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The potential for ENUM in Qatar

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Contents

1 Introduction

1.1 Scope

The Supreme Council for Information and Communications Technology ('ictQATAR') aims to provide policies taking account of international developments and service demand in Qatar. This report is intended to assist in doing this for the specific case of ENUM.

ENUM is intended to be used in mapping phone numbers to communication services and end points (which are usually located in traditional telephony networks or IP networks). The phone numbers are expected to be E.164 numbers, which conform with the international E.164 standard for use in public telephony. There could be other ways of mapping them to communication services and end points, but ENUM is the one that has attracted most attention from standards organisations. Though it is not very difficult to understand, it raises various questions about commercial strategy and regulatory policy.

These questions are considered in this report. It has the following sections, most of which are relevant to countries besides Qatar:

- Operations of ENUM.
- Variants of ENUM.
- Administration of ENUM.
- Experience with ENUM.
- Findings about ENUM.
- Networks in Qatar.
- Possibilities for trials in Qatar.
- Numbering in Qatar.
- Recommendations for Qatar.

The report also includes the following annexes:

- Abbreviations.
- Questions to the network operators in Qatar.

The replies by the network operators to the questions are used to inform the discussion in this report but are not quoted.

1.2 Purposes of ENUM

Networks depend on the Internet Protocol (IP) to an increasing extent, even when their users have traditional phones, with phone numbers. If phone numbers are to be used in IP networks, they must be mapped to IP addresses (for call destinations or for gateways into other networks). ENUM can assist with performing this mapping. There are also ways of performing the mapping without the assistance of ENUM (such as using internal routing data bases in call servers), which are outlined in Section 3.3.

ENUM works with the Domain Name System (DNS) of IP networks to map phone numbers to communication services and end points. In fact, it can map each phone number to several communication services (such as making voice calls and sending text messages), with different end points, ranked by preference. A communication service and end point can then be chosen according to the preference rankings and the capabilities of the equipment originating the communication. The end point chosen does not usually include an IP address, but a further use of DNS can find an IP address for the end point before the communication proceeds.

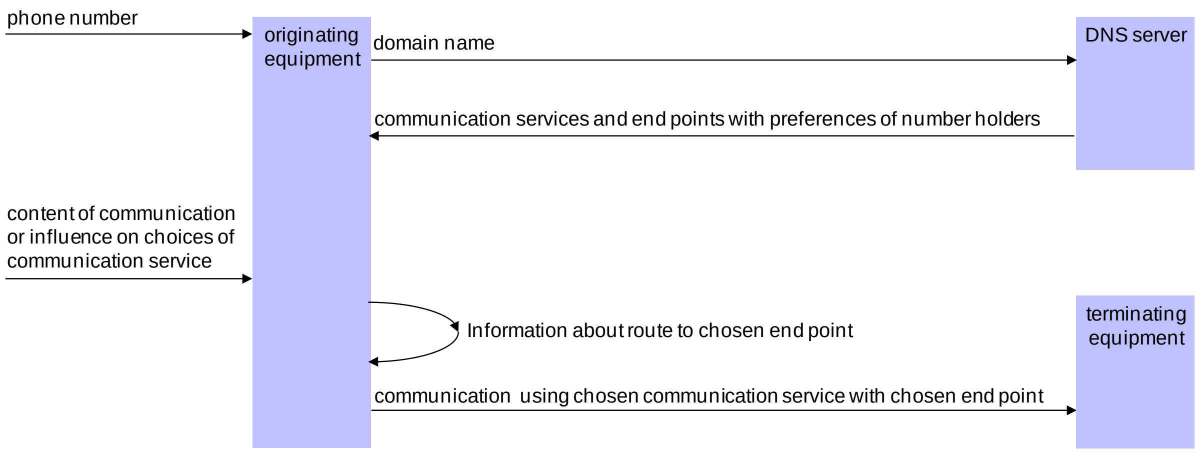
The way in which ENUM works with DNS is illustrated in Figure 1 and Box 1, in which:

- ENUM represents a phone number as a domain name.
- DNS identifies, for each such domain name, communication services and end points ranked by preference.

The 'originating equipment' and 'terminating equipment' might be user terminals or network equipment capable of processing the signalling; for instance, the originating equipment or terminating equipment might comprise a Private Branch eXchange (PBX) or a gateway into another network. The DNS server might, but need not, be in the same network as the originating equipment, but the stringent reliability and latency constraints normally envisaged in public telephony networks could be difficult to meet if the DNS server were on the public Internet.

If the originating equipment does not use ENUM, it instead maps phone numbers to IP addresses by referring to data held by itself or other servers; again those servers might, but need not, be in the same network as the originating equipment.

Figure 1 The role of ENUM in setting up a communication



Box 1 The role of ENUM in setting up a communication

1. The user dials, or otherwise provides, a phone number (with the country code).
2. The originating equipment sends the phone number, represented as a domain name, to a domain name server.
3. The domain name server responds with communication services and end points ranked by preference.
4. The originating equipment uses those of the communication services that it can use, according to their preference rankings.
5. The standard does not define what happens if no communication services are offered that the originating equipment can use.

1.3 Functions of ENUM

ENUM uses rather general notions of 'communication service' and 'end point'[1]. For instance, among the communication services are:

- Making voice calls or video calls.
- Sending text messages, multimedia messages or email messages.
- Retrieving electronic business cards.
- Setting calendar schedules.
- Probing presence indications (such as "busy", "free" and "away").

Thus ENUM regards phone numbers as names that might be independent of telephony: it maps a phone number to communication services and end points but the communication services do not necessarily include voice. Indeed some of these communication services, such as electronic business card retrieval, are related only loosely to communication.

Working with DNS, ENUM can associate phone numbers with end points for Voice Over IP (VOIP) services, but it does not itself provide VOIP services; indeed, it can even be used in implementations of traditional telephony network features (such as number portability). Furthermore, various widespread voice over the Internet services, such as Skype, do not use ENUM, even though one, Viber, associates end points with phone numbers.

By mapping phone numbers to communication services and end points ranked by preference, ENUM (working with DNS) can help to adapt telephony to communication in IP networks. However, ENUM does not implement communication services or on its own determine routes to end points. For instance, it could be used in a gateway that converted Short Message Service (SMS) messages into email, but it would not itself perform the conversion. Moreover, the preference rankings provided by the DNS servers are unconditional: they can only be changed by changing the records stored in the servers. In particular:

- To make voice calls over IP networks, the originating equipment must support the Session Initiation Protocol (SIP), H.323, or some other protocol, such as one for Skype or Viber.
- To try several communication services according to their preference rankings, until one of them succeeds, the originating equipment must respond to failure messages from the communication services.
- To offer different communication services in different conditions (such as "available only for receiving email messages" or "available only for setting calendar schedules"), the records stored in the DNS servers must be changed when the conditions change[2].

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[1] These terms are specific to this report. The information about a communication service that is held in DNS for access through ENUM is sometimes called an 'ENUMservice'; because of the different ways in which communication services have been implemented this information provides different levels of detail for different services. The information about an end point that is held in DNS for access through ENUM is something from which a Uniform Resource Identifier (URI) can be derived; the end point is that URI.

[2] Such "find me / follow me" facilities are sometimes suggested as applications of ENUM. However, they are widely available, even if not widely used, on call servers or application servers.

ENUM is defined generally, independent of national numbering plans at any level other than the country codes. It does not need to be related to national numbering plans and number allocation policies in other respects. It does not require changes to national number plans. In some countries special number ranges have been introduced for use with ENUM, for reasons discussed in Section 6.6, but other number ranges can still be used with ENUM.

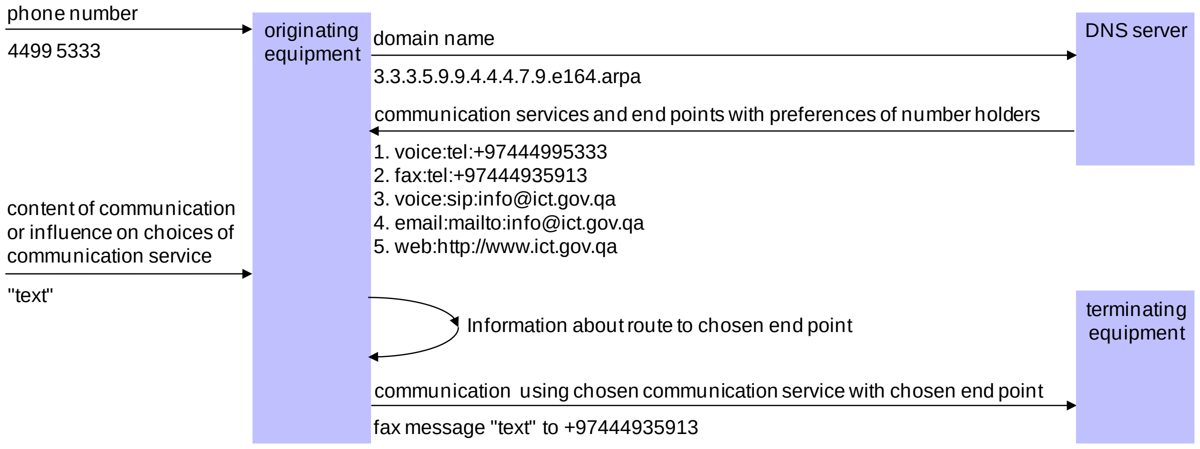
2 Operations of ENUM

2.1 Overall view

To fill in some details for Figure 1 and

Box 1, this section looks at a particular example, concentrating on the messages that are most relevant to the questions raised by ENUM. For this example the details are provided in Figure 2 and Box 2.

Figure 2 The messages for setting up a communication



Box 2 The messages for setting up a communication

1. The user dials, or otherwise provides, a phone number (with the country code); for instance, the combination might be +974 4499 5333.
2. The originating equipment sends the phone number, represented as a domain name, to a domain name server; for example:

   +974 4499 5333 would be represented as 3.3.3.5.9.9.4.4.4.7.9.e164.arpa.
3. The domain name server responds with communication services and end points ranked by preference, such as:

   1 voice tel:+97444995333

   2 fax tel:+97444935913

   3 voice sip:info@ict.gov.qa

   4 email mailto:info@ict.gov.qa

   5 web http://www.ict.gov.qa
4. The originating equipment uses those of the communications services that it can use, according to their preference rankings; for example:

   "text" would not be sent by voice (if that had preference 1) but would be sent by fax (if that had preference 2).
5. The standard does not define what happens if no communication services are offered that the originating equipment can use; for instance, the originating equipment might generate a “number unobtainable” indication for the user.

2.2 The ENUM representation of phone numbers

The ENUM representation of E.164 numbers as domain names is entirely systematic and straightforward, even if its results look odd; something much like it can be used for private network numbers, too. It is outlined step-by-step in Box 3 in the form that can be used wherever the E1.64 standard is applied[3].

Box 3 The steps in representing a phone number as a domain name

1. Any national prefix is removed from the phone number; for example:

   0 4499 5333 with national prefix 0 (if present) would be replaced by 4499 5333.
2. The phone number is completed with the country code; for example:

   4499 5333 with country code 974 would be replaced by +974 4499 5333.
3. All characters except for digits are deleted from the phone number; for example:

   +974 4499 5333 would be replaced by 97444995333.
4. "." is inserted between the digits; for example:

   97444995333 would be replaced by 9.7.4.4.4.9.9.5.3.3.3.
5. The order of the digits is reversed; for example:

   9.7.4.4.4.9.9.5.3.3.3 would be replaced by 3.3.3.5.9.9.4.4.4.7.9.
6. ".e164.arpa" is attached at the end; for example:

   3.3.3.5.9.9.4.4.4.7.9 would be replaced by 3.3.3.5.9.9.4.4.4.7.9.e164.arpa.

2.3 The DNS identification of communication services and end points

The DNS way of identifying communication services and end points for ENUM is not straightforward. It is exemplified in Box 4, but that shows only some of the possible complications[4]. The records stored in a DNS server that identify communication services and end points for ENUM are Naming Authority PoinTeR (NAPTR) records; such records are also used in some other cases, such as domain names under the top level domain tel[5]. The

[3] The examples in this report use the fixed phone numbers and email addresses in the publicly available contact details of ictQatar where possible, with adaptations for uses (such as in mobile phone numbers and SIP addresses) where necessary. In many countries a national prefix, which is typically 0, is attached to phone numbers so that national dialling (including the area code) can be distinguished from local dialling (excluding the area code). However, in Qatar there is no national prefix attached to phone numbers, so a phone number takes a form such as 4499 5333, not 0 4499 5333.

[4] For instance, it ignores the possibility that one record in the DNS server may link to another (and the consequential need to check for potential loops), and also the possibility of substituting parts of a regular expression into the record when finding an end point.

[5] For an account of the value of such domain names see *.tel: Innovation in DNS Data Storage* (telnic 2008) at http://dev.telnic.org/docs/dottel_innovation.pdf. For a description of the corresponding use of NAPTR records see *NAPTR Records in .tel* (Telnic, 2008) at http://dev.telnic.org/docs/naptr.pdf.

format of these records has changed in minor ways from time to time; that adopted in this report is the current one[6].

NAPTR records allow the same communication service to be associated with different Uniform Resource Identifier (URI) schemes (and also different end points); for example:

- Multimedia Message Service (MMS) messages can be associated with both mailto for the Simple Mail Transfer Protocol (SMTP) and tel for traditional telephony.
- Voice calls can be associated with both sip for SIP and tel[7].

Conversely, NAPTR records allow different communication services to be associated with the same URI scheme (and even the same end point); for example:

- Both multimedia messages and calendar schedules can be associated with mailto.
- Both electronic business cards and web access can be associated with http for the HyperText Transfer Protocol (HTTP).

[6] For a discussion of restrictions on the content of these records to make implementations interoperable see *Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Minimum requirements for interoperability of ENUM implementations* (ETSI, April 2005) at http://pda.etsi.org/pda/queryform.asp.

[7] They can also use skype for Skype, though the information about a Skype communication service for NAPTR records has not been registered as an official 'ENUMservice'.

Box 4 The records in DNS identifying ENUM communication services and end points

A list of communication services and end points associated with the phone number 4499 5333 and the country code (in this case +974), ranked by preference, might be:

1 voice tel:+97444995333

2 fax tel:+97444935913

3 voice sip:info@ict.gov.qa

4 email mailto:info@ict.gov.qa

5 web http://www.ict.gov.qa

The NAPTR records for the domain name 3.3.3.5.9.9.4.4.4.7.9.e164.arpa representing the phone number would then need to be:

NAPTR 100 1 "u" "E2U+voice:tel" "!^.*$!tel:+97444995333!" .

NAPTR 100 2 "u" "E2U+fax:tel" "!^.*$!tel:+97444935913!" .

NAPTR 100 3 "u" "E2U+sip" "!^.*$!sip:info@ict.gov.qa!" .

NAPTR 100 4 "u" "E2U+email:mailto" "!^.*$!mailto:info@ict.gov.qa!" .

NAPTR 100 5 "u" "E2U+web:http" "!^.*$!http://www.ict.gov.qa!" .

Taking the fields in the NAPTR records in turn:

- NAPTR signifies that a NAPTR record is being provided.
- 100 is the order (which overrides the preference in determining the preference ranking).
- 1, 2, 3, 4 or 5 is the preference.
- "u" indicates that a URI is to be constructed.
- "E2U+voice:tel", "E2U+fax:tel", "E2U+sip", "E2U+email:mailto" or "E2U+web:http" indicates that the ENUM to URI ("E2U") mapping is being used with the stated communication service (where a SIP communication by voice is just labelled sip).
- "!^.*$!tel:+97444995333!", "!^.*$!tel:+97444935913!", "!^.*$!sip:info@ict.gov.qa!", "!^.*$!mailto:info@ict.gov.qa!" or "!^.*$!http://www.ict.gov.qa!" is a rule for constructing the URI by combining the stated scheme (such as tel, sip, mailto or http), fixed information (such as +97444995333, +97444935913, info@ict.gov.qa or //www.ict.gov.qa), and parts of a regular expression (which is not needed in this example).

3 Variants of ENUM

3.1 Forms of ENUM

The form of ENUM outlined in Section 2.1 is, strictly speaking, 'user ENUM' (which is sometimes called 'public ENUM'). It lets number holders associate communication services with their phone numbers. There is another important form of ENUM, 'carrier ENUM' (which is sometimes called 'operator ENUM', 'provider ENUM', 'infrastructure ENUM' or, when it is used within only one network, ‘private ENUM’). It lets service providers associate communication services with the phone numbers of number holders. More fully:

- **User ENUM**. For user ENUM, number holders (not service providers) supply information about their preferred communication services and end points, and other users can obtain that information: the information is controlled by the number holders, is held in DNS servers as records accessible from the public Internet to all users and is therefore publicly available.

