure ENUM
In dit model bevindt de Infrastructure ENUM database zich niet in het publieke DNS, maar in een private DNS van een bepaalde federatie van operators. Dit betekent dat 'requesting' niet zomaar voor iedere partij mogelijk is. Men kan er voor kiezen om de Infrastructure ENUM database in een in 'closed' environment onder te brengen en de rest van de interconnectie bilateraal te laten verlopen. Men kan er ook voor kiezen om de organisatie die de infrastructure ENUM beheert ter gelijkertijd een soort hub functie te laten vervullen. Waardoor er dus een centralisatie van SIP verkeer ontstaat.

- Zijn er alternatieve technologieën die in de plaats van Infrastructure ENUM gebruikt kunnen worden in deze context?
Ja, namelijk...
Nee

- Hoe beoordeelt u de beperkte toegankelijkheid van de Infrastructure ENUM database in deze context?
helemaal niet wenselijk, niet wenselijk, neutraal, wenselijk, zeer wenselijk

- Is een adres van de 'serving SIP server' als URI de meest geschikte keuze in de context van model 1 Closed Infrastructure ENUM?
Ja
Nee
Geen idee

- Bent u het eens / oneens met de volgende stelling?
'Het zou vanuit de overheid verplicht gesteld moeten worden dat een operator zich met zijn nummers maar bij één federatie kan aansluiten om zo de kans zo klein mogelijk te houden dat er conflicterende informatie over één bepaald nummer terugkomt'
oneens eens

- Hoeveel federaties schat u dat er zullen komen in Nederland in de komende 10 jaar?
0, 1, 2, 3, 4 of meer

- Zullen de federaties voornamelijk nationaal of internationaal georiënteerd zijn?
Nationaal, Internationaal, beide, geen van beide

- Hoe belangrijk is het dat de organisatie die de closed Infrastructure ENUM database runt ook de centrale plaats is waar SIP berichten worden uitgewisseld?
helemaal niet belangrijk, niet belangrijk, neutraal, belangrijk, zeer belangrijk

- Welke rol schat u dat de volgende actoren zullen spelen bij model 1 Closed Infrastructure ENUM?

	voortrekker	neutraal	ongeïnteresseerd
Operators met eigen toegangsnetwerk			
Operators zonder toegangsnetwerk			
Onafhankelijke Post en Telecommunicatie Autoriteit (OPTA)			
Directoraat−generaal voor Energie en Telecom (DGET)			
Vendors			

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 1 Closed Infrastructure ENUM zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 1 Closed Infrastructure ENUM ***niet*** zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee *Graag een korte toelichting waarom er geen redenen zijn om model 1 Closed Infrastructure ENUM te steunen/niet te steunen.*

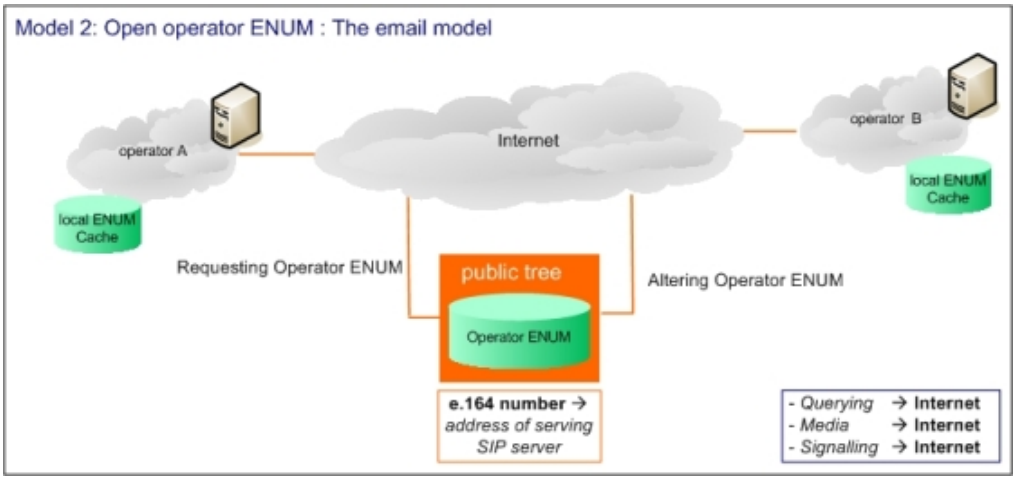
- Hoe wenselijk is het gebruik van model 1 Closed Infrastructure ENUM voor uw bedrijf/organisatie?helemaal niet wenselijk, niet wenselijk, neutraal, wenselijk, zeer wenselijk

Hoe sluiten de volgende 'business' aspecten aan bij model 1 Closed Infrastructure ENUM?

	slecht	matig	neutraal	redelijk	goed
Aansluiting op huidige business					
Toegankelijkheid voor nieuwe operators					
Aansluiting op sender keeps all business (peering model)					
Aansluiting calling party pays (beller betaalt)					

- Hoe groot schat u de kans in dat het model 1 Closed Infrastructure ENUM over 10 jaar op grote schaal geïmplementeerd is?
zeer kleine kans, kleine kans, niet groot niet klein, grote kans, zeer grote kans

Model 2 Open Infrastructure ENUM: The email model



Toelichting model 2 Open infrastructure ENUM: The email model
Belangrijkste kenmerk is dat er tussen de partijen A en B vooraf geen business afspraken bestaan. Het is mogelijk om een klant van operator B te bellen zonder dat operator A ooit met operator B een deal gesloten heeft. Infrastructure ENUM is geplaatst in de 'public tree' die gedefinieerd is voor ENUM. Momenteel zijn er discussies binnen de IETF gaande om een apart gedeelte van de ENUM tree te reserveren voor Infrastructure ENUM. Daar bestaan in het geval van Nederland de volgende 2 mogelijkheden voor: .i.1.3.e164.arpa of .1.3.ie164.arpa. De precieze tree voor infrastructure ENUM ligt nu als draft bij de IETF, maar het ligt in de verwachting dat die er zeker gaat komen. Als een klant van operator A wil bellen met een klant van operator B dan zoekt operator A door middel van het invoeren van een query in de 'public
tree', op welke SIP server de klant van B te bereiken is. Daarna lopen de signalling en media via het Internet.

- Denkt u dat DNS technologie geschikt is voor het gebruik binnen VoIP interconnectie?
Ja, Nee

- Hoe beoordeelt u de publieke toegankelijkheid van de Infrastructure ENUM database in deze context?
helemaal niet wenselijk, niet wenselijk, neutraal wenselijk, zeer wenselijk

- Is een adres van de 'serving SIP server' als URI de meest geschikte keuze in de context van model 2 Open Infrastructure ENUM: The email model?
Ja, Nee, Geen idee

- Bent u het eens / oneens met de volgende stelling?
'Stichting Internet Domeinregistratie Nederland (SIDN) is de aangewezen partij om de 'Registry' van Nederland te zijn'
oneens eens

- Welke rol schat u dat de volgende actoren zullen spelen bij model 2 Open Infrastructure ENUM: The email model?

	voortrekker	neutraal	ongeïnteresseerd
Operators met eigen toegangsnetwerk			
Operators zonder toegangsnetwerk			
Onafhankelijke Post en Telecommunicatie Autoriteit (OPTA)			
Directoraat−generaal voor Energie en Telecom (DGET)			
Vendors			

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 2 Open Infrastructure ENUM: The email model zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 2 Open Infrastructure ENUM: The email model ***niet*** zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee *Graag een korte toelichting waarom er geen redenen zijn om model 2 Open Infrastructure ENUM: The email model te steunen/niet te steunen.*

