A Study on Implementation issues of Number Portability in IMS Networks

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Abstract—**With the acceleration of network evolution to the packet-based all-IP network, a demand for the IMS which is de-facto standard framework to provide IP services in the packet-based network, is increasing rapidly. Number Portability(NP) which has been contributing to facilitating of telephony company competition and increasing of user convenience in legacy circuit-based networks, is also becoming more challenging issue in IMS networks. However, there is no definitely specified solution to provide NP in the IMS standard. In this paper, we overview the general four NP schemes which have been used in the CS networks. Afterward, we discuss practical implementation issues to be considered when employ them into the IMS networks on the basis of the existing basic standards.**

Keywords— **Number Portability, all-IP, IMS, ENUM, ACQ**

I. Introduction

Number Portability(NP)[1] is a service to enable the telephony subscribers to retain their telephone numbers even when they change the service provider(Service Provider Portability), change the subscribed services(Service Portability) and move to the new location(Location Portability). From a business perspective, it is not only to facilitate the telephony company competition but also to increase the user convenience. And in terms of technique, it means changing the fundamental nature of a dialed E.164 telephone number[2] used in circuit-based PSTN/PLMN CS Domain from a hierarchical physical routing address(routing number or routing prefix) to a logical address(dialed directory number) to provide the transparent translation of the later to the former.

IMS is a de-facto standard framework to provide IP-based services(e.g. VoIP, Mobile IM, Presence) in the packet-based network. With the acceleration of network evolution from the voice centric, circuit-switched world to the flexible IP environment supporting rich voice and data services, a demand for the IMS is increasing rapidly. But there is no exactly specified solution to provide NP in IMS global standard. Therefore, the more industries move to the all-IP networks, the more NP capability in the IMS environment is also becoming challenging issue.

In this paper, we will overview the general NP schemes which have been used conventionally in the legacy CS networks, and discuss the practical implementation issues to employ the general NP schemes into the IMS networks. In chapter two, an overview of general four number portability schemes in the CS networks is presented. Chapter three describes the expected NP cases in IMS networks. And the detailed discussion about the implementation issues of employing those schemes into the IMS networks is presented in chapter four. Finally, conclusions are driven in chapter five.

II. Overview of General Four Number Portability(NP) Schemes

There are four kinds of NP schemes[1] generally used in the CS legacy networks. They can be categorized as two groups according to whether they use the internal(on-switch) DB or the external(centralized) DB to look the NP-related information up. The internal DB only contains information about the numbers that were ported out of the donor network, but the external DB contains all ported number information from the multiple networks.

A. Internal(On-switch) DB based approach

One of the internal DB based NP scheme is Onward Routing(OR). The left side on Figure 1 shows call steps for the OR NP scheme. Those call steps are as follows:

1) An originating network receives a call from the caller and routes the call to an old terminating(donor) network.
2) The donor network checks that a dialed Directory Number(DN) has been ported out of the donor switch with an internal(on-switch) DB.
3) The internal NPDB returns a Routing Number(RN) associated with the dialed directory number.
4) The donor network uses the routing number to route the call to a new terminating(recipient) network.

The OR is the least efficient scheme in terms of network transmission because it requires the donor network's resource to relay the call to the recipient network. Furthermore, it may cause the charging issues about the interconnection of operators.

The right side on Figure 1 shows the call steps for the Call dropback, which is the other kind of internal DB based NP scheme. Its difference with OR is that the donor network releases a call instead of relaying it to the recipient network. Therefore, the donor network must provide a releasing message including RN obtained from the internal DB and the originating network can route a new call to the recipient network by using the RN. This scheme is able to relieve the donor network's overload to relay the call which has the ported out number compared with the OR.

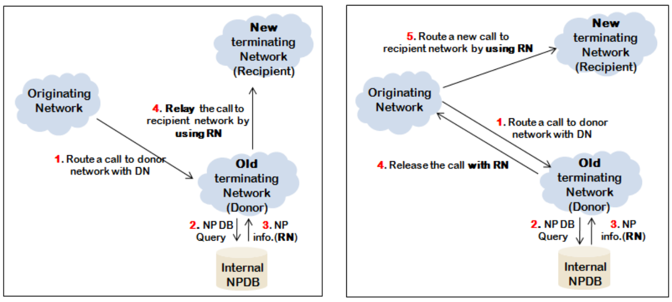

Figure 1. Internal(On-switch) DB based approach among the general Number Portability schemes in legacy CS networks

B. External(Centralized) DB based approach

The external DB based NP schemes are more efficient then the internal DB based NP schemes by minimizing or even eliminating the involvement of the donor networks in the aspect of network transmission. QoR(Query on Release) is one of the two external(centralized) DB based NP schemes. The left side on Figure 2 shows call steps for the QoR scheme. The difference of QoR with Call dropback is that donor networks only provide the NP triggering indication of the dialed directory number which has been ported out from that switch and the originating network should obtain the routing number of the released call by sending a query to its copy of external NPDB. Therefore, the external NPDB must contain all ported numbers from the all donor networks which are related with the originating network. Maintaining of such information and querying for the routing numbers are overhead in the side of originating networks compared with the internal DB based approach.