  The preferences for communication services held in the DNS servers are those of the number holders irrespective of the service providers that the number holders use.

  The mapping from phone numbers to communication services and end points is as described in Section 2.2 and Section 2.3.

  The organisations that administer and implement the mapping are determined nationally according to internationally established conventions.

- **Carrier ENUM**. For carrier ENUM, service providers (not number holders) supply information about the preferred communication services and end points of their customers, and participating service providers can obtain that information: the information is controlled by the service providers, is held in DNS servers as records accessible only from a private network of the service providers, and might include network details that the service providers share among themselves but do not make public.

  The preferences for communication services held in the DNS servers are likely to be those of the service providers; in fact one service provider may not have, or may not wish to supply, information about all the communication services preferred by its customers (especially when the services are those of competing service providers).

  The mapping from phone numbers to communication services and end points is not quite as described in Section 2.2 and Section 2.3; in particular, the second level domain is not likely to be e164.arpa.

  The organisations that administer and implement the mapping are determined by the service providers participating in the use of the system.

The differences between user ENUM and carrier ENUM are depicted in Figure 3. Their characteristics are summarised in Table 1[8]. An elaboration of these comparisons is in Section 6.7.

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[8] For a discussion of the characteristics see *Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); ENUM scenarios for user and infrastructure ENUM* (ETSI, June, 2007) at http://pda.etsi.org/pda/queryform.asp.

Figure 3 Differences between user ENUM and carrier ENUM

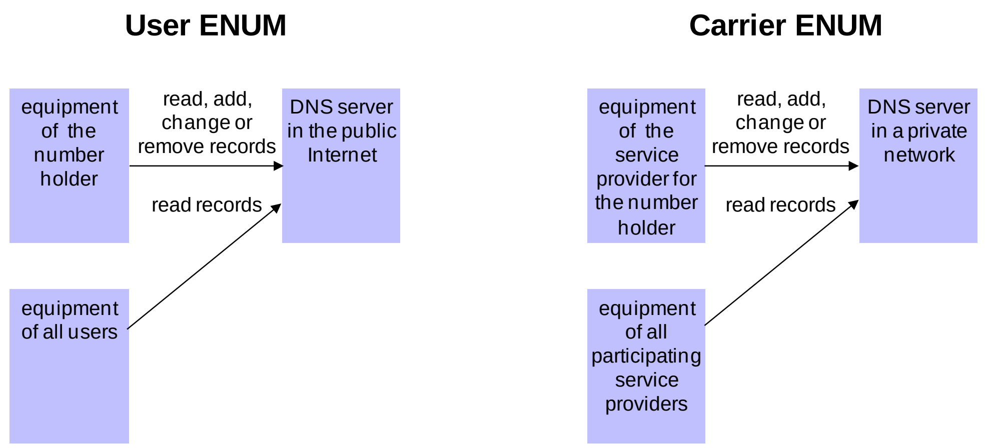

Table 1 Characteristics of user ENUM and carrier ENUM

Characteristic	User ENUM	Carrier ENUM
Control of the content of the records in DNS	By the number holder	By the service provider for the number holder
Availability of the records in DNS	To all users	To all participating service providers
Choice of the second level domain	By the standards organisations	By all participating service providers
Assignment of the responsibility for administration and implementation	By the national governments	By all participating service providers

3.2 Alternative domains for ENUM

The domain e164.arpa is not acceptable for user ENUM in some countries, because of its institutional governance arrangements[9]. Even where e164.arpa is acceptable for user ENUM, it is not satisfactory for carrier ENUM, as it could lead to:

- Misconfiguration leading to accidental leakage into the user ENUM space.
- Complications in the use of country codes by the originating equipment[10].

[9] The arpa top level domain is operated by the Internet Assigned Numbers Authority (IANA), which is managed by the Internet Corporation for Assigned Names and Numbers (ICANN) under a contract from the Department of Commerce of the United States (US). Some countries want control of ENUM to be vested fully in the International Telecommunication Union (ITU).

There are therefore systematic representations of phone numbers as domain names that differ from that outlined in Section 2.2 only because they use domains other than e164.arpa. These representations can be used together with DNS, just as the representation provided by ENUM can, to provide mappings from phone numbers to communication services and end points. Examples of domains used by these representations are:

- e164.org, which is a domain for something like user ENUM, in that users supply the information directly.
- e164.info, which is the domain for carrier ENUM provided by XConnect with Voice Over IP (VOIP) providers as participants[11].
- e164enum.net, which is the domain for carrier ENUM provided by the GSM Association (GSMA) with mobile service providers as participants.
- nrenum.net, which is the domain for carrier ENUM provided by the Trans-European Research and Education Networking Association (TERENA) National Research and Education Network (NREN) providers as participants.

As these examples demonstrate, top level domain managers typically do not have policies that would prevent the introduction of domain names containing “e164”. This is so for country code top level domains as well as generic top level domains[12].

Alternative domains with the functions of user ENUM might confuse users and fail to ensure the authenticity and accuracy of the information that they provide, especially if they resembled e164.arpa (as would e164.ar and e164.pa, for example). They are likely to create problems unless they are purely mirror images of e164.arpa that are continuously updated to remain consistent with it. In principle they should not be needed, as DNS already has its own mechanism for maintaining its consistency on a worldwide basis; they arise because there are very few records in DNS for almost all country codes under e164.arpa (and indeed there are no records at all for many country codes). They would be unnecessary and undesirable if e164.arpa was widely adopted.

Alternative domains for carrier ENUM make fewer problems, but might still require regulatory oversight to ensure that they are not prejudicial to the interests of users or non-participating service providers. They also require careful configuration of the DNS servers, to ensure that confidential phone numbers and sensitive network structure details are not publicly available.

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[10] Before closing its working group on ENUM in 2011, the Internet Engineering Task Force (IETF) considered for carrier ENUM both an ‘interim’ proposal, which would adopt the ‘interim’ delegation procedures of user ENUM, and a ‘long term’ proposal. Both proposals would let there be two mappings from phone numbers to communication services (for user ENUM and carrier ENUM), so number holders and service providers could have separate registrations. There was a suggestion to insert "i" in national subdomain names under e164.arpa to distinguish the two mappings; thus the phone number 4499 5333 with country code 974 would be represented as 3.3.3.5.9.9.4.4.i.4.7.9.e164.arpa. This suggestion did not find favour, partly because any originating equipment presented with a full international phone number would need to know the country code.

[11] The intention is to let VOIP service providers use routes that go direct between IP networks as far as possible. Such routes are preferable to those that pass through traditional telephony networks, because they avoid converting between voice representations suitable to IP networks and voice representations suitable to traditional networks. Such conversions increase call costs (by needing extra equipment) and decrease call quality (by introducing delay and distortion).

[12] For one example see http://www.e164.ph. In fact e164.ph (in which ph is the domain of the Philippines) is the domain for carrier ENUM adopted by a company aiming to implement VOIP and other services (such as fax-to-email conversion) worldwide. Furthermore “e164” is used as part of the branding of VOIP providers on the Internet; for instance, http://www.e164.co.uk identifies a web site that sells phone numbers in countries to which VOIP calls can be routed with the aid of carrier ENUM.

3.3 Other ways of finding communication services and end points

The use of ENUM is not essential for mapping phone numbers to communications services and end points. For instance, the Home Location Register (HLR) of a mobile network, which associates phone numbers with subscriber details, is sometimes extended to provide this mapping for such purposes as multimedia message transmission.

Furthermore, a call server might have its own internal routing data base. This routing data base does not need to have a standard form and could have different features, depending on the markets intended for the call server. For instance:

- It might have a structure extending a proprietary one already in Time Division Multiplexing (TDM) switches that could facilitate migration from traditional telephony networks to IP networks.
- It might contain records resembling NAPTR records so closely that they can be used much as if they were provided by ENUM (working with DNS).

A traditional routing data base differs from a data base that functions like user ENUM: the information in it is controlled by the service providers, is held as records accessible only from a private network of the service providers, and might include network details that the service providers do not make public. In all this it resembles a data base that functions like carrier ENUM. It differs from a data base that functions like carrier ENUM by not being based on DNS; instead, it could well have a proprietary access technique and a proprietary structure, which would reflect the history of a particular service provider and a particular equipment supplier and could preclude sharing records between several service providers.

The internal routing data base of a call server is normally provisioned in management operations (unless it is just a cache of an external routing data base). However, a server might use communications with other servers to extend its internal routing data base: when it did not hold records that it needed it would interrogate the servers that it trusted to find whether they held suitable records. If those, too, did not hold suitable records, the server might resort to a shared external routing data base. In one variant of this technique, Distributed Universal Number DIscovery (DUNDI), the trusted servers would if necessary themselves interrogate other servers that they trusted, and those servers would repeat the process until suitable records were found. DUNDI is not well suited to public networks because of their requirements for scale and security: public networks often have many servers, and those servers do not trust the servers of other public networks.

A server in one public network does not usually hold records about the routes inside other public networks. However, it can still determine the routes to gateways into those networks, even if it does not determine the routes all the way to the call destinations themselves.

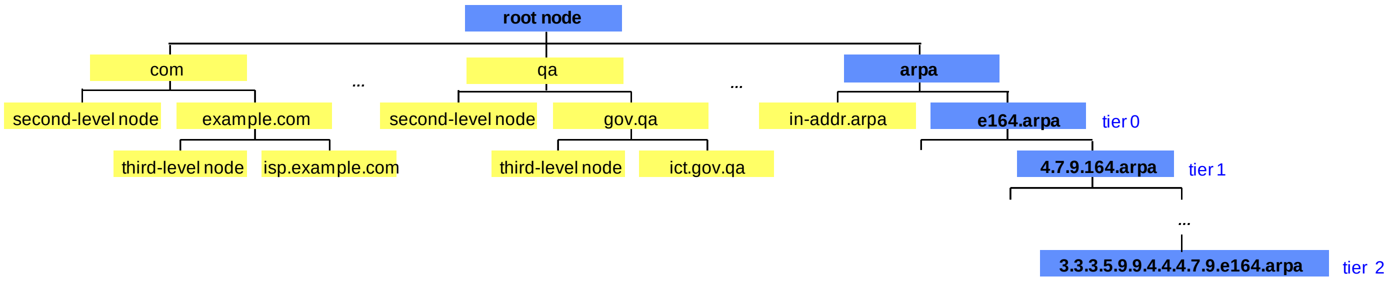
A further alternative to user ENUM that was under consideration some years ago conceived of a Universal Communications Identifier (UCI). UCIs would comprise numbers (which could be phone numbers), alphanumeric labels (which could be personal names) and status indicators. By not using the public Internet DNS, UCIs could avoid some of the problems described in Section 6.2 that beset user ENUM However, the value of such a naming scheme is questionable, for reasons mentioned in Section 6.4. Since their conception, UCIs have not had extensive trials and have largely disappeared from sight

4 Administration of ENUM

4.1 The domain hierarchy

ENUM domains are arranged in tiers. For user ENUM, e164.arpa is the tier 0 domain, and the subdomain of that representing a country code is a tier 1 domain[13]. The domains representing individual phone numbers are regarded as the tier 2 domains. The relationship of user ENUM domains to the rest of DNS is illustrated in Figure **4**.

Figure 4 The position of ENUM domains in the DNS hierarchy



4.2 International authorities

The technical rules for user ENUM were laid down by the Internet Engineering Task Force (IETF)[14]. They deal mainly with the representation of phone numbers as domain names, the identification of communication services, and the format and content of records in DNS. They do not deal with various related technical matters (such as security for DNS, which is the subject of several other IETF documents), organisational matters or political matters.

The organisational matters relate to the management of domains and, in particular, to delegation, which makes an organisation responsible for managing a subdomain.

[13] There are country codes retained by ITU and country codes assigned to service providers, as well as country codes assigned to ITU member states (or, in the case of country codes 1 and 7, to groups of member states). Typical tier 1 domains are 4.7.9.e164.arpa for Qatar, which has country code +974, and 0.0.1.5.3.8.8.e164.arpa for the iNum Initiative, which has country code +8835100. .

[14] For successive versions of these rules see *E.164 number and DNS*, RFC 2916 (IETF, September 2000) at http://www.ietf.org/rfc/rfc2916.txt, *The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM)*, RFC 3761 (IETF, April 2004) at http://www.ietf.org/rfc/rfc3761.txt, and *The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM)*, RFC 6116 (IETF, March 2011) at http://www.ietf.org/rfc/rfc6116.txt.

Some organisational matters were taken up by the International Telecommunication Union (ITU)[15]. It ensures that a delegation of a country code under e164.arpa proceeds only if the government concerned approves the request for delegation.

Other organisational roles and responsibilities were suggested by the European Telecommunications Standards Institute (ETSI)[16]. These largely mirrored the distinctions widely used for DNS, between the organisations responsible for maintaining the authoritative DNS data base and operating the DNS servers ('registries') and the organisations ('registrars') responsible for registering names on behalf of users ('registrants'). The organisations are described in Section 4.3 and Section 4.4.

The political matters remain; they relate to what should be the tier 0 domain and what should be the user ENUM domain name manager at a global level. Meanwhile, some organisations are introducing systems like ENUM such as those mentioned in Section 3.2 that are "unofficial" and not encumbered by the failure to answer the questions.

4.3 The organisation hierarchy

When an IP network finds communication services from phone numbers, the phone numbers are just treated as familiar unambiguous names; other naming schemes could be devised and used instead. In particular, VOIP service providers could choose to by-pass the national number allocation arrangements by adopting their own numbers looking like phone numbers. These numbers would provide VOIP but would not give access to traditional telephony networks; they could even cause number changes when they are finally found to conflict with the national numbering plan[17].

To ensure that only valid numbers are used, there must be agreements between the service providers and any central authority. For user ENUM, ITU acts as this central authority at the global level and a neutral organisation (which might be a ministry, a regulator or a third party) acts as this central authority at a national level. That central authority is responsible for managing the domain but it is not necessarily responsible for operating the servers, which is an essential skilled task in its own right.

There needs to be one authoritative primary source of the user ENUM information; secondary sources then extract this information for service providers or users[18]. The primary source of the information is the global DNS system.

To become the central authority at a national level, an organisation requests delegation by applying to ITU or to Réseaux IP Européens Network Coordination Centre (RIPE NCC)[19].

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[15] For full descriptions see *Operational and administrative issues associated with national implementations of the ENUM functions*, ITU-T Recommendation E.164 Supplement 3 (ITU, May 2004) at http://www.itu.int/rec/T-REC-E.164-200405-I!Sup3, and *Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes*, ITU-T Recommendation E.164 Supplement 4 (ITU, May 2004) at http://www.itu.int/rec/T-REC-E.164-200405-I!Sup4. These 'interim' procedures have existed for ten years. Their 'long term' replacements have been under study at ITU for as long, partly because of the difficulties in agreeing on the tier 0 domain.

[16] For a full discussion see *ENUM Administration in Europe* (ETSI, July 2002) at http://pda.etsi.org/pda/queryform.asp. This is relevant outside Europe as well as inside it.

[17] At one stage some voice over IP service providers in the US risked doing this, by giving users numbers that were too long to conform with ITU-T recommendation E.164 and that began with codes not allocated in the North American Numbering Plan (NANP).

[18] Similar primary sources of information are needed for some implementations of directory enquiries and number portability.

Before the delegation proceeds, ITU checks that the government of the country approves the request by the organisation and RIPE NCC checks that the organisation has relevant operating arrangements for the DNS servers[20]. In this way ITU and RIPE NCC co-ordinate their efforts.

At a national level, the central authority typically becomes or selects (after a bidding process) the organisation operating the DNS servers for the tier 1 domain[21]. There can be several obvious candidates with the appropriate skills; one is the organisation operating the DNS servers for the country code domain, but another might be the organisation that was responsible for operating the DNS servers for a national trial of ENUM. If a dominant telephony service provider operates the servers at the tier 1 level it might need to separate out these operations from the rest of its organisation to ensure that competitors are treated fairly.

These servers at the tier 1 level in turn point to the DNS servers for the tier 2 domains, which hold information about ENUM subscribers and which are typically operated by competing organisations that collect, check and update the information about their subscribers.

The same organisations might wish to operate DNS servers for the tier 1 and tier 2 domains, which would eliminate competition at the tier 2 level. However, that is where competition is worth having, as there most costs are incurred and services can be differentiated. In fact operations at the tier 2 level might be provided by every organisation skilled in operating DNS servers, other than the organisation operating the DNS servers for the tier 1 domain.