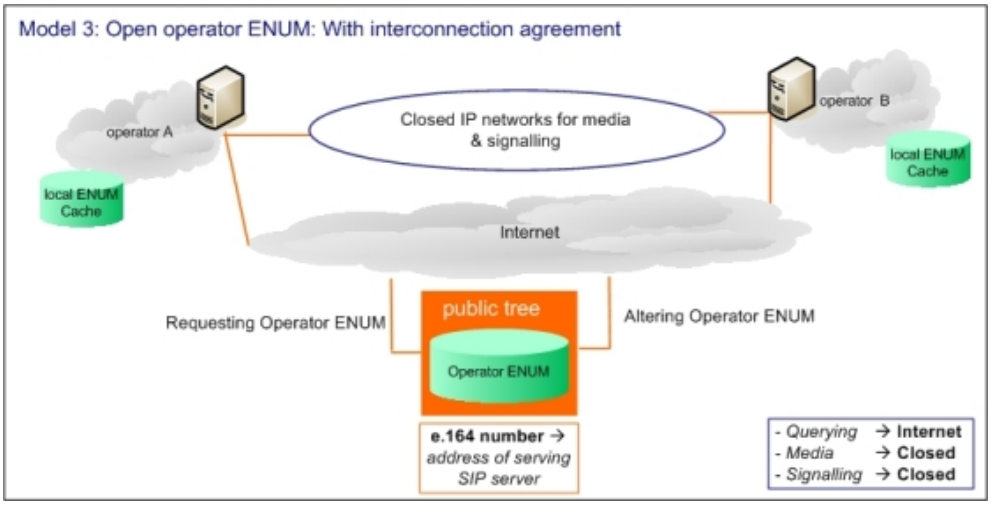
- Hoe wenselijk is het gebruik van model 2 Open infrastructure ENUM: The email model voor uw bedrijf/organisatie?
helemaal niet wenselijk, niet wenselijk, neutraal, wenselijk, zeer wenselijk

- Hoe sluiten de volgende 'business' aspecten aan bij model 2 Open Infrastructure ENUM: The email model?

	slecht	matig	neutraal	redelijk	goed
Aansluiting op huidige business					
Toegankelijkheid voor nieuwe operators					
Aansluiting op sender keeps all business (peering model)					
Aansluiting calling party pays (beller betaalt)					

- Hoe groot schat u de kans in dat het model Open Infrastructure ENUM: The email model over 10 jaar op grote schaal geïmplementeerd is?
zeer kleine kans, kleine kans, niet groot niet klein, grote kans, zeer grote kans

Model 3 Open infrastructure ENUM: With interconnection agreement



Toelichting model 3 Open infrastructure ENUM: With interconnection agreement
Het grote verschil met Open infrastructure ENUM: The email model (model 2) is dat er tussen de partijen A en B een overeenkomst moet bestaan over het afhandelen van elkaars verkeer.
Dus als operator A kan succesvol een 'query' doen op de infrastructure ENUM database, maar vervolgens kan hij het gesprek niet afleveren als hij geen afspraken gemaakt heeft met operator B.
Operator B laat hem zonder afspraken niet toe op zijn netwerk. Net als bij model 2 bevindt de Infrastructure ENUM database zich in het publieke DNS. Dit is de manier waarop ze het ook in Oostenrijk doen.

- Zijn er alternatieve technologieën die in de plaats van Infrastructure ENUM gebruikt kunnen worden in deze context?
Ja, namelijk... , nee
- Hoe beoordeelt u de publieke toegankelijkheid van de Infrastructure ENUM database in deze context?
helemaal niet wenselijk, niet wenselijk, neutraal, wenselijk, zeer wenselijk

- Is een adres van de 'serving SIP server' als URI de meest geschikte keuze in de context van model 3 Open infrastructure ENUM: With interconnection agreement?
Ja, Nee, Geen idee

- In Oostenrijk heeft men gekozen om de kosten als volgt te verdelen. De volgende prijzenstructuur geldt daar:
− 1 euro per nieuw e.164 nummer (bij start geen 'entry' kosten)
− 0,08 euro fee per update e.164 nummer
− 0,02 per e.164 nummer per month

Minimum fee 250 euro
Zou u onder deze opstandigheden meedoen?
Ja, Nee, geen mening

- Welke rol schat u dat de volgende actoren zullen spelen bij model 3 Open infrastructure ENUM: With interconnection agreement?

	voortrekker	neutraal	ongeïnteresseerd
Operators met eigen toegangsnetwerk			
Operators zonder toegangsnetwerk			
Onafhankelijke Post en Telecommunicatie Autoriteit (OPTA)			
Directoraat−generaal voor Energie en Telecom (DGET)			
Vendors			

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 3 Open infrastructure ENUM: With interconnection agreement zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 3 Open infrastructure ENUM: With interconnection agreement ***niet*** zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee *Graag een korte toelichting waarom er geen redenen zijn om model 3 Open infrastructure ENUM: With interconnection agreement te steunen/niet te steunen.*

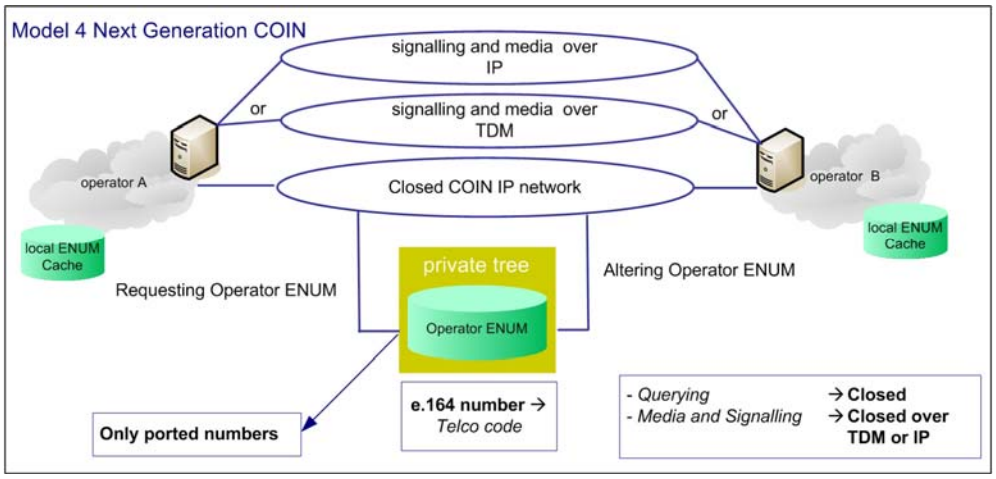
- Hoe wenselijk is het gebruik van model 3 Open infrastructure ENUM: With interconnection agreement voor uw bedrijf/organisatie?
helemaal niet wenselijk, niet wenselijk, neutraal, wenselijk, zeer wenselijk

- Hoe sluiten de volgende 'business' aspecten aan bij model 3 Open infrastructure ENUM: With interconnection agreement?

	slecht	matig	neutraal	redelijk	goed
Aansluiting op huidige business					
Toegankelijkheid voor nieuwe operators					
Aansluiting op sender keeps all business (peering model)					
Aansluiting calling party pays (beller betaalt)					

- Hoe groot schat u de kans in dat het model 3 Open infrastructure ENUM: With interconnection agreement over 10 jaar op grote schaal geïmplementeerd is?
zeer kleine kans, kleine kans, niet groot niet klein, grote kans, zeer grote kans

Model 4 Next Generation COIN



Toelichting model 4 Next Generation COIN
Zoals de naam al aangeeft wordt Infrastructure ENUM hier gebruikt als technologische opvolger voor de huidige technologie van COIN. De hoofdfunctie van infrastructure ENUM is hier het faciliteren van nummerportabiliteit. Het belangrijkste kenmerk van dit model is dat een nummer op de door ENUM gedefinieerde manier, een e.164 nummer vertaald in een Telco code. De operator kan aan de hand van deze Telco code zelf bepalen hoe hij wil gaan routeren.