All Call Query(ACQ), the other one of the two external DB based NP schemes, totally eliminates the involving of donor networks by making originating networks carrying out queries to the external NPDB for every single originating call in the purpose of getting the routing number as in the right side on figure 2. It is the most efficient scheme in terms of network transmission but consumes originating network's resources to fulfill the querying job for every single originating call, even if the dialed number of the originating call is not ported out. Consequently, the more NP is becoming pervasive, the more ACQ is becoming advantageous compared to the QoR.

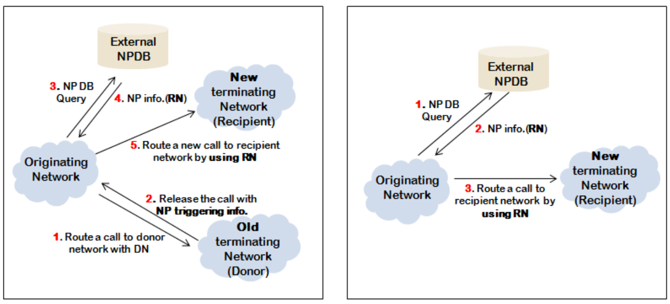

Figure 2. External(Centralized) DB based approach among the general Number Portability schemes in legacy CS networks

The QR and Call dropback NP schemes are a kind of remote call forwarding measures. Generally, such a call forwarding-like NP solution is considered as an interim NP. Whereas, the QoR and ACQ seeking to remove the donor network's involvement from the call path is considered more advanced NP solution compared with QR and Call dropback.

III. EXPECTED NP CASES IN IMS NETWORKS

Before the discussion on the implementation issues which must be considered to employ the general NP schemes into the IMS networks, it is necessary to explain the IMS addressing scheme and the expected NP cases in such addressing scheme.

Conventionally, circuit-switched networks like PSTN/PLMN CS domain use the E.164 telephone numbers to identify the destination of a call, whereas the IMS networks uses a domain name in SIP URIs(Universal Resource Identifiers)[3] to route a SIP signalling, because the SIP is a foundation protocol of the IMS. And the domain name must be translated into IP address by DNS because the SIP uses an IP as a lower layer transport protocol.

In addition to the SIP URIs, the IMS may also use tel URIs[4] which express the traditional E.164 telephone number in URI syntax to support backward compatibility. The tel URIs must be translated into the SIP URIs so that IP addresses are obtainable from those domain names by DNS and the calls using the tel URIs can be routable by IP as mentioned above.

Table 1 shows the three expected NP cases in the IMS networks. The first case is that the URI(SIP or tel) address is ported between the IMS networks. The second case is that the E.164 telephone number in CS network is ported to the URI address in the IMS networks. The last case is that the E.164 telephone number is ported between the CS networks. It should be noted that the IMS networks need to have inter-working capability with the legacy CS networks so that it is also able to handle the ported calls which are related with the CS networks until the legacy networks disappear completely.

TABLE 1. EXPECTED NP CASES IN IMS NETWORKS

NP Cases	From	To
IMS A→IMS B	sip : bob@operatorA.com tel : +1 234 567	sip : bob@operatorB.com tel : +7 654 321
CS A→IMS A	+1 234 567	sip : bob@operatorA.com tel : +1 234 567
CS A→CS B	+1 234 567	+7 654 321

IV. EMPLOYING OF GENERAL NP SCHEMES INTO IMS NETWORKS

A. Onward routing(Remote call forwarding) NP scheme in IMS

The IMS can use a session redirection procedure[5] to realize the Onward Routing(OR) NP schemes. Figure 3 shows the basic call flow of the session redirection procedure in the IMS. When a S-CSCF in a donor(old terminating) network receives an INVITE message from an originating network, whether the session should be redirected to a new destination or not is determined by service logic in the S-CSCF, and after that it relays the message according to the URI indicating the new destination if it concludes that redirection is needed.

The procedure to provide OR NP scheme is completely same as above. The NP-related information, about whether the called party address is ported or not and where to go if ported, is obtainable from the user/service profile downloaded from the HSS to the S-CSCF during the registration. In the case that the number is ported, redirection triggering for NP is performed in the S-CSCF's service logic. The user/service profile in the HSS only contains the information about the numbers that were ported out from the donor network like an internal(on-switch) DB scheme in the legacy CS networks.