The international arrangements were designed for user ENUM. Under them, many matters remain national responsibilities, including:

- How to cover the costs.
- Which trials should be held.
- Who operates the name servers.
- Who may register phone numbers.
- Which phone numbers may be registered.
- How to ensure that registrars do not discriminate.
- How to ensure that registrants preserve their privacy.
- How to verify that registrants have rights to the phone numbers.

Some similar matters arise for carrier ENUM, but it does not suffer from the problems mentioned in Section 6.2 and Section 6.3.

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[19] RIPE NCC has as its main function to allocate IP addresses in Europe and the Middle East. However, it has been appointed by the Internet Architecture Board (IAB) at the global level to operate the tier 0 registry for e164.arpa.

[20] Country codes 1 and 7 are assigned to groups of member states. For country code 1, each member state looks after its own area codes. For country code 7, Kazakhstan and Russia have yet to publish an arrangement.

[21] In principle, different organisations could operate different DNS servers for different parts of the tier 1 domain, but doing this would be complicated.

4.4 Customer interfaces

Registrars interact with the registry to change the DNS information about phone numbers. Their natures and roles different between user ENUM and carrier ENUM. In fact at a national level:

- **User ENUM**. For user ENUM, the registrars can be any organisations with appropriate Information Technology (IT) skills. They change the DNS information in response to requests, having checked that the people making the requests are entitled to do so (as discussed in Section 6.2).
- **Carrier ENUM**. For carrier ENUM, the role of the registrars is usually filled by the participating service providers, who are mainly interested in routing calls across their own networks. They change the DNS information in response to requests by other participating service providers (who might be opening new number blocks or ensuring that numbers are ported).

Even for user ENUM, service providers might ensure that there is some DNS information available for all number holders, using a process like that described in Box 5[22].

Box 5 A process using service providers to provide initial records for user ENUM

1. The service provider registers a block of phone numbers allocated to it.
2. The service provider supplies to the registry a domain name for at least a SIP service (and possibly a call server) associated with the block, such as sip.isp.example.com.
3. The registry checks the allocation of the block to the service provider.
4. The registry adds records into DNS to associate a URI with each phone number in the block and indicate (with "user=phone") that the digit string in the sip URI is a phone number instead of a user name; for example:

   4499 5333 with country code 974 might be associated with sip:+97444995333@sip.isp.example.com;user=phone.
5. The number holder can opt in to supply extra information, such as mailto:info@ict.gov.qa.

[22] For a full description see *Carrier Registrations in User ENUM (CRUE)* (Nominet, May 2006) at http://download.nominet.org.uk/ENUM/CRUEv7.pdf. The process assumes that service providers are prepared to publish information that might be used for making inferences about network structure. It also requires elaboration, to ensure that the information remains correct when numbers are ported. However, it exposes the personal information of only those number holders that opt in to supplying this.

5 Experience with ENUM

5.1 Trial systems

In various countries between 2001 and 2006 there were consultations about whether to conduct trials of ENUM. Usually these consultations produced positive responses, with the effect that some time later the trials started. Examples providing discussions of the questions and responses include Austria[23], France[24], Ireland[25], Portugal[26] and Switzerland[27]. There were also initiatives more recently in other countries that were left incomplete. For instance:

- In Lebanon, a briefing paper and consultation document were prepared for the regulator in 2008 but never issued (though an intention of the regulator was said in 2009 to involve having ENUM "to ease the introduction of VOIP").
- In Bahrain, the draft plan of the regulator in 2010 stated for 2010 the objective of having ENUM "to facilitate end user choice and ease market entry", but the draft plan in 2013 did not mention that objective, which remains unfulfilled.

Often the trials were led by local enthusiasts, but some were sponsored by governments or regulators. Their participants varied but generally came from national IT centres, country code top level domain managers, domain name registrars, telecommunications regulators and telecommunications service providers (including Internet service providers). They usually focussed on user ENUM much more than carrier ENUM, but they ranged widely, with investigations of applications, interfaces, security, roles, supervision, financing and administration. There were also particularly demanding technical tests, organised by ETSI to check interworking.

Following the trials there were useful reports in Ireland[28] and the United Kingdom (UK)[29], for example. The trials generally concluded that:

- The use of DNS for ENUM was technically successful. Both DNS access and DNS provisioning are effective, and DNS is robust and scalable.

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[23] See *Zusammenfassung der Stellungnahmen zur öffentlichen Konsultation zu ENUM* (RTR, October 2001) at http://www.rtr.at/de/komp/ENUMKonsultationZusammenfassungStellungnahme/ENUMergebnis.pdf.

[24] See *Principes et conditions de mise en œuvre du protocole ENUM en France: Synthèse des contributions à la consultation publique* (ART, July 2001) at http://www.arcep.fr/index.php?id=2231&tx_gspublication_pi1[typo]=8&tx_gspublication_pi1[uidDocument]=89.

[25] See *ENUM: Accessing Multiple Customer Services Through Telephone Numbers* (Commission for Communications Regulation, March 2003) at http://www.comreg.ie/_fileupload/publications/ComReg0336.pdf.

[26] See *Relatório: Consulta Pública sobre o Serviço ENUM* (ANACOM, January 2007) at http://www.anacom.pt/streaming/cons_enum23022006.pdf?contentId=337346&field=attached_file.

[27] See *ENUM: Report on the consultation of the interested parties* (BAKOM, September 2003) at http://www.bakom.admin.ch/themen/internet/00485/index.html?lang=en&download=NHzLpZeg7t,lnp6I0NTU042l2Z6ln1ad1IZn4Z2qZpnO2Yuq2Z6gpJCDdH59fGym162epYbg2c_JjKbNoKSn6A--.

[28] See *ENUM forum final report* (Irish ENUM Forum, July 2005) at http://oak.enum.ie/forum/docs/ENUM Final Report v4.0.pdf.

[29] See *Status report on the trial implementation of ENUM in the UK* (UK ENUM Trial Group, May 2004) at http://www.enumorg.ca/pdfs/UKETGReportFinal.pdf.

- Number holders might be reluctant to use user ENUM. They could fear a loss of security (or, at least, privacy) and fail to maintain the records in DNS, especially when there were few applications available.
- Service providers might be prepared to use carrier ENUM. However, if similar capabilities were already implemented in other ways, the benefits offered by DNS (identified in Section 6.7) would not be enough to justify changing the implementation.

Though the trials were often seen as precursors to live services based on user ENUM they were not always followed in that way. The initial enthusiasm faded away as the business cases remained unclear. The developments in Japan, Jordan, Korea, Sweden and Switzerland are summarized in Box 6, Box 7, Box 8, Box 9 and Box 10 (respectively).

Box 6 The user ENUM project in Japan

There were user ENUM trials from 2003 to 2005 and from 2006 to 2008. In 2006 a special number range was made available for ENUM; however only two organisations requested such numbers. There was little interest in commercial deployment thereafter.

Participants in the trials raised concerns about the need for special numbers, incompatibilities in the definitions of NAPTR records, the lack of demand for applications and the requirement to make personal information publicly available.

Box 7 The user ENUM project in Jordan

There was a user ENUM trial from 2009 to 2010 by the national IT centre. The service providers were interested in participating once the initial tests had been performed. Also, after that initial phase there was to be collaboration on test design with the trial in Malaysia. However, the trials did not enter phases in which this happened: further work would have required funding that was not available at the time.

A general conclusion from the project was that the business case was weak and the market was not ready.

Box 8 The user ENUM project in Korea

There were user ENUM trials from 2003 to 2004 and from 2006 to 2007. The first trial had about 1300 registrants; the second involved two application service providers that were interested in commercial opportunities for user ENUM, with 183 registrants and 2700 usage cases. There was also a carrier ENUM trial that involved three Internet service providers that were interested in VOIP routing.

Subsequently user ENUM was not deployed, due to the lack of demand for applications and the requirement to make personal information publicly available. Also, carrier ENUM was not deployed, because there were already mature implementations of number portability (using a centralised data base) and VOIP peering (using internal call server tables).

Box 9 The user ENUM project in Sweden

The regulator produced several reports about ENUM. The first report, in 2001, recommended holding a trial. During 2002 three industry working groups produced studies for the trial about suitable applications, the procedures for registering ENUM domains and the shared infrastructure for ENUM. The trial lasted from 2002 to 2003 and was operated by the country code top level domain manager.

The second report, in 2003, suggested continuing the ENUM project until 2004 so that proper administrative procedures could be introduced. This suggestion was adopted; the project then ended, with a report by the industry to the regulator.

On the basis of that report and international studies the regulator produced a further report, in 2004, recommending commercial deployment. In 2006 there was a temporary agreement that the country code top level domain manager would continue to operate the ENUM system (though not on a strictly commercial basis) and the registrars would be the service providers.

A forum came into being but was discontinued because the service providers and the users lacked interest. .

In 2010 the country code top level domain manager wanted to replace the temporary agreement with a permanent one but rejected two proposals from the regulator. The regulator determined that there was very little commercial interest in user: in the country there were only about fifty users, almost all of whom had been active during the trial, and a similar position held in other countries.

The regulator requested the withdrawal of the delegation. However, a small service provider objected, so the regulator revoked its request.

Box 10 The user ENUM project in Switzerland

In 2002 the regulator launched a user ENUM consultation, to which there were fourteen responses, and held a user ENUM workshop. The workshop considered work towards international standardisation and initiatives in European countries, and discussed the forming a working group to launch a user ENUM project.

In 2003 the telecommunications trade association set up the working group. After three meetings of the working group, only one organisation was interested in setting up infrastructure to evaluate user ENUM; this organisation was SWITCH, which provides network and application services to universities. The working group then decided unanimously to suspend its activities, so SWITCH could apply for, and the regulator could award, a licence to be the user ENUM domain manager for evaluation over two years.

In 2005 the regulator extended the licence for two years.

In 2007 the regulator consulted the organisations that had taken part in the evaluation, and other interested parties, about the appropriate follow-up. It received only six comments in response to more than 450 invitations sent. It concluded that user ENUM was no longer highly topical and outlined four points to be considered in moving to commercial deployment. It then held discussions with SWITCH, the main party interested in user ENUM, and specified conditions for a licence to be the user ENUM domain manager for commercial deployment. However, SWITCH decided to abandon the project and the regulator requested the withdrawal of the delegation.

5.2 Production systems

After the trials, in some countries where user ENUM was not abandoned there were consultations to look again at matters such as demand levels, management arrangements and the privacy implications. Such was the case in the Netherlands[30] and the UK[31], for example. Elsewhere experiences in trials and expectations about markets were regarded as enough to motivate commercial deployments. The government or the regulator then determined the supervisory framework, sometimes by endorsing the recommendations of the local enthusiasts, and the operator of the DNS servers system (which was usually the country code top level domain manager).

Nonetheless, user ENUM has not been adopted rapidly; in fact there have been only about fifty requests from countries for delegation, with only ten resulting in commercial deployments[32]. These ten are Austria, Czech Republic, Finland, Germany, Ireland, Lithuania, the Netherlands, Poland, Romania and the UK. The most successful of these is Austria, where in 2010 there were 7,700 users with NAPTR records[33]. The corresponding figures for Czech Republic and Germany are provided month-by-month in Figure 5 and Figure 6 (respectively)[34]. In summary, user ENUM has not proved popular (for reasons like those mentioned in Section 6.1), even in countries such as Austria where it has been pursued most enthusiastically.

As carrier ENUM has fewer disadvantages than user ENUM, it might be deployed more often than user ENUM[35]. Indeed various alternative domains already used for carrier ENUM are mentioned in Section 3.2. Some of these uses are quite substantial; for instance, in 2011 XConnect handled 3 billion ENUM queries and had records for 2.2 billion phone numbers. Some potential and actual applications of carrier ENUM drawn from these and other domains are described in Box 11, Box 12, Box 13, Box 14 and Box 15.

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[30] See *Public User ENUM in Nederland* (ENUM Innovatieplatform Nederland, December 2007) at http://www.enuminnederland.nl/files/Concept Eindrapport ENUM InnovatiePlatform dd 18dec07.pdf.

[31] See *ENUM: Response to the Consultation* (DTI, April 2005) at http://www.berr.gov.uk/files/file14531.pdf.

[32] For a report on the status of ENUM deployment in many countries, maintained by RIPE NCC, see http://ENUMdata.org. However, the entries provided by some countries are not fully up to date. The entries include three "country codes" for service providers that are not confined to individual countries.

[33] For a list of the results obtained by crawling through e164.arpa to find NAPTR records see http://crawler.enum.at. The list excludes certain registries, which the crawler could not enter, but the results otherwise give very much larger numbers of entries than those mentioned in this report. In some countries service providers have simply registered blocks ranging in size from 100 to 10,000 phone numbers (with "wildcard" entries that simply replicate the phone numbers). Fourteenth in the list of "top country codes" is Qatar, with two entries, for h323:ofdul@ict.gov.qa and h323:njelani@ict.gov.qa.

[34] For comparison, at the time of drafting this report the five largest top level domains were com (with 107,617,731 registrations), de (with 15,347,639 registrations), net (with 15,042,695 registrations), uk (with 10,386,743 registrations), and org (with 10,213,003 registrations).

[35] Some deployments of carrier ENUM are not widely known. This is partly because, unlike user ENUM, carrier ENUM does not necessarily use e164.arpa and therefore is not necessarily recorded with RIPE NCC. It is also because some organisations that are believed to operate carrier ENUM systems are quite secretive about their operations.

Figure 5 Numbers of user ENUM domains in Czech Republic (2006-2012)

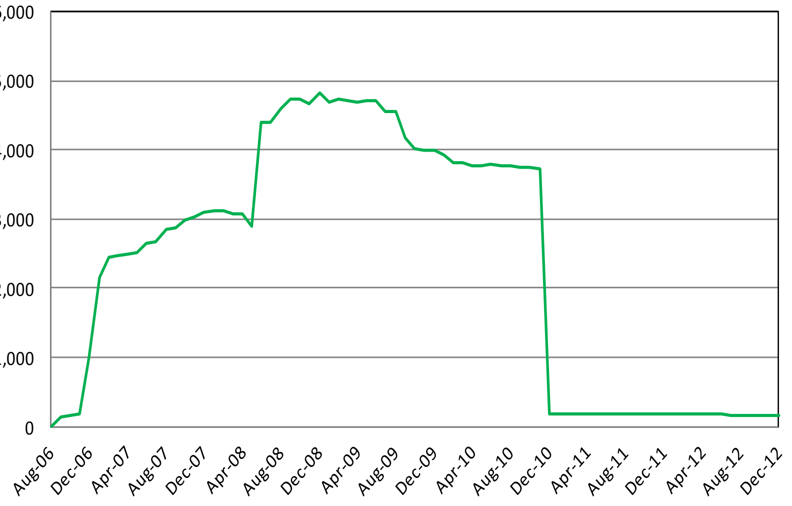
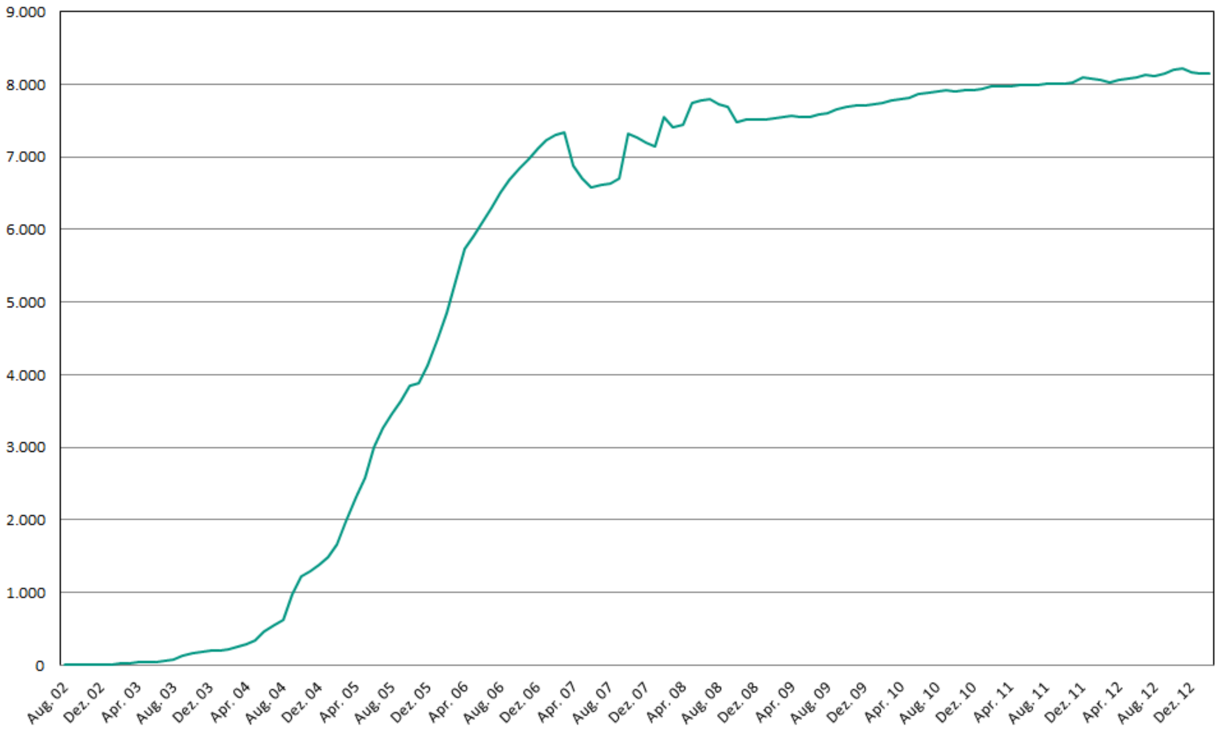


Figure 6 Numbers of user ENUM domains in Germany (2002-2012)



Box 11 A carrier ENUM system for number portability

A phone number that has been ported between TDM networks usually needs to be accompanied in the signalling by a 'routing number'; that identifies at least the switch or the gateway into the network to which the number has been ported and is sometimes formed by attaching a routing prefix to the number. A phone number that has not been ported does not need to be accompanied by a routing number, as the routing is determined by its digits (possibly in conjunction with location data bases).