- Er zijn al eerder pogingen geweest op tot een nieuw COIN systeem te komen, het zogenaamde COIN 2. Het project COIN 2 is nu van de baan. Gaat het infrastructure ENUM lukken om de technologie van de volgende generatie COIN te zijn of beschouwt u een andere technologie kansrijker?
ENUM wordt de technologie van de volgende generatie COIN, Een andere technologie is kansrijker, namelijk

- Momenteel is het zo dat COIN alleen de geporteerde nummers bevat. Hoe wenselijk is het dat COIN ***alle*** nummers bevat?
helemaal niet wenselijk, niet wenselijk, neutraal, wenselijk, zeer wenselijk

- Bent u het eens / oneens met de volgende stelling? 'Nummerportabiliteit moet via COIN geregeld blijven'
Oneens, eens

- Is een Telco code als URI de meest geschikte keuze in de context van model 4 Next Generation COIN?
Ja, Nee, Geen idee

- Welke rol schat u dat de volgende actoren zullen spelen bij model 4 Next generation COIN?

	voortrekker	neutraal	ongeïnteresseerd
Operators met eigen toegangsnetwerk			
Operators zonder toegangsnetwerk			
Onafhankelijke Post en Telecommunicatie Autoriteit (OPTA)			
Directoraat−generaal voor Energie en Telecom (DGET)			
Vendors			

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 4 Next Generation COIN zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee

- Kunt u redenen bedenken waarom uw bedrijf/organisatie model 4 Next Generation COIN ***niet*** zou steunen?
Ja *Geef een omschrijving van deze reden(en).*
Nee *Graag een korte toelichting waarom er geen redenen zijn om model 4 Next Generation COIN te steunen/niet te steunen.*

- Hoe wenselijk is het gebruik van model 4 Next generation COIN voor uw bedrijf/instantie?
helemaal niet wenselijk, niet wenselijk, neutraal, wenselijk, zeer wenselijk

- Hoe sluiten de volgende 'business' aspecten aan bij model 4 Next Generation COIN?

	slecht	matig	neutraal	redelijk	goed
Aansluiting op huidige business					
Toegankelijkheid voor nieuwe operators					
Aansluiting op sender keeps all business (peering model)					
Aansluiting calling party pays (beller betaalt)					

- Hoe groot schat u de kans in dat het model 4 Next Generation COIN over 10 jaar op grote schaal geïmplementeerd is?
zeer kleine kans kleine kans niet groot niet klein grote kans zeer grote kans

Afsluiting

Als afsluiting wil ik u nog één keer alle modellen voorleggen. Ik wil u vragen per model een oordeel te geven met een paar steekwoorden.

Model 1: Uw oordeel in een paar steekwoorden:
Model 2: Uw oordeel in een paar steekwoorden:
Model 3: Uw oordeel in een paar steekwoorden:
Model 4: Uw oordeel in een paar steekwoorden:

Dit was de laatste vraag, bedankt voor uw medewerking!

Mocht u nog opmerkingen/vragen hebben dan kunt u die in de onderstaande box kwijt.

Appendix E First round questions

Agenda:
- toelichting inhoud interview
- vertrouwelijkheid
- toelichting onderzoek

Dit interview gaat over VoIP interconnectie en de mogelijke rol van infrastructure ENUM daarbij. Allereerst zou ik de structuur van het interview willen toelichten. Het interview zal bestaan uit twee delen:

Deel I VoIP Interconnectie
Deel II De rol van infrastructure ENUM bij VoIP interconnectie

Per deel zijn de vragen gesorteerd op: algemeen, technische aspecten, business aspecten en beleidsaspecten

Deel I VoIP interconnectie

Algemeen

- **[operators]** Wanneer met VoIP begonnen en waarom?
- **[operators]** Aantal VoIP klanten momenteel?
- **[everyone]** Ik wil u graag de lijst laten zien met personen die ik ga interviewen. Mist u nog bedrijven/organisaties?
- **[everyone]** Waarom een trend naar triple play?

Technische aspecten

- **[operators]** Hoe is technisch de huidige interconnectie met andere VoIP providers en het PSTN geregeld?
- **[everyone]**Op welke manier is VoIP interconnectie anders dan 'gewone' interconnectie'?
- **[everyone]** QoS?
- **[operators]** Waar is het point of interconnection/hand over point?
- **[everyone]** Wat is er goed aan de huidige situatie?
- **[everyone]** Wat zijn de technische knelpunten?
- **[everyone]** Zijn er nog belangrijke technische aspecten die belangrijk zijn bij VoIP interconnectie die nog niet aanbod zijn geweest?
- **[vendors]** Wat zijn de technische uitdagingen bij jullie product ….?

Business aspecten

- **[operators]** Welke tariefstructuur is er van toepassing op de interconnectie met andere VoIP providers en het PSTN?
- **[operators]** Zijn er met elke VoIP provider aparte overeenkomsten?
- **[everyone]** Welke trends ziet u in de markt op VoIP interconnectie gebied?
- **[everyone]** Wat zijn belangrijkste knelpunten mbt tot VoIP interconnectie en business aspecten?

- **[vendors]** Wat zijn bedrijven die zich in dezelfde markt bevinden als jullie?
- **[vendors]** Jullie product …., bij hoeveel bedrijven /organisaties draait dit al? Wat voor organisaties zijn dit?
- **[interest group]** Hoe liggen de verhoudingen in de markt?

Beleidsaspecten

- **[everyone]** Wat is uw ogen de rol van het E.164 nummer? In de toekomst?
- **[everyone]** Is het gewenst dat gewone domeinnamen van het Internet gebruikt kunnen worden in VoIP telefonie? Hoe gaat dit interoperabiliteit beïnvloeden?
- **[everyone]** Knelpunten met huidig interconnectie beleid?
- **[everyone]** Is er in de huidige situatie gezonde concurrentie mogelijk?

Deel II Infrastructure ENUM

Algemeen

- **[everyone]** Wat is uw definitie van Infrastructure ENUM?
- **[everyone]** Wat voor rol kan Infrastructure ENUM spelen voor VoIP interconnectie?

Technische aspecten

- **[everyone]** Zijn er technische knelpunten met de huidige toepassing van Infrastructure ENUM?
- **[everyone]** Welke informatie zit er in de huidige Infrastructure ENUM database en welke juist niet?
- **[everyone]** Bevindt de ENUM DNS tree zich puur op een privé netwerk of kan er ook connectie zijn met het Internet?

Business aspecten

- **[everyone]** Wat voor soort business model ziet u voor ENUM? Welke partijen (bestaand of nieuw) zouden welke taken moeten vervullen?
- **[everyone]** Wat zijn belangrijkste knelpunten mbt tot het invoeren van Infrastructure ENUM op nationaal/internationaal niveau?
- **[everyone]** Gaat ENUM het kostenmodel van telefonie of van het Internet bewerkstelligen?
- **[everyone]** In welke tree moet de ENUM DNS tree komen ? (e164.arpa, ander publiek domein, privaat domein)

Beleidsaspecten

- **[everyone]** Hoeveel Infrastructure ENUMs zullen er bestaan? Gaan die samen? Hoe gaat Infrastructure ENUM groeien?
- **[everyone]** Hoe belangrijk is internationale afstemming?
- **[everyone]** Onder welke voorwaarden kan Infrastructure ENUM efficiënte VoIP interconnectie tot stand brengen? Welke bedrijf/organisatie is hier belangrijk voor?

- **[everyone]** Is er een rol voor de overheid weggelegd om de invoering van infrastructure ENUM te bewerkstelligen?
- **[government]** Wat is jullie visie op ENUM?

[everyone] Zijn er nog andere aspecten die uw inziens van belang zijn maar in dit gesprek nog niet aan bod zijn gekomen?

Afsluiting
Bedankt voor u medewerking.
Is het goed als ik nog eens contact met u opneem, mochten er nog wat zaken onduidelijk zijn?
Tweede ronde toelichten.

Bijlages
A: lijst met personen die meewerken

Appendix F Model properties

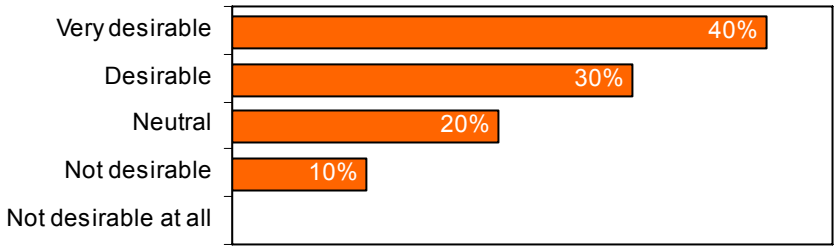
	Model 1: Closed Infrastructure ENUM	Model 2: Open Infrastructure ENUM: The email model	Model 3: Open Infrastructure ENUM: With interconnec-tion agreement	Model 4: Next Generation COIN
Function				
Facilitating Number portability				x
Facilitating VoIP interconnection	x	x	x	
Requesting the Infrastructure ENUM database				
Able to request	**Only operators**	**Everyone with access to the Internet**	**Everyone with access to the Internet**	**Only operators**
Altering the Infrastructure ENUM database				
Able to alter	**Only operators**	**Only operators**	**Only operators**	**Only operators**
Location within the DNS				
In Public DNS Tree		x	x	
In Private DNS Tree	x			x
Content of the Infrastructure ENUM database				
1. NUMBERS				
Which numbers?	**Only VoIP numbers**	**Only VoIP numbers**	**Only VoIP numbers**	**Only ported numbers**
2. URI				
address of serving sip server	x	x	x	
telco code				x
Publishing of interconnection point	**yes**	**yes**	**yes**	**no**
interconnection point has meaning within the Internet	**no**	**yes**	**no**	**n/a**
interconnection point has meaning only is closed network	**yes**	**no**	**yes**	**n/a**
Business relations				
interconnection agreements in advance	**yes**	**no**	**yes**	**yes**
calling party pays possible	**yes**	**no**	**yes**	**yes**
sender keeps all possible	**yes**	**yes**	**yes**	**yes**
Network				
Quering	**closed IP**	**Internet**	**Internet**	**closed IP**
Signalling	**closed IP**	**Internet**	**closed IP**	**TDM or IP**
Media	**Internet or closed IP**	**Internet**	**closed IP**	**TDM or IP**

Appendix G Extensive questionnaire results

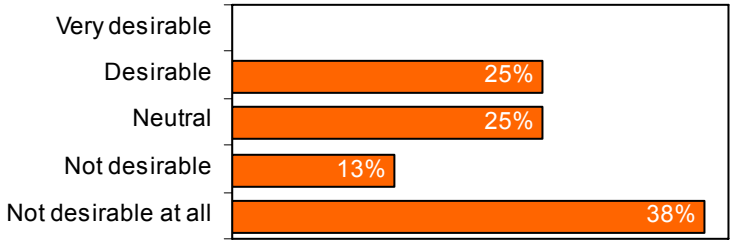
Model 1

Model 1: How do you evaluate the limited accessibility of the Infrastructure ENUM database in this context?

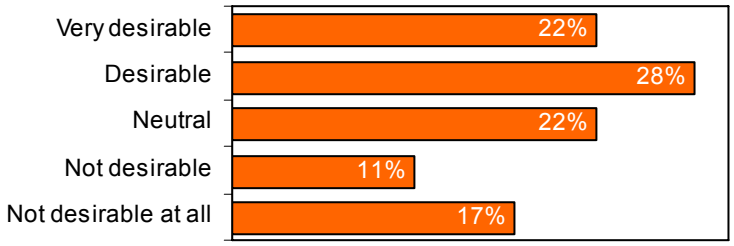
Operators



Others

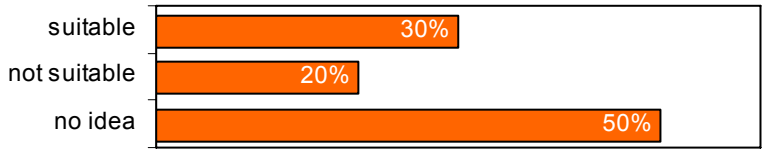


All

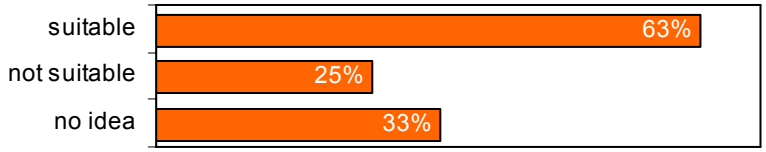


Model 1: Is an address of the serving SIP server as URI the most suitable choice within the context of model 1 Closed infrastructure ENUM?

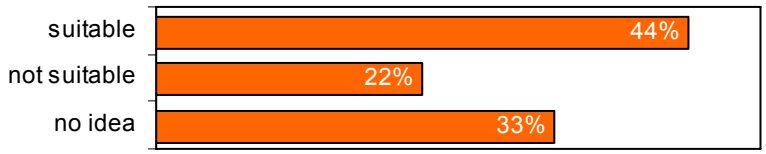
Operators



Others

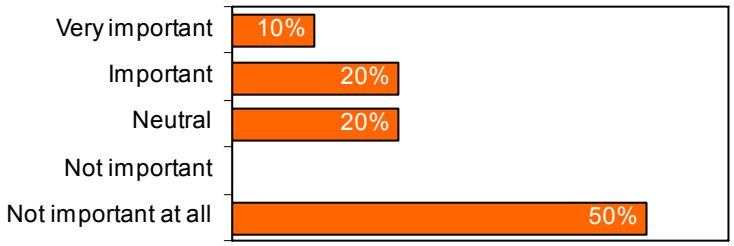


All

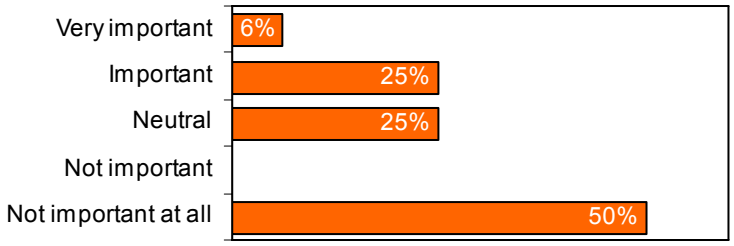


Model 1: How important is it that the organisation which manages the closed Infrastructure ENUM database also is the central place where SIP Messages are exchanged?