A TDM network could use carrier ENUM in number portability by issuing an ENUM query for a ported number (and possibly for any number). The response to the query would provide any routing number needed and indicate (with the 'number portability dip indicator', "npdi") that no further number portability data base query was required to obtain number portability information. For instance, with the routing number +97400000003:

> 4499 5333 with country code 974 might be associated with tel:+97444995333;npdi;rn+97400000003.

An IP network could use carrier ENUM by issuing an ENUM query similarly. The response would again provide any routing number needed and indicate that no further number portability data base query was required in any TDM network encountered in the path of the signalling. It would also provide a sip URI that identified at least the SIP service (and possibly the call server or the gateway into the network) next in the path and indicate (with "user=phone") that the digit string in the sip URI was a phone number instead of a user name. For instance, with the SIP service sip.isp.example.com:

> 4499 5333 with country code 974 might be associated with sip:+97444995333;npdi;rn=+97400000003@sip.isp.example.com;user=phone.

This application of carrier ENUM can be extended to cover freephone and other numbers that have to be not merely ported but also translated to identify geographical locations.

Box 12 A carrier ENUM system for video and text relay

In the US, someone with hearing or speech disabilities can have a phone number in a normal geographic number range; having a special number range would be seen as discriminatory. A call to that number is first connected to a relay service centre which is then connected to the intended end point. In the case when the call is made from the network of another service provider, the Interstate Telephony Relay Service (ITRS) uses ENUM to associate the phone number with an end point for 'video relay' or for 'IP relay' (which is essentially text relay), as chosen by the number holder.

Video relay lets people communicate using sign language that is generated or interpreted (as appropriate) by a relay service assistant. Between service providers video relay uses H.323. If the user terminal of the number holder uses SIP instead of H.323 the phone number is associated with an H.323 gatekeeper instead of that terminal.

IP relay lets people communicate using text that is generated or interpreted (as appropriate) by a relay service assistant. There are several IP text communication applications, so there are several different schemes for an end point with which the phone number might be associated.

These arrangements could be extended in several ways as technology matures. For instance, the phone number could be associated with end points for both video relay and IP relay which could be tried in sequence. Also, speech-to-text or text-to-speech applications could replace the relay service assistant.

Box 13 A carrier ENUM system for multimedia interconnection and roaming

Internationally IP eXchange (IPX) supports roaming and interconnection between service providers. Its DNS uses the domains gprs, grx, 3gppnetwork.org, e164enum.net and ipxsp.org; 3gppnetwork.org, e164enum.net and ipxsp.org arose because of concerns that, following misconfigurations that would be difficult for service providers to observe, queries using grps or grx would reach the public Internet DNS servers, thereby degrading their performance with searches for non-existent domains.

IPX currently provides ENUM for use with MMS, SIP for an IP Multimedia Subsystem (IMS) and SIP for encapsulated ISUP (SIP-I). Phone numbers are represented as subdomains of e164enum.net (instead of e164.arpa). The NAPTR records for these subdomains reference URIs in subdomains of gprs or 3gppnetwork.org that are identified by the Mobile Country Code (MCC) allocated by ITU and the Mobile Network Code (MNC) allocated in that country. In this example the MCC is 427 (for Qatar) and the MNC is 006.

MMS always sends messages between message centres, not direct from or to users (by contrast with SMS). Between message centres MMS uses SMTP. The originating message centre uses carrier ENUM (working with DNS) or the Home Location Register (HLR) to map the phone number to an end point. In the case of carrier ENUM, for example:

> 4493 5913 with country code 974 might be associated with mailto:+97444935913/TYPE=PLMN@mms.mnc006.mcc427.gprs.

IMS subscribers have sip URIs (which have user identifiers alongside domain names or IP addresses) or tel URIs (which are essentially phone numbers). The IMS specifications take ENUM to be the preferred way of incorporating phone numbers in sip URIs; for example:

> 4493 5913 with country code 974 might be associated with sip:+97444935913@ims.mnc006.mcc427.gppnetwork.org;user=phone.

SIP-I also gives rise to sip URIs; for example:

> 4493 5913 with with country code 974 might be associated with sip:+97444935913@sip-i.mnc006.mcc427.gppnetwork.org;user=phone.

Originally, only IPX nodes resolved domain names under 3gppnetwork.org. However, user equipment needs to do this for some services, so the pub.3gppnetwork.org and ipxuni.3gppnetwork.org subdomains were introduced: user equipment can resolve domain names under pub.3gppnetwork.org if it is connected to the Internet and can resolve domain names under ipxuni.3gppnetwork.org it is not connected to the Internet (but is, say, connected to IPX).

Box 14 A carrier ENUM system for video conferencing

Internationally eduCONF facilitates the use and adoption of video conferencing within and between NRENs. Currently it relies on centralised H.323 gatekeepers to support 'dialling' for video conferences, but it proposes to let phone numbers be used in dialling through the use of ENUM (working with DNS). Phone numbers will then be represented as subdomains of nrenum.net and associated through ENUM with end points signifying video conferences. The private network numbers used by eduCONF, as well as E.164 numbers, will need to be represented in nrenum.net.

Doing this will help to harmonise implementation and addressing for different communication infrastructures (for video conferencing, VOIP and so on): calls will be able to be placed to varied end points offering varied communication services, going beyond VOIP. It will also move the support of dialling from centralised gatekeepers to distributed DNS servers, which are more efficient, robust and manageable.

Box 15 A carrier ENUM system for routing information exchange

In the US, PeerConnect lets cable service providers and their peering partners exchange the data for establishing voice and video calls, SMS and MMS messages and other IP communications. Cable service providers can provision service data dynamically and have secure independent ways of distributing session routing data to selected partners (such as SMS and MMS service providers and valued-added service providers).

PeerConnect provides ENUM so that cable service providers and their peering partners can perform number analysis and make routing queries. For each phone number the ENUM system can identify multiple communication services and end points that use different URI schemes and signify different gateways into networks. The gateways can be located in the originating network or the terminating network.

Thus phone numbers might be used in finding routes for instant messages (with im URIs), say, as well as voice calls; for example, ignoring the fact that the US country code is not 44, with the gateway im.isp.example.com capable of handling instant messages:

> 4499 5333 with country code 974 might be associated with im:contacts@im.isp.example.com.

At the same time, with the gateway sip.isp.example.com capable of handling sip:

> 4499 5333 with country code 974 might be associated with sip:contacts@sip.isp.example.com.

6 Findings about ENUM

6.1 The perspective on user ENUM

The trials mentioned in Section 5.1 have confirmed that user ENUM presents the following problems:

- User ENUM requires contact details (as information about communication services and end points) to be held in the public Internet DNS. It thereby offers scope for breaches of privacy, and even of other aspects of security (in the absence of precautions), as described in Section 6.2.
- User ENUM relies on number holders to supply their contact details. It thereby affects the quantity and quality of the details in ways described in Section 6.3.

Besides having these intrinsic problems, user ENUM has been overtaken by:

- The rise in social networking web pages.
- The growth in the capabilities of mobile phones
- The fall in call charges.
- The growth of voice over the Internet completely without phone numbers.

More precisely, user ENUM has not lived up to expectations in the following respects:

- User ENUM might have let users make personal information available globally for new internet applications just by using phone numbers as individual identities. However, it has not really done so (and is not ideally suited to doing so), for reasons discussed in Section 6.4.
- User ENUM might have strengthened competition between service providers in various ways. However, it appears to have had little effect for reasons discussed in Section 6.5.
- User ENUM could have helped to avoid the invention of special phone numbers that make communication more difficult by being outside the global numbering space. However it does not seem to have succeeded in this, as indicated in Section 6.6.

Generally for user ENUM the commercial drivers are weak and the potential difficulties are substantial. By contrast, for carrier ENUM there can be good reasons for adoption (as considered in Section 6.7).

6.2 Security of contact details

6.2.1 Reading contact details

User ENUM lets people read the contact details of number holders. They could then indulge in “spamming” (communicating with someone else without any implied consent, particularly through email) and “spoofing” (pretending to be someone else). Casual prying could be deterred by not offering a WHOIS function that would translate phone numbers to information about number holders. However, DNS has an architecture that lets millions of records be read from it rapidly, potentially by 'bots' trained to harvest contact details.

To limit abuse like this, contact details should be made available through user ENUM only if the number holders have explicitly opted in to this. However, restricting the available contact details merely limits the abuse, without eliminating it, and reduces the potential market for user ENUM[36].

6.2.2 Changing contact details

User ENUM lets people try to change the contact details of number holders. They could then redirect communications, perhaps to commit impersonation, steal personal or business information, or indulge in “slamming” (transferring the service for a user to another service provider without consent).

To prevent abuse like this, attempts to provide initial or revised contact details should be authenticated. The process could be rather like that for establishing and using a bank account on-line: the identity of someone attempting to provide initial contact details should be verified by referring to some acceptable information 'outside' the system, and the identity of someone attempting to provide revised contact details should be verified by checking personal information such as passwords. In particular, the process for authenticating attempts to provide initial contact details for numbers could adopt techniques like those used to authenticate attempts to port numbers. For instance:

- In the Czech Republic, a robot makes calls to the numbers, to provide initial passwords which the number holders then use to complete authentication.
- In Ireland, the number holders submit by fax or email official identifications and phone listing checks or invoices to receive initial passwords.

Another possibility is to provide initial passwords that permit changes to contact details only to people requesting to be assigned new phone numbers; in practice this requires the introduction of a special number range for user ENUM.

Often the service provider with whom the number holder has a billing relationship could authenticate readily attempts by the number holder to change contact details. However, the service provider might not help, believing that user ENUM wastes effort or even reduces revenue (by replacing voice calls by email, for example). An alternative is to have a separate agent authenticate the attempts.

The authentication of attempts to change contact details held in a DNS server can prevent illegitimate changes to the details while they are in the server. However, the contact details provided by a DNS server could be changed deliberately on the way from it to another DNS server. To prevent such changes, DNS SECurity extensions (DNSSEC) can be used to validate the authenticity and integrity of messages. Though the deployment of DNSSEC is now under way throughout the world it is not complete. For users of DNS servers without DNSSEC there remain risks of illegitimate changes to the contact details that they receive.

[36] Other techniques are also available for reducing the loss of privacy. For instance, SIP users could impose SIP called party control and provide only end points containing SIP aliases, not their usual names, to DNS. However all such techniques run the risk of impeding wanted communications as well as unwanted communications.

6.3 Quantity and quality of contact details

6.3.1 Providing initial contact details

The security considerations in Section 6.2 suggest that number holders should need to opt in before their contact details could become available through user ENUM. As people are suspicious of on-line systems, the proportion opting in might not be high, and the incentive for applications to get contact details through user ENUM would then be low.

In the event that the proportion opting in becomes high, number holders that have chosen not to opt in will feel under pressure to opt in, if they are to continue in contact. Something intended to be allow opting in will have become in effect compulsory. Such pressures are partly responsible for the spread of social networking web sites[37].

If important applications automatically get contact details through user ENUM, the onus is placed on number holders to maintain the completeness of the communications system. Thus user ENUM gives number holders responsibilities to look after their contact details as well as rights to do so.

6.3.2 Maintaining current contact details

The security considerations in Section 6.2 suggest that there should be authentication of requests to change contact details available through user ENUM. Unless the number holders make conscious efforts, the contact details might become out of date, just as links to web sites become broken.

User ENUM could support "find me / follow me" facilities (which let calls track the locations and availability of users), but it would then require the number holders to update the DNS servers frequently. The need to maintain the global integrity of DNS could limit the simplicity and frequency of doing this. In fact, any number holders wanting "find me / follow me" facilities could instead get them separately, perhaps as unified communications applications, and might not then bother to maintain their records in DNS for user ENUM[38].

Out of date contact details would pose particular problems for emergencies. In an emergency call the phone number of the caller is passed automatically to the emergency service centre so that there can be return calls. If the emergency service centre used ENUM, and the contact details available for the phone number through user ENUM were out of date, the return calls could be misdirected; even if the contact details were correct, there could be difficulties, as the emergency service equipment should choose the communication service currently preferred by the original caller, which might not be first in the preference ranking provided by DNS.

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[37] However, currently pressure seems unlikely anywhere to make user ENUM use effectively compulsory. For instance, in Lithuania user ENUM has been deployed since 2010 (by the company that operates the number portability data base), but no organisation has become a commercial registrar and there were only about 700 registered users at the last count.

[38] Unified communications applications aim to let users vary how they communicate, by offering choices between, and combinations of, calls, messages, email, web access, interactive white boards, and presence indications. The choices presented by the applications might be those made available through ENUM as preferences for communication services. However, typically users can change them more easily than the records in DNS needed for ENUM, and the call servers or application servers have internal routing data bases.

6.3.3 Removing defunct contact details

Unless the number holders make conscious efforts, the contact details available through user ENUM might not be removed when the number holders cease to hold the numbers. The service providers might not check that the contact details are removed, especially when the details relate to their former customers. Without the removal of the details, people assigned the numbers in future might be denied authenticated access to user ENUM or might never receive communications intended for them but misdirected by the details.

This problem can usually be addressed by taking account of national regulations on the re-use of phone numbers. For instance, user ENUM registrations might be required to be renewed at intervals which are less than the period (of six months, say) during which phone numbers must not be used before they can be issued to new number holders; however, this requirement would discourage number holders from continuing to make their contact details available.

6.3.4 Avoiding exploitative contact details

By changing the contact details available through user ENUM, number holders might be able to redirect communications from the apparent destinations to other destinations with higher charges for the users originating the communications. They could thereby exploit the users; for instance, they might silently redirect calls made apparently to freephone numbers to reach numbers for mobile services or premium rate services. Of course, user ENUM is not alone in aiding the exploitation of users in this way: other applications for redirecting communications, in traditional TDM networks or with redirect servers for SIP, also do it.

To prevent such exploitation, redirected communications should be subject to at least the requirement that the users originating the communications do not pay any extra charges without their informed consent, given after they have received clear and simple messages about these charges but before any charging starts. In several countries calls to premium rate services are already subject to an analogous requirement. For premium rate services, which have numbers in particular ranges, compliance with such requirements is difficult to monitor; it is yet more difficult if number holders can redirect communications to reach any number (as is so, in principle, if user ENUM is available). Moreover, even with such requirements some users will be misled or pay no attention to the messages. The most satisfactory remedy is to require that the users do not pay any extra charges (because the number holders pay instead) but doing this complicates greatly billing between networks.

6.4 Limitations of phone numbers as individual identities

6.4.1 The inability to find other contact details without phone numbers

User ENUM expects callers to know phone numbers. Yet address books and directories are more generally useful if they are indexed by contact names than if they are indexed by phone numbers, especially as many people find long numbers difficult to remember. Other means of finding contact details are now widely available: very many people have taken to displaying details on social networking web pages.

6.4.2 The inability to find phone numbers from other contact details

User ENUM lets users find email addresses (for example) from phone numbers but does not let users find phone numbers (or other contact details) from email addresses. Other services would be needed to supply such information. Yet email addresses could well be more memorable than long phone numbers. Also, as intrusions into privacy are less offensive and more easily countered for email than for voice calls, number holders who have not opted in to making contact details available through user ENUM (particularly those who keep their phone numbers confidential) might be prepared to make their email addresses known.