Operators



Others



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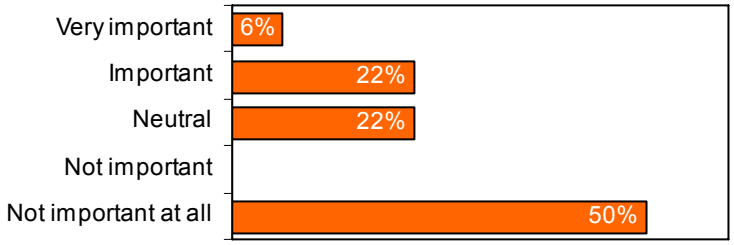
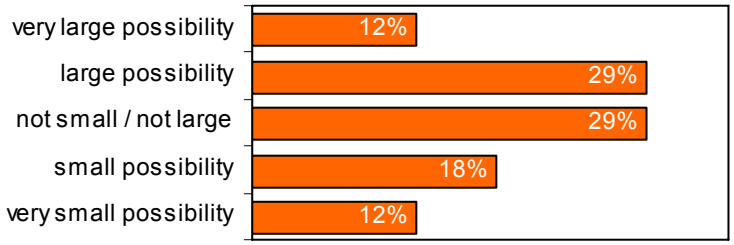


Model 1: What are the chances that model 1 Closed Infrastructure ENUM is implemented on a large scale within 10 years?



Model 1: What are the chances that model 1 Closed Infrastructure ENUM is implemented on a large scale within 10 years?

	Operators	DGET / Vendors OPTA	Facilitators	Interest group	Overall
Possibility	•••	••••	•••	••	•••

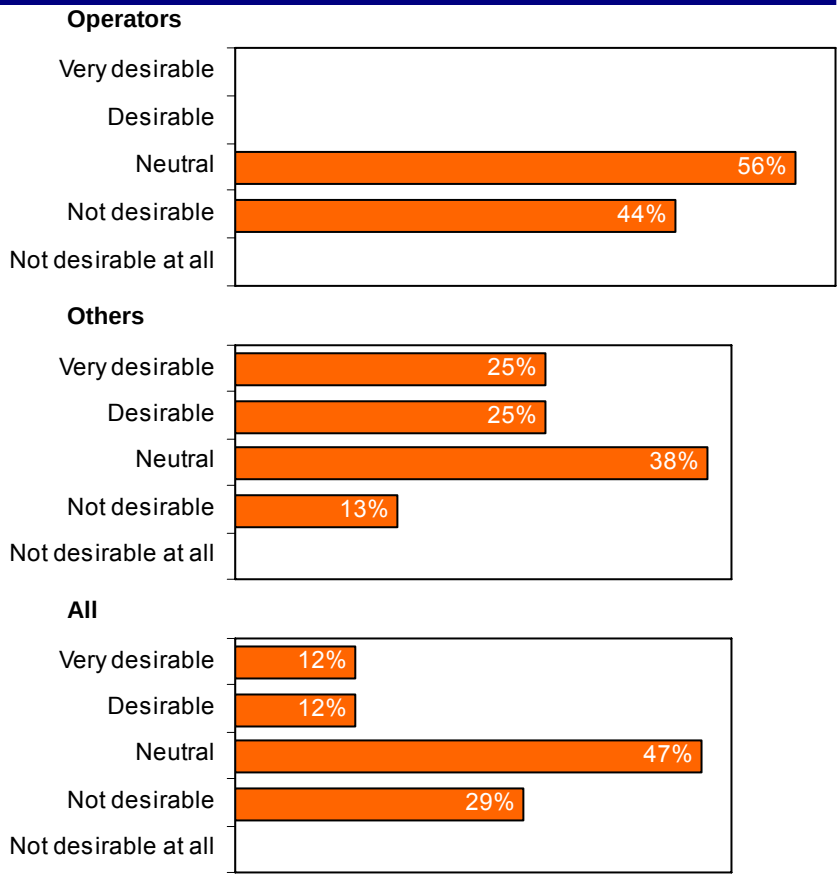
•not likely at all •• not likely •••neutral ••••likely •••••very likely

Model 1: How desirable is the use of model 1 Closed Infrastructure ENUM for your company / organisation?

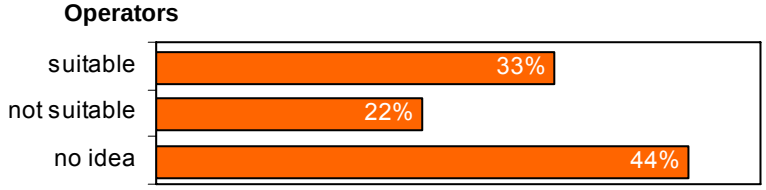
	Desirablity
Operators	Desirable
DGET / OPTA	Neutal
Facilitators	Not desirable
Vendors	Not desirable
Interest Group	Not desirable
Overall	Neutral

Model 2

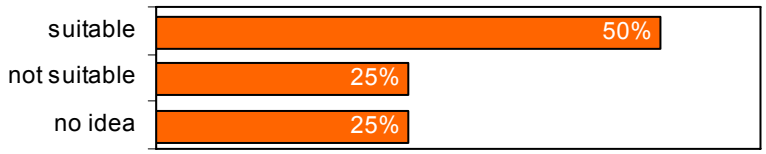
Model 2: How do you evaluate the public accessibility of the Infrastructure ENUM database in this context?



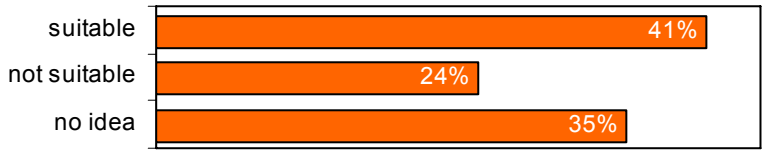
Model 2: Is an address of the serving SIP server as URI the most suitable choice within the context of model Open Infrastructure ENUM: The email model?



Others



All



Model 2: What are the chances that model 2 Open Infrastructure ENUM: The email model is implemented on a large scale within 10 years?

	Operators	DGET / OPTA	Vendors	Facilitators	Interest group	Overall
Possibility	•••	•••	••••	••••	••	•••

•not likely at all •• not likely •••neutral ••••likely •••••very likely

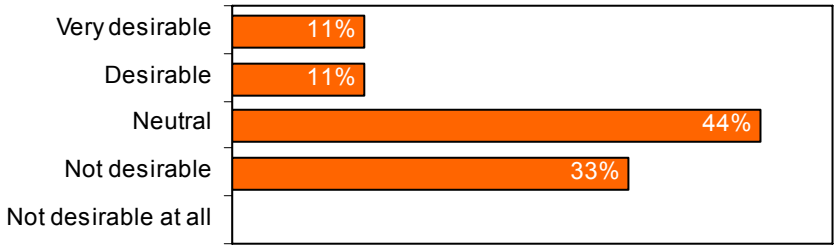
Model 2: How desirable is the use of model 1 Closed Infrastructure ENUM for your company / organisation?