6.4.3 The need to identify phone numbers with individuals

User ENUM envisages having phone numbers as individual identities. However, VOIP is widely associated with fixed networks, in which (by contrast with mobile networks) phone numbers tend to identify households, not individuals. The personal numbers introduced in some countries have not become very popular, partly because mobile phones have spread almost everywhere and partly because callers are suspicious about charges for calls to unfamiliar numbers[39].

In principle, phone numbers could serve as individual identities in several applications, not just in the listing of communication services as in user ENUM. Personal domain names could serve instead of phone numbers as individual identities and might be expected to be more popular and more memorable; nonetheless, they have not become widespread[40]. Even tel domain names, which are personal domain names (instead of phone numbers) associated with contact details through making the same use of DNS as ENUM, have not become very popular[41]. Instead people use different variants of their own names for different social networking web sites and different multimedia communication applications, and select contact names in their address books when they need phone numbers.

6.5 Contributions to competition

6.5.1 Network by-pass

User ENUM lets callers dial phone numbers to establish communications on IP networks. The communications might originate, terminate or both originate and terminate on IP networks. As IP networks offer economies of scope (and perhaps in equipment procurement) in relation to TDM networks, user ENUM should enhance competition, at least when new networks are being built.

In practice, though service providers are replacing their TDM networks with IP ones, user ENUM has not played a major role in this process so far. The competition has come from service providers using the Internet (and sometimes managed IP connections) to carry voice between personal computers or between gateways into TDM networks; carrier selection, and the proprietary protocol of Skype, have thus been very influential. Mobile service providers have also contributed to competition, especially through their uses of prepaid tariffs and call minutes allowances. Other price reductions have been achieved by regulation intended to mitigate market failure (by capping wholesale termination and international roaming charges, for example).

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[39] In the UK personal numbers can have high call charges and resemble mobile numbers in their initial digits. They have been used to mislead callers into believing that the charges are those for mobile numbers (though they also have legitimate uses, such as providing fixed phones for hospital patients when mobile phones are not permitted). Even in Ireland, where the charges for calls to personal numbers accrue to the number holders, not the callers, if they are higher than the national rate, personal numbers have not proved popular and are being withdrawn.

[40] There might be something to be learned from what happened in the Netherlands. Individuals could register third level personal domain names, with numerical second level domain labels (giving second level domains such as 123.nl) to distinguish between people having the same name. Only about 500 were registered when the scheme was suspended after six years. At the time of drafting this report there were 5,186,126 second level domains.

[41] About 300,000 tel domain names have been registered. Their failure to spread is probably due to poor marketing as well as the existence of alternatives, such as social network web sites, that are free and offer extra information.

Arguably, caps on wholesale termination charges could diminish the likelihood that user ENUM could contribute to competition in the future, by:

- Forcing prices down.
- Limiting the scope for terminating VOIP service providers to be subsidised by receiving terminating charges.
- Reducing the incentive for originating VOIP service providers to stop paying termination charges by reaching further end points.

6.5.2 End point address portability

By using phone numbers to index contact details in real time, user ENUM could provide end point address portability: number holders would tell people their phone numbers, leaving their other contact details to be found and used as required, so those other contact details could be varied without inconvenience. For instance, a number holder might switch end points from mailto:person@isp1.example.com to mailto:person@isp2.example.com without needing to tell potential users, because the mail address used would be the phone number. User ENUM would thereby enhance competition, much as number portability does.

This argument for user ENUM does not seem to be noticed widely (perhaps because personal domain names can achieve the same results without user ENUM). To be convincing it must assume that phone numbers themselves are portable. It also demands that users accept phone numbers as individual identities, despite the problems discussed in Section 6.4[42]. It does not appear to have been a factor in increasing competition.

6.5.3 Communication service access

User ENUM facilitates access to new communications services by letting users find end points through the use of phone numbers instead of unfamiliar URIs. The users could even have phones as the originating equipment or the terminating equipment. For instance:

- Keypad phones could be used to set calendar schedules.
- Multimedia messages could be sent to display phones.

Accordingly user ENUM should encourage the development of new communications services, market growth and further competition. However, mobile phones, whether smart or stupid, have achieved many such effects without the assistance of ENUM. In particular they exploit terminal capabilities instead of network capabilities such as DNS to provide contact details (though they might also upload those contact details from a cloud somewhere)[43]. Competition between terminal suppliers thereby becomes more important to users than competition between service providers.

If developers do not provide applications of user ENUM, number holders will not use it; if number holders do not use it, developers will not provide applications of user ENUM. The general uncertainty about how to overcome the problems of user ENUM has prevented the emergence of a critical mass of applications or users.

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[42] SMTP and SIP offer their own ways of achieving similar results (such as relay servers for SMTP and redirect servers for SIP). However, these entail continued reliance on the equipment of the service provider that is losing the number holder. They are therefore more expensive, open to obstruction by that service provider and lacking resilience to a failure of that service provider.

[43] Sometimes, however, they have used other network capabilities instead of ENUM. The use of Home Location Registers (HLRs) to map phone numbers to end points for multimedia messaging is a case in point: the use of HLRs instead of ENUM is often preferred, perhaps because of potential regulatory concerns about sharing contact details internationally between service providers.

Also, if there are few good applications, the costs of user ENUM (such as maintaining the records in DNS) fall on the number holders while the benefits (of cheapness and convenience) accrue to the originating parties, at least in countries where originating parties pay for calls. In that respect the costs and benefits of user ENUM are then distributed like those of freephone. However, originating equipment currently supports freephone much more often than it supports user ENUM. For user ENUM to supplant freephone, it would need to be supported widely and offer clear advantages, such as reducing costs or being used to provide through a single phone number access to multiple communications services, with the choice between them determined by the capabilities of the originating equipment.

6.5.4 Communication service choice

By invoking user ENUM the originating equipment obtains communication services and end points ranked by preference. It then makes a choice between these according to the preference rankings.

However, in practice the originating equipment has rarely been presented with any significant choice, so a striking feature of user ENUM has rarely been exploited. Instead some communication service applications have expanded to include other applications and make the choice themselves. For instance, SIP services and Skype services can provide presence indications and instant messages as well as voice calls, video calls, voice messages and video messages.

There is a technical justification, going beyond a competitive urge, for why applications make the choice: in user ENUM the communication services and end points ranked by preference do not limit the choice to exactly what the terminating equipment will accept. For instance, the URIs that identify the end points do not list the voice encodings acceptable to the terminating equipment. Consequently individual applications incorporate negotiations between the originating equipment and the terminating equipment and do not leave much for the preference rankings to determine. The URIs could be extended (with, say, “voice=g722” to indicate that the G.722 wideband voice encoding was acceptable), so that the negotiations could be done by examining the preference rankings instead of invoking applications. However, SIP services and Skype services already do such negotiations, so the extensions are not needed.

As this illustrates, when communication service applications expand they can do so in ways that are not immediately available to user ENUM, which is constrained by the rules governing records in DNS. For instance, without recourse to SIP an application using ENUM could select the call destinations for unconditional call forwarding (in which phones with one number are rung) but not for simultaneous ringing (in which phones with different numbers are rung): the multiple call destinations that ENUM can provide need to be tried according to the preference rankings, not simultaneously. By contrast, SIP features include simultaneous ringing as well as unconditional call forwarding, albeit at the cost of extra complexity

The effect is that individual communication service applications become more inclusive: real-time choices are made within communication service applications, not between them. For instance, number holders become less likely take instant message services from one provider and video call services from another. In parallel, the opportunity that user ENUM offers, to make real-time choices between different communication services from different service providers, becomes less useful and less relevant to choices between competitors.

6.6 Effects on numbering

6.6.1 The global numbering space

ENUM is intended to provide a simple standard for mapping phone numbers to communication services and end points. Without such a standard, service providers might invent their own techniques and even their own phone numbers, thereby possibly:

- Confusing users.
- Fragmenting the market.
- Making interworking impractical.
- Violating national numbering plans.
- Breaking national consumer protection principles.

There are precedents for inventing special phone numbers. For instance, service providers sometimes occupy short codes (or even area codes) outside national numbering plans. The introduction of ENUM has not prevented this: there have been implementations of the ENUM mapping that have invented new global numbering spaces without ITU standardisation[44].

6.6.2 The national numbering plan

The ENUM representation of phone numbers as domain names is perfectly general. Hence ENUM itself has no implications for the structure of phone numbers and does not need to affect national numbering plans or number allocation policies. In several countries the user ENUM systems let contact details be available for almost any phone number. Restrictions on the uses of numbers have not inhibited the adoption of user ENUM.

In some countries there are special number ranges for user ENUM. These are intended to simplify authentication of number holders: when the numbers are assigned, the number holders are given passwords so that their initial attempts to provide the contact details can be authenticated. Subsequent attempts need to follow the same procedure as attempts to change contact details for other numbers, so the advantage of special number ranges is slight. There are also the following significant disadvantages, which apply more generally to special number ranges (including those for people with hearing or speech disabilities, as mentioned in Section 5.2):

- Users are wary of calling numbers in ranges that are unfamiliar, have unknown call charges or are excluded from standard tariff packages[45].
- Service providers are unwilling to carry calls for which the national and international termination rates, and the consumer protection rules, are little understood[46].

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[44] For one example see http://www.freenum.org. This had a trial in 2007 that is said to have attracted participants from 38 countries (though the vast majority of participants were in the US). Since then interest in it has declined.

[45] For a survey that reinforces this point see *Study of Geographic Telephone Number Demand* (Intercai Mondiale, May 2006) at http://www.ofcom.org.uk/consult/condocs/numberingreview/statement/demandmodel.pdf.

[46] For instance, in Austria, when a special number range was introduced for user ENUM, calls from some networks failed because they were not covered by some interconnection agreements. More generally, access to special ranges of numbers from other networks, both nationally and internationally, is often uncertain. In many countries, there is no access from abroad (or sometimes from the networks of service providers other than the incumbent) even for well established number ranges, such as those for freephone and premium rate services.

6.7 The perspective on carrier ENUM

Most of the problems of user ENUM arise mainly because all users can read records from DNS directly and the number holders can change records in DNS directly. They are much less severe for carrier ENUM, in which only the participating service providers can read records from DNS and only the service providers acting for the number holders can change records in DNS: regulating the activities of service providers should be much less taxing than ensuring that users do what they should, and only what they should, with user ENUM. A summary of the capabilities of parties using user ENUM and carrier ENUM that relate to the security of contact details is given in Table 2; a summary of the responsibilities of parties using user ENUM and carrier ENUM that relate to the quantity and quality of contact details is given in Table 3.

Carrier ENUM can offer all the functions mentioned in Section 1.3. As outlined in Section 5.2, it can be used in implementations of traditional telephony network features like number portability (and indeed specially tariffed number translation and small number pool allocation) as well as services that are usually confined to IP networks. For these reasons it is now under consideration by several service providers and forms part of the IP Multimedia Subsystem (IMS) specified by the Third Generation Partnership Project (3GPP).

Carrier ENUM can be used in providing a mapping from phone numbers to communication services and end points, either for a single network or for multiple networks. There are other ways of providing such a mapping, as mentioned in Section 3.3, but carrier ENUM has the advantage of being based on DNS, which offers the following benefits:

- DNS implementations are well established and widely available.
- DNS servers provide a distributed replicated data base that scales owing to the hierarchical structure of domain names (which can be exploited by phone numbers).
- DNS operations can be fast and support resilience (by sending queries to multiple servers and accepting the first response), as they take single transactions and use a connectionless protocol.

The choice of a mapping, whether by carrier ENUM or by some other technique, is likely to be made best by the service providers. It could be made separately by individual service providers for their own networks; alternatively it could be made jointly and result in a shared system. Such a shared system would need a common data base containing at least some of the information that, in an ENUM system, would be provided by the tier 1 servers (though individual service providers might well operate DNS servers for their own networks).

When carrier ENUM needs a common data base shared between service providers, there must be a legal organisation that can request tenders, choose suppliers and operate the data base. All service providers need to be allowed to participate by being offered service by this organisation on fair and non-discriminatory terms. If this is not done, carrier ENUM can make entry into the market harder, instead of easier.

There could actually be several carrier ENUM systems in a country, formed by individual carriers or external organisations (such as those with the domains e164.org and e164.info). However, having just one ENUM system would simplify interworking and achieve economies of scale. This is particularly so when there is already a centralised data base for number portability that might be used for mapping phone numbers to communication services and end points more generally.

Carrier ENUM is largely a matter for service providers, not regulators. It is intended mainly to implement features such as call routing for number portability. Ensuring fair and non-discriminatory participation by all service providers is perhaps then the main regulatory requirement (beyond generic ones about the confidentiality of personal information).

Table 2 Capabilities of parties for user ENUM and carrier ENUM

Capability	User ENUM	Carrier ENUM
Reading contact details	All users	All participating service providers
Changing contact details	The number holder	The service provider for the number holder

Table 3 Responsibilities of parties for user ENUM and carrier ENUM

Responsibility	User ENUM	Carrier ENUM
Providing initial contact details	The number holder	The service provider for the number holder
Maintaining current contact details	The number holder	The service provider for the number holder
Removing defunct contact details	The number holder	The service provider for the number holder
Avoiding exploitative contact details	The regulator	The regulator

7 Networks in Qatar

7.1 Current developments

As yet the service providers in Qatar have not deployed ENUM. However, each intends to deploy the IP Multimedia Subsystem (IMS) in its Next Generation Network (NGN); this can use ENUM but does not always do so.

IMS is described in outline in Box 16; the role of ENUM in IMS is described in Box 17. For simplicity these descriptions refer to IMS components as if they were physical entities; in fact several components can be implemented in one item of equipment, and several items of equipment can implement one component. Moreover, IMS specifications generally distinguish functions that control components from components that are controlled. For these reasons IMS has many internal interfaces and complicated combinations of equipment from different suppliers that need to be tested for interoperation, even if (as often happens) a supplier combines the implementations of several functions in one item of equipment.

IMS aims to offer service continuity across different access networks and service consistency between different access networks as far as possible. It also aims to apply telephony standards of predictability and reliability, and to reconcile the implementation of different equipment suppliers. All this contributes to its complexity and makes its specifications and implementations slow to emerge.

Service providers that wish to use IMS are therefore in constant danger of being overtaken by those that provide free or inexpensive services Over The Top (OTT) (on public IP networks) for the most popular features and terminals. Some of them have introduced their own OTT services as well, without waiting for IMS; for instance, Telefónica has developed and deployed Tu Go, an OTT service which can provide voice calls, voice messages or text messages to multiple user terminals simultaneously. The effects of such services on numbering are discussed in Section 9.4.

The service providers in Qatar are developing Long Term Evolution (LTE) networks. Telephony is supported in such networks by VOIP services using IMS. The specifications and implementations of VOIP for LTE are not quite settled. Once they are settled, and sufficient LTE user terminals are available, the service providers can consider withdrawing their earlier mobile networks. Whether they should do this is one of the questions about universal services raised by the deployment of IMS; other such questions arise because of the introduction of wider ranges of services. They include:

- Which services should be universally available, accessible and affordable, bearing in mind that video and text interfaces provide new means of access to disability groups.
- Which services should offer any-to-any connectivity (so users can communicate with each other whichever service providers serve them).
- How emergency service obligations, including the provision of caller location information, should be extended to terminals offering video and text interfaces.

The deployment of IMSs, and of NGNs more generally, might also require actions concerned with traffic management and interconnection, such as:

- Preventing discrimination against services from competitors, or degradation of the performance of public Internet traffic, if IP traffic is managed.
- Apportioning the costs of signalling conversion and media conversion, if an IP network and a TDM network interconnect.

Box 16 The facilities and features of IMS

IMS is conceived as a core network using SIP with the objectives of:

- Making services uniformly available irrespective of user terminal types and access network protocols, by mediating access to traditional telephony networks, whether fixed or mobile, through gateways.
- Making third party applications easier and faster to deploy, by ensuring that applications executed by application servers interact with services according to well established logic.

IMS supports multimedia services over IP networks by providing facilities for:

- Registering SIP terminals, whether fixed or mobile.
- Establishing and routing sessions between SIP end points.
- Invoking services associated with sessions, even in the middle of the sessions.
- Interconnecting IMS infrastructures with other IMS infrastructures and traditional TDM networks.
- Roaming, to let subscribers on one IMS infrastructure access their services from another IMS infrastructure.
- Storing information about which services a subscriber takes.
- Authorising traffic with a given quality of service.
- Collecting billing and usage data.

Thus IMS provides the essential facilities of call servers, which it extends to manage roaming, access, charging and traffic flow in a controlled environment (not the public Internet). For these purposes the call control protocol is SIP and the authentication, authorisation, and accounting protocol is Diameter.