	Desirablity
Operators	Neutral
DGET / OPTA	Neutral
Facilitators	Desirable
Vendors	Desirable
Interest Group	Not desirable
Overall	Neutral

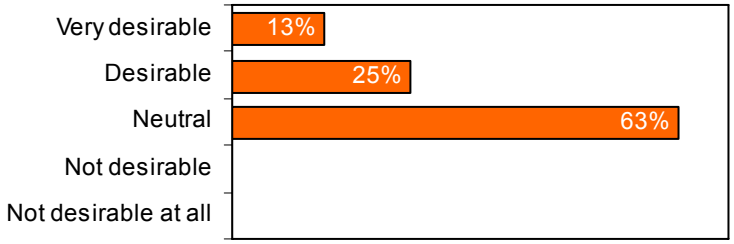
Model 3

Model 3: How do you evaluate the public accessibility of the Infrastructure ENUM database in this context?

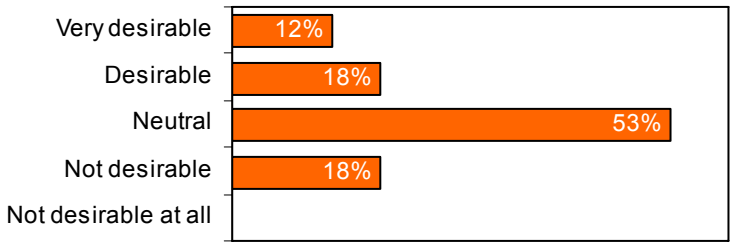
Operators



Others

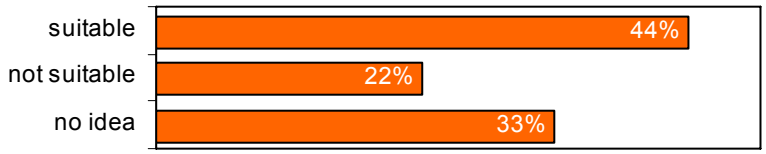


All

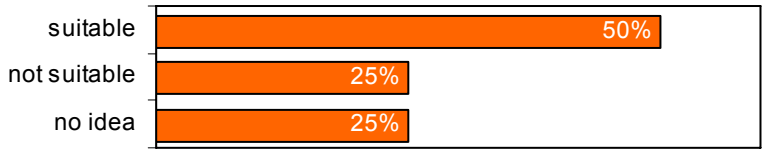


Model 3: Is an address of the serving SIP server as URI the most suitable choice within the context of model 3 Open Infrastructure ENUM with interconnection agreement?

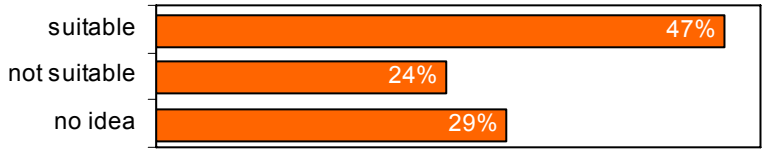
Operators



Others



All



Model 3: What are the chances that model 3 Open Infrastructure ENUM with interconnection agreement is implemented on a large scale within 10 years?

	Operators	DGET / Vendors OPTA	Facilitators	Interest group	Overall
Possibility	•••	••• •••	••••	••	•••

•not likely at all •• not likely •••neutral ••••likely •••••very likely

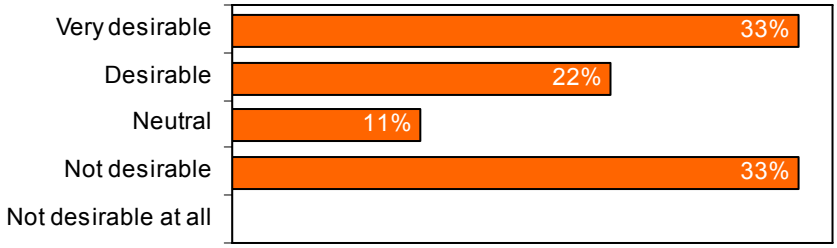
Model 3: How desirable is the use of model 3 Open Infrastructure ENUM with interconnection agreement for your company / organisation?

	Desirablity
Operators	Neutral
DGET / OPTA	Neutral
Facilitators	Neutral
Vendors	Neutral
Interest Group	Desirable
Overall	Neutral

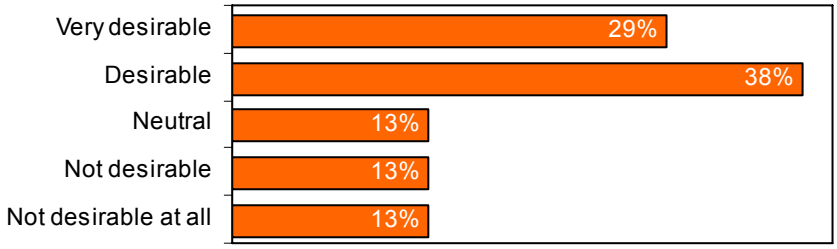
Model 4

Model 4: Currently, COIN only contains 'ported' numbers. How desirable is it that COIN contains all numbers?

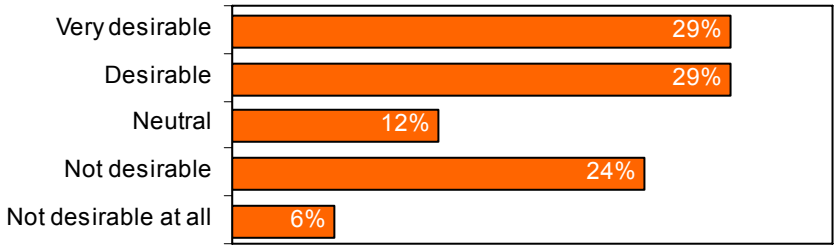
Operators



Others

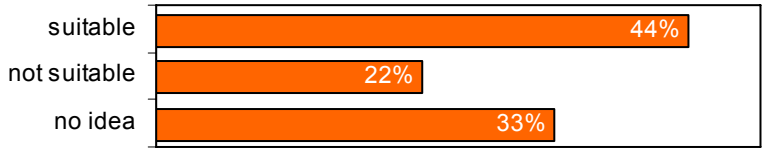


All

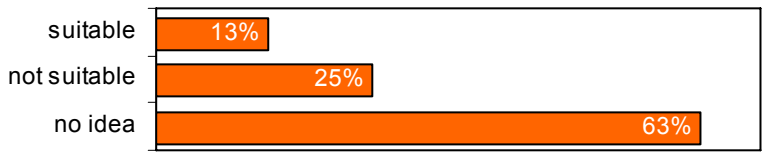


Model 4: Is a Telco code as URI the most suitable choice within the context of model 4 next generation COIN?

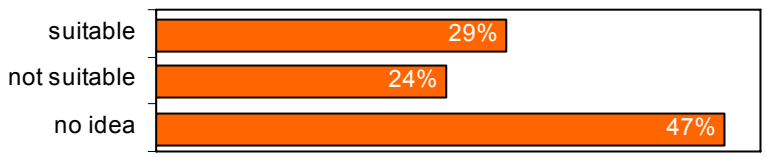
Operators



Others



All



Model 4: What are the chances that model 4 next generation COIN is implemented on a large scale within 10 years?

	Operators	DGET / Vendors OPTA		Facilitators	Interest group	Overall
Possibility	••••	•••	••	•••	••	•••

•not likely at all •• not likely •••neutral ••••likely •••••very likely

Model 4: How desirable is the use of model 4 next generation Open Infrastructure ENUM with interconnection agreement for your company / organisation?