To provide multimedia services IMS must be equipped with application servers that share the use of its facilities. The IMS specifications cover supplementary services for 'multimedia telephony', such as originating and terminating identifier presentation and restriction, communication diversion and barring, explicit communication transfer and conferencing. They also include 'rich communication' services which are intended for use with or without voice services but which are not yet as widely available as their more specialised OTT competitors. Initially these are intended to offer:

- Service capability and presence indication.
- Instant message and chat communication.
- Image and video sharing.
- File transfer.

Some equipment suppliers provide implementations of extra services, which are not yet covered by the IMS specifications.

SIP phones can be connected directly to IMS. By contrast, user terminals in a traditional public telephony network must be connected to gateways and application servers in an ‘emulation subsystem’ that itself can be connected to IMS. The gateways convert between SIP and call control protocols for the traditional public telephony network; the application servers provide supplementary services for the traditional public telephony network. Over time the switches in the traditional public telephony network are expected to fall out of use and be replaced by direct connections from user terminals to IMS.

Box 17 The role of ENUM in IMS

During call processing, IMS performs number analysis on the dialled phone numbers so that calls are routed either to user terminals directly connected to IMS or to gateways to other networks. The IMS specifications suppose that the number analysis uses ENUM for E.164 numbers (in national numbering plans) and uses a 'corresponding function' in an application server for private network numbers (in numbering plans of organisations). However, some equipment suppliers offer their own implementations of number analysis functions (and indeed of several other functions of IMS); ENUM does not then have even this limited role in IMS.

As used in IMS, ENUM serves just to associate a phone number with one (or possibly more than one) network route. It uses the preference rankings of communication services simply to provide choices between alternative routes, not to provide choices between different modes of communication.

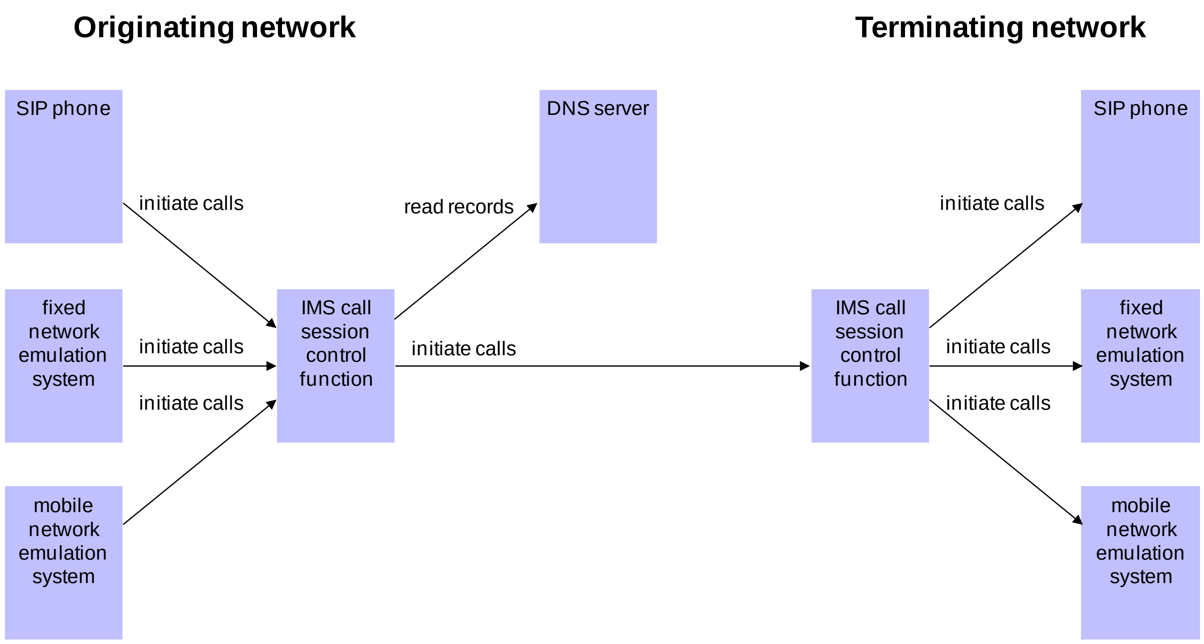
Because IMS is a core network using SIP, it expects end points to be sip URIs. It does not (for example) use ENUM to signal that SMS messages to particular end points should be converted into email messages or voice messages.

7.2 Number portability

The service providers in Qatar have deployed mobile number portability very recently. Though number portability could be a good application for carrier ENUM, it would not justify replacing an existing system by ENUM in the absence of very clear advantages of cost or functionality.

When the deployment of IMS is well established, so that many calls to ported numbers pass through IMS, there would be a case for making all calls pass through IMS and making IMS provide number portability. One way of doing this is outlined in Figure 7 and Box 18.

Figure 7 One possible implementation of number portability



Box 18 One possible implementation of number portability

There are various ways in which IMS can provide number portability, essentially as an extension of number analysis; for instance, it can include an application server that intercepts and modifies SIP messages intended to initiate calls to ported numbers.

The number analysis of the dialled phone numbers ensures that IMS routes calls to either user terminals directly connected to IMS or to gateways to other networks. If it uses carrier ENUM (working with DNS) to map a phone number to an end point, then the sip URI for the end point can incorporate any routing number needed for number portability. It should also indicate that no further number portability data base query is required. It would also provide a sip URI that identified at least the SIP service (and possibly the call server or the gateway into the network) next in the path and indicate (with "user=phone") that the digit string in the sip URI was a phone number instead of a user name. For instance, with the routing number +97400000003 and the gateway sip.isp.example.com:

> 4499 5333 with country code 974 might be associated with sip:+97444995333;npdi;rn=+97400000003@sip.isp.example.com;user=phone.

Carrier ENUM is used to obtain number portability information only in the network in which the call originates. The network in which the call terminates does not necessarily not use carrier ENUM for any purpose. Hence the carrier ENUM data base could be private to one service provider, though there would be advantages of cost and consistency in sharing it between service providers.

7.3 Broadband connectivity

The National Broadband Network (NBN) intends to lay optical fibre to 95% of households and 100% of businesses by 2015. For this purpose it is using Gigabit-capable Passive Optical Network (GPON) topology, in which a single optical fibre is split at unpowered optical splitters to serve multiple premises (typically between 16 and 32). If bandwidth requirements grow beyond the capacity of one fibre further optical fibres can be laid or commissioned from an NBN central office to the splitting point, where further splitters can be inserted.

The customers of NBN will be the service providers, who will operate networks and provide services to users. The NBN wholesale operation, distinct from the retail operations of the current service providers, might open the way for new licensed service providers to serve national traffic by acquiring rights of use without depending on the current service providers.

As there will be collocation facilities in a NBN central office, a case could be made for developing an Internet eXchange Point (IXP) there. Indeed, the ictQATAR Regulatory Strategy mentions the development of plans for an IXP. Local communications are growing in volume as social networking grows. Having an IXP could reduce their cost and improve their quality. In doing so it could intensify the use of OTT services for multimedia communications.

Particularly in new building developments optical fibre is likely to take over from copper for fixed access, and VOIP services are likely to be required; in such cases IMS can be used for call control and for interoperation with traditional telephony.

8 Possibilities for trials in Qatar

8.1 Status of ENUM

The technology of ENUM is well established but little used.

ENUM can do more than just associate a phone number with one (or possibly more than one) network route. However, when it just does this, it is competing with alternative ways of doing the same thing. Equipment suppliers have developed alternatives which they prefer if special non-standard functions can provide competitive advantages; only if standardisation is important (because, for example, the same interface is to be available to several networks) are they likely to prefer ENUM.

More specifically, as discussed in Section 6.1 and Section 6.7:

- **User ENUM**. Deployments of user ENUM are not widespread and are rarely used. There is no prospect of this situation changing.

  In practice user ENUM has been ignored by the market: competition has intensified without it and applications have spread without it.

  The demand for user ENUM is now negligible. It is no longer likely to be important for any purpose. It has failed to gain acceptance by potential users, service providers and application developers. It has intrinsic problems, of the confidentiality, correctness and completeness of the contact details that it provides. The commercial drivers are weak and the potential difficulties are substantial.

- **Carrier ENUM**. Deployments of carrier ENUM are not yet common. However, they are under consideration for various purposes and are likely to become more common as networks depend ever more heavily on IP and phone numbers persist.

  In practice carrier ENUM is regarded as one among various ways of associating phone numbers with network routes, to be selected or rejected on technical and economic grounds. If an alternative is already implemented, changing the implementation to carrier ENUM just for TDM networks is unlikely to be justified. When TDM networks are being replaced with IP ones, carrier ENUM might assist with the transition or take over from an alternative suited mainly to TDM networks.

  A decision to adopt carrier ENUM is entirely a technical and economic one. When carrier ENUM data bases are shared between different service providers, there are regulatory requirements to permit fair and non-discriminatory access, for carrier ENUM data bases just as there are for number portability data bases. These regulatory requirements would also apply to any other way of associating phone numbers with network routes.

8.2 Implications for trials

Probably the service providers in Qatar would not dissent from the opinions in Section 8.1. They have stated fairly clearly that to be willing and active participants in an ENUM trial they would need to understand the business benefits and to schedule their involvement to fit with other activities that might have higher priorities. Convincing them of the business benefits could be difficult, bearing in mind prior experience elsewhere with user ENUM. Their own potential uses of carrier ENUM, in IMS, will be the subject of their own tests but will not necessarily require joint trials with ictQATAR and are likely to have higher priorities than such joint trials. There will inevitably need to be careful tests of how ENUM works with the features of a particular service provider network.

In Qatar ictQATAR has roles both as the ICT regulator and as an ICT champion. A trial of ENUM that might seem to fit these roles is described in Box 19. However, there is not a strong case for ictQATAR to organise such a trial, where that trial is conceived narrowly, around the regulatory and technological implications of ENUM. The reasons for this are that:

- The technology of ENUM is understood well.
- Though user ENUM raises regulatory concerns, it is very unlikely to be deployed willingly by a service provider or used seriously by many customers in Qatar
- Though carrier ENUM is quite likely to be deployed in Qatar, it does not create severe regulatory problems[47].

.A trial that was not conceived so narrowly but that still involved ENUM would be easier to justify, through its contribution to understanding the future regulatory framework and technological developments beyond ENUM. Options for such trials are outlined in Box 20 and Box 21.

Each trial has its own disadvantages, but the following disadvantages are common to them all:

- They are unable to exploit fully a distinctive feature of ENUM, the preference rankings for communication services. There are no applications available for them that exploit ENUM to provide choices between different modes of communication.
- They just demonstrate services that people regularly use without ENUM, such as voice calling and instant messaging; in fact they are likely to require at most tel URIs and h323 URIs besides sip URIs. Applications that change modes of communication (by, for example, changing voice encodings or message delivery mechanisms) do so without recourse to ENUM.
- They do not let users change their contact details easily. Thus, though they can demonstrate redirection of calls to end points other than the dialled ones, they do not provide realistic bases for "find me / follow me" facilities.
- They entail the procurement, installation, configuration and testing of equipment specifically for trials. The equipment would at least include a SIP PBX with ENUM functionality, and SIP phones; in some trials it might be extended with servers for unified communications or video conferences, and soft clients on personal computers. Only in certain cases could some of the equipment or expertise be available in partner organisations.

[47] There might be situations in which suitably qualified customers, such as IT departments in large corporations, might make or request changes to the records in a carrier ENUM data base through tightly constrained user interfaces. Such limited changes, to a data base that is not publicly available, do not pose particular regulatory problems.

Box 19 A potential trial without other partners

Objectives:

- Use ENUM in simple ways.

Background:

- IT operations in ictQATAR are largely outsourced to Ooredoo, which hosts the DNS servers and call servers and provides the phone numbers and IP addresses. Though ictQATAR has skills in IT administration it is unlikely to have expertise in (for example) configuring a DNS server or a SIP PBX; such expertise would need to be brought in for this trial without partners besides ictQATAR.
- Though the ENUM domain 4.7.9.e164.arpa has been delegated to ictQATAR, its use for this trial is questionable: the Registry is not registering any domains under it or looking up records for it, and the software provider for the Registry might need to provide tools or support.
- The trial would initially use its own segment of the ictQATAR LAN for very local tests on a private network. It would subsequently, with the agreement of the IT department and Ooredoo, use a connection to the existing ictQATAR network so national and international dialling could be tested on the public network.

Activities (not necessarily all performed by ictQATAR):

- Formulate a numbering plan for the private network numbers.
- Procure the equipment.
- Install, configure and test the equipment.
- Activate and demonstrate the ENUM functionality with end points having sip URIs in the private network.
- Arrange for connectivity between the call server and public network, perhaps through the main ictQATAR PBX (with the agreement of Ooredoo).
- Formulate a numbering plan for the public network numbers (preferably by taking a vacant range from those already assigned to ictQATAR by Ooredoo).
- Activate and demonstrate the ENUM functionality with end points having tel URIs in the public network.

Possible start year:

- 2013.

Disadvantages (besides those common to all the trials):

- Investment of effort just to show that voice calls can be made.
- Failure to transfer technology knowledge or use outside ictQATAR.
- Failure to provide any insight into regulation.

Box 20 A potential trial with academic institutions as partners

Objectives:

- Extend the understanding of ENUM technology in Qatar.
- Strengthen links between the National Research and Education Network (NREN) in Qatar and analogous networks elsewhere.
- Promote the use of multimedia communications by research and education institutions in Qatar.

Background:

- The Qatar Foundation has indirect connections (through Internet2) with GÉANT, the international research and education network that interconnects NRENs in Europe and elsewhere. TERENA, the association formed to represent the interests of these NRENs, has established its own ENUM data base at nrenum.net, in order to facilitate voice and video conferences. Each NREN looks after its own national part of this data base on behalf of the research and education institutions in its country.
- The trial would initiate the provision and use of the Qatar part of this data base, with national and international dialling between research and education institutions on a private network.
- The degree of involvement of ictQATAR in the trial would depend on whether ictQATAR itself was regarded as a research and education institution.

Activities (not necessarily all performed by ictQATAR):

- Arrange for participation in nrenum.net of at least one research and education institution in Qatar (if ictQATAR was not itself regarded as one).
- Arrange for the delegation of the Qatar country code under nrenum.net to the NREN or a participating institution (if the NREN did not have the right skills).
- Formulate a numbering plan for the private network numbers.
- Procure the equipment.
- Install, configure and test the equipment.
- Activate and demonstrate the ENUM functionality with end points having sip URIs and h323 URIs in the networks of the participating institutions.
- Activate and demonstrate the ENUM functionality with end points having sip URIs and h323 URIs in the networks of foreign research and education institutions.

Possible start year:

- 2013.

Disadvantages (besides those common to all the trials):

- Unclear viability of delegation to the NREN.
- Failure to provide any insight into regulation.

Box 21 A potential trial with service providers as partners

Objectives:

- Ensure interoperation between the SIP capabilities of the service providers.
- Consider the regulatory framework appropriate to a Next Generation Network (NGN).

Background:

- IMS is central to commercial plans for service enhancement, so each service provider is more likely to use it in a private trial than to provide it for a shared trial. Yet the service providers should make sure that SIP calls between the two networks pass across directly, through the IMSs, without the delay, degradation in quality and limitation in functionality due to conversion to and from traditional telephony.
- The trial would spur the service providers on to ensure interoperation for calls.
- The degree of involvement of ictQATAR in the trial could be adjusted; for instance, ictQATAR might choose to have its own call server or user terminals that would connect with the IMSs of the service providers.
- Like all the other trials described here, the trial would exercise relatively little of ENUM; indeed it would exercise none of ENUM if ENUM was not incorporated in both IMSs. However, it would enable ictQATAR to see at first hand the interactions in IMS between calls and applications and to explore the extent to which interoperation for calls should extend interoperation for applications (so an application available to customers of one service provider would necessarily be available to customers of the other).

Activities (not necessarily all performed by ictQATAR):

- Agree a cost split and a work programme meeting the objectives of both service providers despite the priority of their other trials.
- Ensure commercial confidentiality for the service providers.
- Ensure that the IMSs of both service providers incorporate ENUM.
- Interconnect the IMSs of both service providers.
- Procure the equipment.
- Install, configure and test the equipment.
- Activate and demonstrate the ENUM functionality with end points having sip URIs and tel URIs in the networks of the service providers.

Possible start year:

- 2014.

Disadvantages (besides those common to all the trials):

- Disturbance to the work plans of the service providers.

8.3 One trial in more detail

In this section one possible trial is examined in some detail. This trial is best regarded not as a technical test but as an unspectacular demonstration of the use of the main components of any trial. As such it could help to gauge what would be done in something more complicated.

The trial is essentially a common core of the trials outlined in Section 8.2 that uses only a private network. It thereby circumvents complications due to traversal of Network Address Translation (NAT) equipment, calls to or from public networks, and access to or from the public Internet. It also requires only few, currently commercially available, types of hardware and software, to minimise irrelevant problems of compatibility and avoid work to bring obsolescent but otherwise attractive developments into line with current standards.

The trial demonstrates the use of ENUM by a SIP PBX and by three SIP phones, in conjunction with a DNS server. The equipment is used first without ENUM and then with ENUM, as depicted in Figure 8. The trial proceeds through stages of:

- Devising the numbering, naming and addressing.
- Procuring the equipment.
- Installing, configuring and testing the equipment.
- Activating and demonstrating the ENUM functionality.

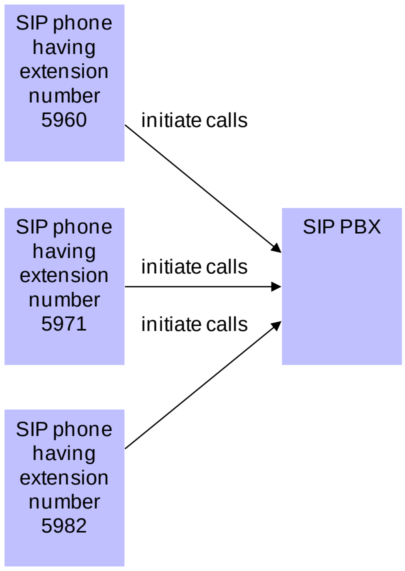
These are described in

Box 22, Box 23, Box 24 and Box 25. Some of their details inevitably represent theory rather than practice and should be treated cautiously: without conducting the trial there can be no certainty about its results.

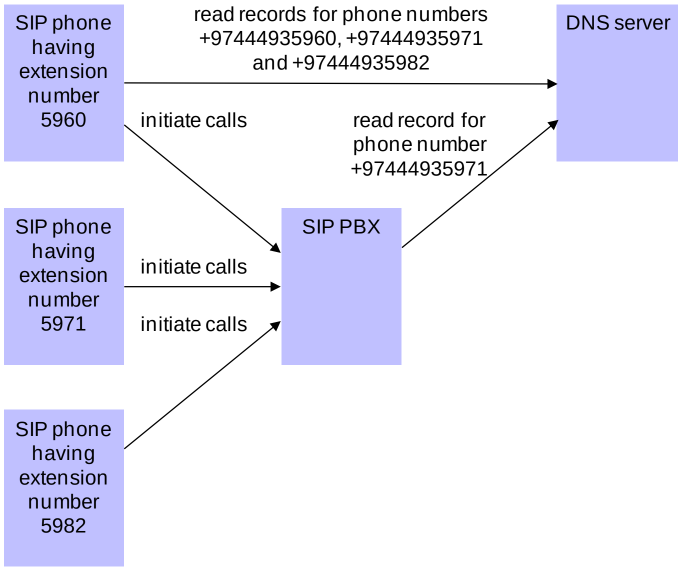
The installation, configuration and testing activities could be performed by ictQATAR by following the documents cited in this section. However, the activities might happen with more speed and less irritation if they were at least supervised, and perhaps performed, by experts in the DNS server and the SIP PBX. For instance, the details of how to provision NAPTR records for use by ENUM are rarely well documented but could be implemented easily by a skilled DNS administrator with an understanding of NAPTR records; specifying the requirement in a change request to an outsourced IT provider would be laborious by comparison. In addition, there might be quirks in the default settings on the SIP phones that would interfere with interoperation with the SIP PBX.

Figure 8 Equipment arrangment and call connection in the trial

Without ENUM



With ENUM



The SIP phone treats the extension number dialled as the extension number to be passed to the SIP PBX .

The SIP phone initiates the call by requesting the SIP PBX to connect it to the SIP phone having the extension number passed to the SIP PBX.

The SIP PBX treats the extension passed to it as the extension number of the SIP phone to be connected.

If the SIP phone has extension number 5960, it reads the DNS record for phone number +97444935960, +97444935971 or +97444935982, depending on whether 5960, 5971 or 5982 was dialled, and treats the result of reading the record as the extension number to be passed to the SIP PBX; if the SIP phone has extension number 5971 or 5982, it treats the extension number dialled as the extension number to be passed to the SIP PBX .

The SIP phone initiates the call by requesting the SIP PBX to connect it to the SIP phone having the extension number passed to the SIP PBX.

If the extension passed to the SIP PBX is 5971, the SIP PBX reads the DNS record for phone number +97444935971, and treats the result of reading the record as the extension number of the SIP phone to be connected; if the extension passed to the SIP PBX is 5960 or 5982, the SIP PBX treats the extension passed to it as the extension number of the SIP phone to be connected.

Box 22 Devising the numbering, naming and addressing

The IP addresses are taken from an unused range for the ictQATAR private network.

The extension numbers for the three phones are taken to be unused ones for the ictQATAR private network. Here they are assumed to be 5960, 5971 and 5982, in order to be definite. These extension numbers are the "obvious" ones for the international phone numbers +97444935960, +97444935971 and +97444935982 (respectively), because the country code is 974 and the area code in the national numbering plan is 4493. However, in the trial ENUM is used to associate these international phone numbers with extension numbers that are not the “obvious” ones.

The PBX and phones chosen make the second level domain for ENUM lookup be e164.arpa by default. A different domain could be used but would require slightly more complicated configuration operations, so in the trial e164.arpa is used and the domain name for ENUM representations of phone numbers is 4.7.9.e164.arpa. The domain name for equipment and services can be enumtrial.ictqatar.qa, for example. These domains are not exposed on the public Internet, at least for the trial.

If the network for the trial is completely isolated, strictly speaking there should be no need to adopt otherwise unused addressed and numbers for it. However, doing so simplifies potential enhancements of the trial and reduces potential problems from misconfiguration.

Box 23 Procuring the equipment

The LAN segment is to have DHCP capabilities and be separate from the main ictQATAR network. It can use almost any small router with Ethernet connections.

A small desk top computer can support the network services for the trial, such as the DNS server and the SIP PBX. It might come packaged with an open source operating system such as Linux. In fact the SIP PBX suggested for the trial comes with a version of Linux that can be used also by the DNS server.

The DNS server is taken to have Berkeley Internet Name Domain (BIND) software; version 9.9.3 of that was current at the time of drafting this report and can be downloaded from https://www.isc.org/downloads. It can run on the same computer and operating system as the SIP PBX.

There are tools that can simplify provisioning DNS servers (particularly with NAPTR records). Their installation and use for the trial is not justified, especially as the trial does not require the complicated regular expression substitutions permitted by NAPTR records.

The SIP PBX is taken to have Asterisk software; version 11 of that was part of AsteriskNOW at the time of drafting this report and can be downloaded from http://www.asterisk.org/downloads/asterisknow. Very little of the SIP PBX functionality is needed for the trial.

There are packaged and restricted variants of Asterisk software designed to simplify the user interfaces. However, they do not generally allow the ENUM functionality of Asterisk to be activated optionally in the way demonstrated in the trial, and in some cases (such as Snom ONE mini) they do not allow the attachment of port modules, which would be beneficial in an enhanced trial.

The SIP phones are taken to be Snom 320 phones; three are needed (though some tests could be done with just two). The choice of phones is limited, as in the trial one phone is assumed to have ENUM functionality that can be activated optionally. The other two phones are taken to be Snom 320 phones, too, for ease of description, but they could be different.

Box 24 Installing, configuring and testing the equipment

The DNS server and the SIP PBX can be installed on one computer with a CentOS 6 version of Linux as the operating system. AsteriskNOW provides not only Asterisk software but also CentOS 6 (and the FreePBX user interface), so AsteriskNOW (or at least the CentOS 6 version of Linux) should be installed before BIND. This system could also provide the router and DHCP server functionality. However, some system administration would be needed to adapt its default settings to the trial.

When the CentOS 6 version of Linux has been installed BIND can be installed, configured and tested; examples of how to do this are at http://thelinuxsite.wordpress.com/2013/03/10/DNS-server-installation-step-by-step-using-centos-6-3, http://ostechnix.wordpress.com/2013/01/25/setup-DNS-server-step-by-step-in-centos-6-3-rhel-6-3-scientific-linux-6-3-3 and http://www.server-world.info/en/note?os=CentOS_6&p=DNS. Instructions for administering BIND are at http://ftp.isc.org/isc/bind9/cur/9.9/doc/arm/Bv9ARM.pdf.

The DNS server is configured to be authoritative for the zone enumtrial.ictqatar.qa (by extending, or including further files in, the file named.conf) and is given records to associate the SIP PBX and the IP phones with IP addresses and the SIP service with the SIP PBX; for instance, if the domain name of the SIP PBX is sip.enumtrial.ictqatar.qa, the SIP service of enumtrial.ictqatar.qa (which uses port number 5060) is associated with the SIP PBX in SeRVice (SRV) records taking the form:

SRV 0 0 5060 sip.enumtrial.ictqatar.qa .

At this stage the DNS server does not have NAPTR records for ENUM, so the system does not use ENUM. Moreover, in this implementation it should not need NAPTR records that rank transport protocols by the preference of the SIP PBX.

The installation, configuration and testing of the SIP PBX is described at https://wiki.asterisk.org/wiki/display/AST/Home, with the installation of AsteriskNOW covered specifically at https://wiki.asterisk.org/wiki/display/AST/Installing+AsteriskNOW. Instructions for administering Asterisk are at https://wiki.asterisk.org/wiki/download/attachments/19005471/Asterisk-Admin-Guide-11.pdf.

In brief, in the SIP PBX accounts for the extension numbers are added to the file sip.conf and exten actions are added to the file extensions.conf. At this stage the exten actions do not mention ENUMLOOKUP; by analogy with the examples at https://wiki.asterisk.org/wiki/display/AST/Creating+Dialplan+Extensions they can be written (in not the most compact way possible) as:

```
exten => 5960,1,Dial(SIP/5960)
exten => 5971,1,Dial(SIP/5971)
exten => 5982,1,Dial(SIP/5982)
```

The installation, configuration and testing of Snom 320 phones is described at http://downloads.snom.net/documentation/UM_snom3xx_V2.2_en.pdf. It entails giving each of them its extension number and the domain name enumtrial.ictqatar.qa of the SIP service, out of which their sip URIs can be formed. The sip URIs corresponding to the extension numbers 5960, 5971 and 5982 are sip:5960@enumtrial.ictqatar.qa, sip:5971@enumtrial.ictqatar.qa and sip:5982@enumtrial.ictqatar.qa (respectively). The phones thereby become registered with the SIP PBX (which at this stage is just a SIP registrar) and calls can be made by dialling the extension numbers. Some details of interoperation with Asterisk are at http://wiki.snom.com/Interoperability/PBX/Asterisk.

At this stage the extension numbers of the destinations of calls should be those that are dialled to make the calls.

Box 25 Activating and demonstrating the ENUM functionality

NAPTR records for ENUM are now provided for the trial. They associate phone numbers with extension numbers (and sip URIs corresponding to these extension numbers) that are not the "obvious" ones: they associate the phone numbers +97444935960, +97444935971 and +97444935982 with the extension numbers 5971, 5982 and 5960 (respectively), not with 5960, 5971 and 5982. Accordingly the DNS server is configured to be authoritative for the zones 0.6.9.5.3.9.4.4.4.7.9.e164.arpa, 1.7.9.5.3.9.4.4.4.7.9.e164.arpa and 2.8.9.5.3.9.4.4.4.7.9.e164.arpa (by extending, or including further files in, the file named.conf), and these zones are given as their respective NAPTR records:

NAPTR 100 1 "u" "E2U+sip" "!^.*$!sip:5971@enumtrial.ictqatar.qa!" .

NAPTR 100 1 "u" "E2U+sip" "!^.*$!sip:5982@enumtrial.ictqatar.qa!" .

NAPTR 100 1 "u" "E2U+sip" "!^.*$!sip:5960@enumtrial.ictqatar.qa!" .

There is information about how to do this at http://computer-help-please.blogspot.co.uk/2009/11/setup-enum-server-with-linux-and-bind9.html (though it refers to e164.org instead of e164.arpa and deals with multiple records for a single phone number).

Examples of how to activate the ENUM functionality of the SIP PBX are at https://wiki.asterisk.org/wiki/display/AST/ENUMLOOKUP+Examples; further examples, at https://wiki.asterisk.org/wiki/display/AST/More+ENUMLOOKUP+Examples, go beyond the trial by handling multiple NAPTR records per phone number. The trial simply requires changing the file extensions.conf so that the SIP PBX, on receiving signalling messages to initiate calls to extension number 5971, executes ENUMLOOKUP before Dial thus:

exten => 5971,1,Set(enumresult=${ENUMLOOKUP(+97444935971,sip,,,e164.arpa)})

exten => 5971,2,Dial(SIP/${enumresult})

If a second level domain different from e164.arpa is required, it should replace the final parameter of ENUMLOOKUP. If a tel URI were required instead of a sip URI, tel, not sip, would be the second parameter of ENUMLOOKUP.

Configuring a SIP phone to activate its ENUM functionality involves following the procedure illustrated at http://wiki.snom.com/Category:HowTo:ENUM to provide the country code (974) and the area code (4493). In the trial this is done only for the phone having extension number 5960, with the effect that all calls from that phone use ENUM. If a second level domain different from e164.arpa is required, it should be provided to the phone in the manner described at http://wiki.snom.com/Settings/enum_suffix.

At this stage the extension numbers of the destinations of calls should be:

- 5960 or 5982, after 5960 or 5982 (respectively) is dialled from the phone having extension number 5971 or 5982 (as ENUM is not used).
- 5982, after 5971 is dialled from the phone having extension number 5971 or 5982 (as ENUM is used by the SIP PBX).
- 5982 or 5960, after 5971 or 5982 (respectively) is dialled from the phone having extension number 5960 (as ENUM is used by that phone).
- 5982, after 5960 is dialled from the phone having extension number 5960 (as ENUM is used by that phone and by the SIP PBX).

In fact the phone having extension number 5960 will also attempt to set up calls if some other numbers (such as 0097444935971) are dialled. making them succeed would entail changing the dial plan in the phone slightly by applying the rules outlined at http://wiki.snom.com/Category:HowTo:Dial_Plan.

9 Numbering in Qatar

9.1 The current national numbering plan

ENUM is one manifestation of a general trend, to use phone numbers in wider ranges of services. The trend raises the general question of whether there are enough phone numbers available: just as the growth in mobile services is leading to worldwide reconsideration of how to allocate, and constrain the uses of, radio frequencies, so the growth in communications services more generally is leading to concerns about the availability of phone numbers (which, for regulators, are formally, like radio frequencies, "scarce resources"). Inequitable allocation could create problems for the global numbering space like those for the global IP addressing space; arguably the introduction of E.212 numbers, with the distinctions between MCCs and MNCs, was partly a response to such problems. Overall there might be fears of a change in the global numbering space reminiscent of that in the global IP addressing space, with its consequential 'two stack' operation of IPv4 and IPv6.

At a national level, with under two million people and number expansion possible in principle to another four significant digits, Qatar might seem to have no worries about number capacity. However, already 5.6 million numbers have been allocated for mobile services and 1.1 million numbers have been allocated for fixed services[48]. Moreover, all the initial digits are partly occupied and are unable to be used in their entirety for new, longer, numbers. The National Numbering Plan has undergone five sets of changes, most recently in 2010 (when an extra digit was added to numbers for mobile services and fixed services); a further change is to be avoided if possible. All this limits options for expansion and for introducing new, distinctive, number ranges.

This report therefore looks briefly at the National Numbering Plan. It does not provide a full review; rather it points to some effects of using phone numbers in wider ranges of services.

9.2 Distinctions between service types in phone numbers

In some countries special number ranges have been introduced for nomadic services. Such services can be difficult to define, but in practice they are VOIP services[49]. These number ranges have not been popular, for reasons mentioned in Section 6.6, and do not help to alleviate shortages of phone numbers.

The distinction between numbers for nomadic services and numbers for mobile services is elusive when there is hand-over between fixed wireless protocols and mobile wireless protocols or when calls can be re-established with imperceptible delays. There appears to be little justification for making it. Similar remarks apply to a distinction between numbers intended for voice calls and numbers intended for video calls (for example). In general there is little to be gained by using phone numbers to mark distinctions between service types except where the distinctions relate to call charges or destination locations.