	Desirablity
Operators	Neutral
DGET / OPTA	Neutral
Facilitators	Neutral
Vendors	Not desirable
Interest Group	Desirable
Overall	Neutral

Overall: Suitability of URI

	Model 1: Closed Operator ENUM	Model 2: Open Operator ENUM: The email model	Model 3: Open Operator ENUM: With interconnection agreement	Model 4: Next Generation COIN
Suitable	**44%**	**41%**	**47%**	**29%**
Not Suitable	**33%**	**35%**	**24%**	**24%**
No idea	**22%**	**24%**	**29%**	**47%**

percentages are with respect to all respondents

Appendix H Reasons support / no support (quotes)

Questionnaire: *"Are you able to name reasons why your company/organisation would support (not support) model x? Give a description of these reason(s)"*

Model 1

Operators: Support

- Every form of VoIP interoperability is welcome
- Security of queries, media and signalling can be well organised, this is for operators an important condition
- Central agreements concerning database entries are easy to draw up in the rules of a federation. As a result, the reliability is assured, which is important for operators
- Very scaleable and can easily be coupled with other (international) federations
- Most fast deployment of Infrastructure ENUM for enabling new SIP based services
- No mutual agreements with many parties are necessary, one can join the federation and everything is arranged
- Security, control on terminating revenue
- Control over interconnection and settlements
- More secure than public ENUM

Operators: No support

- Sensitivity of information and security
- A closed model does not offer a number of functionalities which are possible with the open Infrastructure ENUM.

Operators: Remarks

- Necessary condition: All the Dutch VoIP service providers who issue E.164 numbers should join
- Sender keeps all will be a good basis for this model, to prevent arbitrage. If no sender keeps, arbitrage will be a problem.
- No comments because of many open questions around ENUM exist and the dependence of the precise design of this closed Infrastructure ENUM
- Costs will be very important factor
- Desirable approach unknown

Others: Support

- Closed structure→ privacy of end users is quite safe, chances on SPIT are smaller than with the open model

Others: No support

- Little different from TDM interconnection; it continues using the same inter-operator structure, as a result current business models will not change
- Walled gardens are limited in scope and have no future

- Not scaleable
- From a global perspective it blocks access to the market. Security by obscurity. Closed model leads to proprietary solutions, limits operability and development of new services. Open access will lead to more innovation and competition
- Risk on monopoly for operators of exchanges. This closely relates to the organisation form which is used for infrastructure ENUM.
- Problems with interoperability when there are several closed systems

Others: Remarks

- We prefer a variant where interconnection is also arranged
- The government will not support (or stop). This is a choice of the market itself. However, government will prefer a model if that is better with regard to: interoperability, equal/easily access for all operators, competition problems. The support will be more policy based than by means of active control.

Model 2

Operators: Support

- Not missing the boat: no exclusion of new services
- Logical next step, your customers get a SIP URI, what they do with it is up to the customer

Operators: No support

- Problems with gateways/Customer premises equipment: which codecs are supported etc
- Problems with accuracy of data entry: In the public environment, control of processes will be cumbersome. Of course this is possible, but it will be organisational complex.
- This form of ENUM is maybe suitable for a best-effort consumer service, but not for inter-operator traffic.
- Security risks, SPIT, tariffs, guarantee of quality of the total connection.
- No/insufficient monitoring of matters such as QoS, security and policy (tariffs for interconnection)
- As long as current interconnection regime of OPTA applies.

Operators: Remarks

- Only if sender keeps all interconnection is the standard.
- As best effort service for example cheap prepaid solution (something like that as Skype Out). For a real KPN replacing service this model is no option.
- A conflict exists between the old and new services. Existing paid services fit well with closed infrastructure ENUM. New inovatieve services fit well with Open Infrastructure ENUM. With Open Infrastructure ENUM accessibility of people is raised in the assumption that people are all spread concerning old and new ' media ' services.
- Desirable approach unknown

Others: Support

- The open model leads to more competiton, more innovation. This leads to competition on service. Public database leads to a a global standard, interoperability, opens other markets for operators and a more efficient settlement of traffic
- Because this is an open structure; traffic is settled in the same way as Internet traffic, as a result considerable cost savings will be gained.
- Open model fits existing current practises of Internet parties well. The business model of existing telco's is radically differently.
- 'Follows the Internet model, data is available for anyone interested.

Others: No support

- Not Interesting
- Very open model, there could be a need for a higher level of security for such a speech network.
- Strong market power of the administrator of the tree.

Others: Remarks

- The business model of traditional telco operators has been based on inclusion and exclusivity. This does not fit this model at the moment.
- The government will not support (or stop). This is a choice of the market itself. However, government will prefer a model if that is better with regard to: interoperability, equal/easily access for all operators, competition problems. The support will be more policy based than by means of active control.

Model 3

Operators: Support

- This model fits best current interconnection models, which have central local number portability (LNP) organised within COIN. This management corresponds to the defined ENUM model here.
- Open standards, without the disadvantages of model 2
- Appropriate for old services and solves partly the security problem
- Once again: every form of operator interconnection on VoIP is welcome; if this is what is supported by the market, I would support it.

Operators: No support

- The added value of placing the Infrastructure ENUM in the public field is doubtful (with respect to model 1). Within this model conversations can not be routed so why not putting the Infrastructure ENUM in a private environment.
- Risk for denial of service attacks, performance problems and spoofing because of the use of public DNS infrastructure.
- Security and protection of information
- Too many bilateral agreements with all SIP parties, will not work

- Too complex: making agreements with every operator does not scale (also international) well

Operators: Remarks

- Depends on agreements, prevention of arbitration is important
- Why no query tariff?
- Is appropriate for traditional telecom operators who want to be innovative, fits current VoIP providers less.
- Desirable approach unknown

Others: Support

- In advance is known with which codec you will communicate with your partner and therefore it is possible to say which additional services you can deliver to your customer.
- This model is the compromise between the advantages of the open model and the disadvantages of the closed model.
- The advantages are that operators have larger certainty concerning QoS and security, and a better support for their cost models.
- The model remains open for new players, leads to one overall standard, opens the market, and leads to competition and innovation.
- Most realistic and realisable option of the 4 possibilities has been described

Others: No support

- Current objections against IX models and tariffs continue to exist
- Entry of new operators without own access network is hampered.
- Apart from my observation that this model does not differ much from model 2 where it concerns ENUM itself (ENUM says nothing about handling traffic, it is only querying). I think that this model only has reason for existence if appears that the existing open infrastructure of the Internet does not make it possible to hold qualitative acceptable conversations. In that case market pressure will arise to settle traffic in a different way. The appreciation for the quality of conversations with parties such as Voipbuster, Skype, and Google voice shows that this is not case yet.

Others: Remarks

- The government will not support (or stop). This is a choice of the market itself. However, government will prefer a model if that is better with regard to: interoperability, equal/easily access for all operators, competition problems. The support will be more policy based than by means of active control.
- Usually companies chose for closed media and signalling paths because or the risks associated with DOS attacks and so called QoS. Usually classical vendors do not have Internet ready software. Once their software gets better there are no reasons to keep closed networks. In the mean time companies could try out Internet ready software which has provision for withstanding the problems that are faced on the real Internet. Also QoS is

solved by simply provisioning more bandwidth in place or deploying equipment that introduce yet other bottlenecks and interoperability issues.

Model 4

Operators: Support

- A more seamless fit with the current model. This is better within COIN next generation than model 3
- If this means that can be determined per desired session whether a session must stay on IP because of the broadband requirements of the session (high quality video telephony; view holiday movie at the same time with speech session, health care consults at distance) or whether a session can endure circuit switching then this is an option. Because more is necessary than the current COIN provides. This is no statement concerning the COIN organisation but concerning the functionality: ALL-IP session sessions versus mixed sessions and how to know what is needed.
- Near real-time availability /modification of routing information. "open" interfaces, cost reduction.
- Makes routing more simple
- ENUM is cheaper than C7-IN. New telephone exchanges can use this.
- Distribution of data is easier by means of ENUM easier.