Though the third digit of a national phone number in Qatar currently often connotes a particular area of the country, this connotation will become less noticeable when people use phone numbers for fixed services that do not have “4" as their second digit. Indeed, the National Numbering Plan states that numbers have no geographical significance.

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[48] At the end of the first quarter of 2013 the phone numbers held by customers amounted to 3.3 million for mobile services and 0.3 million for fixed services.

[49] Often nomadic services are not defined at all or are defined only by exception; for instance, in the national numbering plan for Australia they are said to be “itinerant or otherwise departing significantly from other service types specified in the numbering plan, particularly local [fixed] services”.

Currently tariffs for national calls are independent of whether call destinations are fixed or mobile. The main residual differences between numbers for fixed services and numbers for mobile services are:

- How easily caller location information can be provided in emergency calls.
- How easily numbers can be ported.

Even these differences will reduce when NGNs are deployed. In these circumstances, there might be a case, in due course, for eliminating the regulatory distinctions between numbers for fixed services and numbers for mobile services. These distinctions are not explicit in the National Numbering Plan but might be implicit in the expectations of the service providers and users. Typical of them are:

- Whether numbers for fixed services may reach called parties when they are abroad (as is the case for mobile services, and as would be expected for VOIP services).
- Whether numbers may be ported between fixed and mobile services.

Eliminating such distinctions might facilitate in modest ways the development of services offering fixed-mobile convergence, such as ones offering simultaneous or alternative ringing on fixed and mobile phones.

9.3 Expectations from location information in phone numbers

In many countries customers wish to have numbers drawn from the ranges for fixed services, even when the location information in the numbers is not strictly accurate. For instance:

- A business might want an “out-of-area” number, which has an area code that does not match the location of the business. It might want this number either because it wishes to keep its number on moving offices or because it offers a service for which providers are often chosen after searches for numbers with that area code.
- A person might want a “virtual” number, which lets callers pay less for their calls than they would pay for calls to numbers that provide accurate location information. The person is often, but not always, in a different country from the callers, who are acquaintances that have been told the number.

In Qatar numbers for fixed services convey little information about location or tariffs, so the demand for them is not inflated by these factors. Nonetheless, licensing VOIP service providers in Qatar could raise the demand for numbers for fixed services, as internationally there is a widespread expectation that calls to them are cheaper than calls to numbers for mobile services[50]. Customers in Qatar might therefore choose to acquire numbers intended for fixed services specifically in order to receive VOIP calls; they might even acquire several numbers each, for different purposes or through forgetfulness. Moreover, OTT services for multimedia communications that become very popular might create further, exceptional, demand for numbers; this possibility is explored in Section 9.4.

The resulting increase in demand for phone numbers will probably not exhaust the numbering space when there are two million people and there are ten million phone numbers available for fixed services. However, prudence suggests that ictQATAR should reserve at least one second digit for possible future expansion of numbers for fixed services.

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[50] This expectation is usually correct, but not always so. For calls from the UK to Qatar at the time of drafting this report, though the highest tariff was much greater for calls to mobile numbers than for calls to geographic numbers, the lowest tariff was slightly smaller for calls to mobile numbers than for calls to geographic numbers. Incidentally the highest tariff was nineteen times the lowest tariff for calls to mobile numbers and twelve times for calls to geographic numbers.

9.4 Over the top multimedia communications

OTT services for multimedia communications are spreading fast. Worldwide there are said to be twice as many messages sent by them as by SMS. They vary in their business models and capabilities: they can involve bidirectional, unidirectional or message-based audio, video and text. They also vary in their degrees of dependence on phone numbers, in ways that are not evidently related to their business models and capabilities.

For instance, Skype and Viber offer similar features for Internet-to-Internet calls, but Skype makes its subscribers have special Skype identifiers while Viber uses phone numbers. The differences between these ways of identifying subscribers emerge mainly during registration; registered subscribers might not notice the differences, as they use personal names (with hyperlinks to identifiers or numbers) when making calls and publishing their contact details.

Though Skype identifiers are not formally standardised in URI schemes, they are quite widespread. Various other OTT services have their own ways of identifying subscribers; this is so particularly if they are tied to social networking web sites such as Facebook, do not want to interoperate with competitors or have originated as services such as instant messaging not associated historically with phone numbers. However, the convenience, familiar format and business value of phone numbers, especially for calling to or from public telephony networks, suggests that some OTT services will use phone numbers instead of special identifiers for multimedia communications. Several of these services require the use of phone numbers for mobile services,, because they are available only for mobile phones or to the customers of mobile service providers (such as Libon, for Orange, and +46, for Tele2); Kakao and WhatsApp, for example, require this, even though Kakao offers free Internet-to-Internet calls and WhatsApp offers only messages, not calls.

Overall OTT services increase demand for phone numbers in at least two ways: by encouraging customers to obtain phone numbers specifically for those services, and by encouraging the use of public telephony networks in general. However, particular features of them might be expected to increase demand for phone numbers in other, exceptional, ways. Broadly speaking, this does not appear to happen, as they can make the following uses of phone numbers:

- They might use phone numbers only for calls to or from public telephony networks. Internet-to-Internet calls use special identifiers for the subscribers being called; other calls use the phone numbers. Subscribers can port the numbers. Services that use numbers in this manner, such as Skype, should not increase demand for phone numbers in exceptional ways.
- They might use phone numbers with universally consistent meanings for all calls. All calls use the phone numbers of the subscribers being called, and those numbers are independent of the subscribers making the calls. Subscribers can port the numbers. Services that use numbers in this manner, such as Viber, again, should not increase demand for phone numbers in exceptional ways.
- They might use phone numbers without universally consistent meanings for all calls; All calls use the phone numbers of the subscribers being called, but those numbers are dependent on the subscribers making the calls. The phone numbers are assigned on behalf of the subscribers making the calls (and with the intention of having low charges for calls to the expected locations of the subscribers being called); subscribers are unable to port the numbers or to assume that different subscribers have different numbers. Services that use numbers in this manner, such as Rebtel, could increase demand for phone numbers (in proportion to the square of the number of subscribers, in the worst case); however, they can avoid doing so by sharing numbers between subscribers and having busy tones more often.

Services in which calls can be routed to multiple end points, either in parallel (as with the simultaneous ringing implemented by Tu Go and Google Voice, for example) or in series (as in call forwarding), might appear to need extra phone numbers, so that different end devices could alert a subscriber in different ways in different circumstances. However, they use sip URIs, not phone numbers, to identify many of the end points. Moreover, they often operate in such a way that the user terminals, not the network servers, are configured to determine whether and when there are alerts: all the end points can be reached when one number is dialled, but only some end points alert the subscribers being called. Accordingly such services, too, should not increase demand for phone numbers in exceptional ways.

9.5 Machine-to-machine communications

Each person lives in very few houses and occupies very few offices, so there can be fairly low bounds on how many subscriptions there will be to fixed services, at least for person-to-person communications. This is not so for mobile services (or, strictly speaking, for services using wireless protocols), because of the increasing use of machine-to-machine communications and the decreasing size of the communicating machines. These machines might be not just vehicles, alarms, smart meters and domestic appliances but also actuators and sensors, which might be very small. Some will have phone numbers for mobile services (or possibly fixed services); others, particularly very small sensors, will communicate using low power short range protocols with hubs that themselves have such phone numbers.

Thus many machine-to-machine communications will need phone numbers (though other will just need domain names and IP addresses, especially when LTE is widely used). Fortunately these phone numbers can have different characteristics from phone numbers used by person-to-person communications: a machine does not have the same difficulties as a person in remembering, dialling and recognising phone numbers and might not even need to dial numbers from a public network (as opposed to a private network of communicating machines)[51]. In particular, these phone numbers can be very long. The national numbering plan in Qatar could accommodate 10 billion such numbers on one two-digit prefix.

Whether the demand for machine-to-machine communications justifies having a number range specific to them in Qatar is not immediately clear. It depends on the rate at which the 40 million numbers for mobile services are allocated, bearing in mind that IPv6 addresses will ultimately be used instead[52]. An illustrative estimate of demand is provided in Box 26; it suggests that in Qatar demand does not require there to be a number range specific to machine-to-machine communications, provided that disused numbers are quarantined and recycled, and that relatively few numbers are trapped in the distribution chain awaiting the sale of Subscriber Identity Module (SIM) cards. Again, though, however, however, prudence suggests that ictQATAR should reserve at least one second digit for possible future expansion of numbers for mobile services.

[51] In this respect person-to-machine calls (such as dialling a vending machine to extract goods from it) are often most like person-to-person calls, while machine-to-person calls (such as dialling a house owner to warn of an intrusion) are often most like machine-to-machine calls.

[52] RIPE NCC now allocates at most 1,024 IPv4 addresses to any applicant.

Box 26 The demand for phone numbers in machine-to-machine communications

One estimate is that worldwide there will be 50 billion communicating machines by 2020; scaling this to Qatar according to its proportion of nominal global Gross Domestic Product (GDP) in 2012 suggests that there would be many more than 1 billion communicating machines in Qatar. However, only some of these would need phone numbers.

The need for phone numbers can be estimated by making assumptions about which communicating machines would be used. In 2010, according to the census, there were 259,066 housing units and 146,707 households in Qatar. These had 779,426 occupants; the remaining 920,011 inhabitants might have mobile phones but would perhaps never have terminals for machine-to-machine communications. Every housing unit might ultimately have three vehicles (each equipped separately for emergency calling, vehicle monitoring for maintenance and driving monitoring for insurance), three alarms (for security, fire and health monitoring) and three smart meters (for electricity, water and environment control), each with its own phone number. After matching each housing unit with a business unit, rather fewer than eight million phone numbers are needed. Making comparable assumptions about the remaining inhabitants, left out of the housing units, gives a total of nineteen million phone numbers.

The actual figures could be very much lower than these. Currently a household in Qatar has about three mobile phones on average; also, various estimates by service providers elsewhere suggest that in ten years there would be between one and two communicating machines per household.

The actual figures could be higher than these if, for example, very small sensors could communicate directly with base stations with the aid of new battery technology. Moreover, systems awaiting scrappage or sale might have phone numbers, though scrappage could entail quarantining and recycling numbers and sale could entail Over The Air (OTA) programming of previously empty SIM cards when OTA programming protocols become standardised fully.

10 Conclusions for Qatar

10.1 Recommendations about ENUM

Generally regulators are unwilling now to encourage the introduction of user ENUM: its disadvantages do not outweigh its advantages. They might welcome the introduction of carrier ENUM, which poses much less severe problems and could reduce costs. This report aims to demonstrate why this is so.

Nonetheless, some regulatory requirements for ENUM are stated in this section in ways applicable to both forms of ENUM. Though they are satisfied by deployments of carrier ENUM much more readily than by deployments of user ENUM, they deserve to be considered because they specialise to ENUM generic principles about the confidentiality of personal information. In them "ENUM information" comprises the contact details returned in response to ENUM queries, along with related information (such as given names and physical addresses) needed for the management of an ENUM system.

The regulatory requirements for an ENUM deployment are that:

- The ENUM information of number holders should not be made available to the public without the informed consent of the number holders.
- Number holders should not risk incurring financial or other penalties if they do not consent to making their ENUM information available to the public.
- Requests to add, change or remove the ENUM information of number holders should be authenticated before being fulfilled.
- Processes for assigning, porting and disconnecting numbers should change the ENUM information of number holders appropriately.
- Communications should not be redirected to more expensive destinations without the informed consent of the paying customers.
- The ENUM information of number holders made available to the public should not include phone numbers not allocated in the National Numbering Plan.
- Number holders should not risk discrimination from one service provider if they include in their ENUM information services from another service provider.
- The ENUM system should be accessible on fair and non-discriminatory terms to all service providers if it would assist their operations and is shared between two service providers.

10.2 Considerations for numbering

This report does not aim to provide a full review of the national numbering plan. There are several topics that it does not consider, such as short codes and premium rate numbers. However, it includes some tentative views about the development of the plan as phone numbers are used in wider ranges of services. These views need to be checked with service providers and consumer groups. They are that:

- There is unlikely to be a need for a national numbering plan change just to meet demand for OTT multimedia communications or machine-to-machine communications.

- For numbers for fixed services and numbers for mobile services, there should be a watchful eye kept on utilisations and at least one second digit should be protected from allocation, in case a national numbering change is needed; the second digits “8” and “9” could be protected for this purpose.
- There is no reason to introduce special numbers for nomadic services (or for user ENUM).

10.3 Considerations for next generation networks

The requirements stated in Section 10.1 will usually be fulfilled without difficulty by deployments of carrier ENUM. However, the service providers are likely to be deploying NGNs, not just carrier ENUM. Such deployments can raise regulatory concerns like those mentioned in Section 7.1 for universal services, traffic management and interconnection. If the market fails to address them, ictQATAR might need to consider regulatory remedies that are outside the scope of the current study.

Annex 1 Abbreviations

3GPP	Third Generation Partnership Programme
BIND	Berkeley Internet Name Domain
CC	Country Code
CLI	Calling Line Identification
CRUE	Carrier Registrations in User ENUM
CSCF	Call Session Control Function
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DNSSEC	DNS SECurity extensions
DUNDI	Distributed Universal Number DIscovery
ETSI	European Telecommunications Standards Institute
GDP	Gross Domestic Product
GPON	Gigabit-capable Passive Optical Network
GSM	Global System for Mobile communications
GSMA	GSM Association
HLR	Home Location Register
HTTP	HyperText Transfer Protocol
IANA	Internet Assigned Numbers Authority
ICANN	Internet Corporation for Assigned Names and Numbers
ICT	Information and Communications Technology
IETF	Internet Engineering Task Force
IM	Instant Message
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPX	IP eXchange
IT	Information Technology
ITRS	interstate Telephony Relay Service
ITU	International Telecommunication Union
IXP	Internet eXchange Point
LAN	Local Area network
LTE	Long Term Evolution
MCC	Mobile Country Code
MMS	Multimedia Message Service
MNC	Mobile Network Code
NANP	North American Numbering Plan

NAPTR	Naming Authority PoinTeR
NAT	Network Address Translation
NBN	National Broadband Network
NGN	Next Generation Network
NREN	National Research and Education Network
OECD	Organisation for Economic Co-operation and Development
OTA	Over The Air
OTT	Over The Top
PBX	Private Branch eXchange
RIPE NCC	Réseaux IP Européens Network Coordination Centre
SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SIP-I	SIP for encapsulated ISUP
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SRV	SeRVice
TDM	Time Division Multiplexing
TERENA	Trans-European Research and Education Networking Association
TISPAN	Telecommunications and Internet converged Services and Protocols for Advanced Networking
UCI	Universal Communications Identifier
UK	United Kingdom
URI	Uniform Resource Identifier
US	United States
VOIP	Voice Over IP

Annex 2 Questions to the network operators in Qatar

1. What regulatory, technical or commercial conditions (such as participation by a competitor) would be essential to, or prevent, ENUM trial and deployment in Qatar?
2. What safeguards would be needed to protect commercial confidentiality in the study report and before, during and after an ENUM trial?
3. Would you be interested in the contents of the study report, and of the trial, relating to user ENUM, carrier ENUM or both?
4. An ENUM trial could have various focusses (for example, application services, operating procedures, management tools, or network interoperation). Which would you be most, or least, interested in?
5. Would you participate in an ENUM trial?
6. What would you most, or least, like to be the deliverables from an ENUM trial?
7. What resources (people, software, hardware, services and systems) do you have that you would be willing and able to contribute to an ENUM trial?
8. What assistance would you need from third parties, such as the engineering and technical support groups of your suppliers, to make your contribution to an ENUM trial effective?
9. What constraints do you know that could affect the timing and duration of an ENUM trial?
10. What are your current plans for your IMS trial and deployment?
11. What are the intentions of your IMS trial?
12. The ENUM server associated with an IMS provides an ENUM interface to the IMS and to other 3GPP networks connected directly or indirectly (in particular, over GRX/IPX). Which of these interfaces do you expect to exercise in your IMS trial?
13. Is there any participation in a trial joint of IMSs between the service providers that you would welcome, beyond interoperability testing?
14. What communication services that are assisted by ENUM do you expect to exercise in your IMS trial?
15. ENUM permits a phone number to be associated with several communication services and end points, with an order of preference. Do you envisage trialling applications that actually select between these according to their own capabilities and the order of preference, or only applications that simply use one communication service and end point?
16. How will the NAPTR records be provisioned in your IMS trial?
17. What information in the NAPTR records do you envisage making available to other service providers and to the end users?
18. What equipment will the end users have in your IMS trial?
19. Do you envisage the introduction of new numbering ranges to support services that IMS could make available (such as nomadic voice over IP)?
20. How do you intend that nomadic and mobile services will provide location information in calls and messages to emergency centres?