Operators: No support

- If tariff arbitration will occur.
- Leaves everything as it was
- Process aspects if these can not be fulfilled well within this model.
- If one wants public ENUM for old and new (telephony) services
- Too complex and probably very precious (and therefore reserved to the large operators)
- There are other more international initiatives (= more generic and thus better support of products).
- Current models fit this concept best; as a result no unnecessary modifications need to be made.

Operators: Remarks

- As long as the PSTN exists, COIN in its current form is necessary. This will not change and this does not have to change. The link between the PSTN and VoIP will be necessary for many years. Therefore COIN must continue to exist in its current form.
- The VoIP-VoIP ENUM database has to be seen separately from COIN, because of the likelihood in the short term. This way the transition to fixed-fee IP interconnection can take place gradually.
- Technically it would not be strange to build the Infrastructure ENUM database at COIN. There is a reasonable chance that the Infrastructure ENUM database will become under authority of COIN. However federations according to model 1 will develop more rapidly (not in the last place because of the role of KPN / incumbent operator within COIN).
- Desirable approach unknown

Others: Support

- Fits with existing processes in the organisation.
- Enables complete freedom of routing.

Others: No support

- Current objections against IX models and tariffs continue to exist
- Does not lead to open market, competition and innovation.
- Telecom business in its current form and the use of existing closed-network protocols have little reason to exist anymore.
- BTG has a specific interest in this matter.
- As long this has no impact for the signalling of/to modems, we will support these models
- There are technical reasons why this model is not optimal.

Others: Remarks

- This model is a way of implementing the number portability obligation.
- The market is able to choose their way of achieving number portability.
- The government will not support (or stop). This is a choice of the market itself. However, government will prefer a model if that is better with regard to: interoperability, equal/easily access for all operators, competition problems. The support will be more policy based than by means of active control.

Appendix I Respondent's judgement (quotes)

Questionnaire: *"I want to ask you to give your judgment in a few words"*

Model 1

Positive:

- "This is the model for the coming years" [operator]
- "Most feasible model in the short term, also scaleable" [operator]
- "This currently done all over the world, no regulation and standardization in needed" [operator]
- "Quick realisable and maybe attractive for parties in the short term" [gov/NRA]

Neutral:

- "Big chance that operators will use it to start and evolve from it to model no. 2" [vendor}
- "Possible, but arbitrage remains an issue, when no sender keeps all" [operator]
- "Favourable for old world, not innovative for new services" [operator]
- "Push from incumbent operators, fits best their strategy and business" [gov/NRA]
- "Useful for routing within IP based telephony / multi service networks" [operator]

Negative

- "Offers no advantages with respect to the current situation" [operator]
- "Too narrow minded, not useful in a country with many alternative operators" [operator]
- "Proprietary, not scaleable, restricts competition, defensive, does not utilize all possibilities" [facilitator]
- "No high expectations in COIN context" [interest group]
- "Not desirable as general infrastructure ENUM model, does not comply with RFCs" [facilitator]
- "Too restricted, resembles too much current IX models" [facilitator]

Model 2

Positive:

- "Offers functionally large advantages but deviates strongly from current situation. Business determines whether this is a good model." [operator]
- "Over 5 years as private SIP URIs are provided by the ISPs" [operator]
- "Good, widely accessible solution" [facilitator]
- "Innovative, competitive, scalable, service development" [facilitator]
- "The only reasonable and common sense model" [vendor]

Neutral:

- "Best-effort for consumers. No infrastructure ENUM solution." [operator]
- "Useful for low-cost Internet telephony/multi services without quality guarantees" [operator]
- "In the long run, this would be attractive for newcomers, particularly the ones without an own network" [gov/NRA]
- Resembles User ENUM, can better done by User ENUM [gov/NRA]]
- "Open model, probably very desirable for new players. Old players will not use this" [facilitator]
- "Works only with sender keeps all business model" [operator]

Negative

- "Rather uncontrolled and entirely dependent on an open network" [operator]
- "This model is almost like User ENUM; has in the form of User ENUM more chance" [gov/NRA]
- "Do not think this model will succeed, because the lack of control for operators" [operator]
- "innovative, open, business model?" [operator]
- "Not interesting" [interest group]

Model 3

Positive:

- "Fits well to current models (with regard to agreements between parties)" [operator]
- "Offers from a functional perspective large advantages. From a business perspective this model squares to current situation" [operator]
- "Scalable, limited defensive, QoS and control compromise" [facilitator]
- "Rather open model. It is possible to make agreements concerning accessibility of the service, concerning financial and technical conditions" [facilitator]
- "This model are also sustainable and can co-exist with model 2" [vendor]
- "Must be feasable" [interest group]

Neutral:

- "Difficult to keep closed. It is not impossible that arbitration will occur" [operator]
- Eventually, more open than model 1. However, better DNS security and performance guarantees have been required from the DNS infrastructure + clear agreements concerning processes and procedures are necessary. [operator]
- "Useful for paid Internet telephony/multiservice services with quality guarantees" [operator]
- "An alternative" [operator]
- "Disadvantages with regard to model 1: individual interconnection agreements necessary; as a result, complex and not scalable. Privacy

issues? Data entry assurance? Advantage: number information is also internationally available" [operator]
- "This is what the large established companies wants in the long run" [gov/NRA]
- "Especially embraced by new IP based operators (newcomers), but eventually also by conventional operators" [gov/NRA]
- "Only favourable with proved bad speech quality over open media [vendor]

Negative
- "Not workable" [operator]
- "Resembles too much current IX models, this a restriction with regard to model 2" [facilitator]

Model 4

Positive:
- "Better control in a more safe environment" [operator]
- "Enables value added interconnection. Sender keeps all possibly necessary" [operator]
- "Seems to fit most the current processes, security and quality requirements" [operator]
- "Solves problems with current database by means of innovative new technology" [operator]
- "In the long term this seems a logical architecture. In my eyes model 1 will come first and later possibly under authority of COIN" [operator]
- "Good option on the basis of already existing and proved model" [facilitator]
- "This is the most conservative model and in the first place most likely to happen. Pressure of international parties/new players can change this, but I am not expecting this in the short run. Because of the national character of systems as COIN. Take also possibly existing non-ip technologies into account" [vendor]

Neutral:
- "This is in my opinion a Dutch special of model 1" [operator]
- I do not consider this as the fourth model, but something that can be part of both model 2 and 3. I think that COIN must be absorbed soon into a new model. Therefore eventually there has to be only one main source for number information. [operator]
- "Is also a federation" [operator]
- "No judgement" [operator]
- "It is clear, that the 'old' COIN has to be rapidly replaced by cost efficient alternatives by means of IP/ENUM. [gov, NRA]
- "Older players will propagate this probably. New players will not support this. Technically it are many steps to look up a number. Perhaps technically it would be better to use a separate private ENUM overlay tree" [faciliator]

Negative

- "Not open, not for new services" [operator]
- "Not innovative, not utilizing" [facilitator]
- "Well, if you build something new which resembles COIN, then it is a pity when the functionality remains limited. However it can be that this is the maximum which is feasible" [gov, NRA]
- Dead end [vendor]
- Not interesting [interest group]