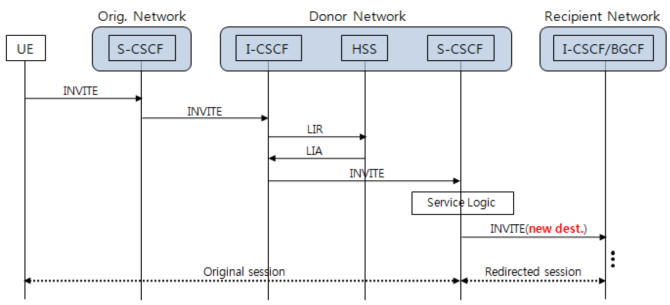

Figure 3. Basic call flow of session redirection schemes in IMS

B. Call dropback NP scheme in IMS

The IMS can utilize a SIP Redirect method[3] to realize the call dropback NP schemes. Originally, the SIP Redirect method intends to reduce the processing load on the SIP proxy servers in the donor networks that are responsible for initial routing requests so that it can improve signaling path robustness and allows for considerable network scalability. Therefore, the SIP redirection server in destination networks have the responsibility of informing the originator of request a redirection indicator and a new destination's address to share the load. The "3xx" status code in the response means that further action needs to be taken in the side of originator to complete the request. The definition of "3xx" status codes are as follows. (Refer to the [3] for the detailed description on status code)

- 300 : Multiple choices
- 301 : Moved permanently.
- 302 : Moved temporarily
- 303 : User proxy
- 380 : Alternative service

Figure 4 shows the basic call flow of SIP Redirect method in the IMS. The SIP redirection servers in S-CSCF push "3xx" status code and routing information for a request back in a response to the client. When an originator of the request receives the redirection response, it should send a new request based on the URI which it has received.

In the Call dropback NP scheme, the "3xx" status code in the response and the new destination's URI pushed by SIP redirect server can be used as a NP redirection triggering indicator and the routing information for the originator of request.

C. QoR(Query on Release) and ACQ(All Call Query) NP schemes in IMS

Both the QoR and the ACQ NP schemes for the IMS networks need not only the external(centralized) NPDB to obtain the routing information but also the new interface between the IP-entities in the originating network and the external NPDB. The QoR NP scheme is same as the Call dropback NP scheme in the aspect of the originating network should receive the NP redirection triggering information

In the QoR NP scheme, however, the originator of request which receives the redirection response must use the address obtained from the external NPDB instead of using the received URI(s) in the Contact header field. The SIP redirection responses including the status code ranged from the "300" to the "303", means that the clients should use the URI(s) in the Contact header field to formulate one or more new requests upon receipt of the redirection response. Whereas, the "380" status code is generally defined to enable the alternative services in the originator side, which is determined by the SIP redirection server.

Therefore, the QoR can use the "380" status code in SIP redirection response as a QoR NP triggering indication discriminated from the other "3xx" redirection response. Figure 5 shows the basic call flow of the QoR NP schemes for the IMS network. The S-CSCF in the originating network must have the NPDB query module and the interface with the external NPDB to get the new destination's URI when it receives the NP redirection response including "380" status code.

In the case of ACQ, the NPDB query should be carried out at session initiation time for every single originating call and the URI address obtained from the NPDB should be used for the initial INVITE message.

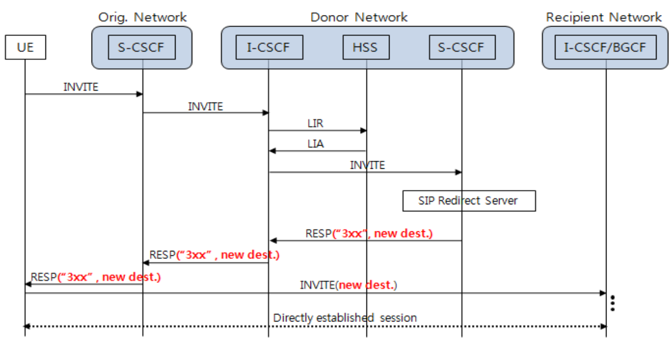

Figure 4. Basic call flow of SIP Redirect method in IMS

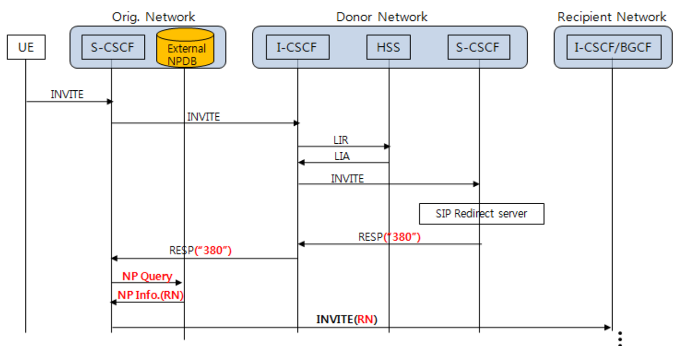

Figure 5. Basic call flow of QoR NP schemes in IMS

D. *Implementation of External NPDB*

There are several alternatives[1] for implementing the external NPDB in the IMS networks. One alternative is to use the existing NPDB which has been built in the legacy CS networks. There are a variety of local standards for the switch-to-legacy NPDB interfaces in those networks. Therefore, a certain entity in the IMS networks should have the responsibility for supporting those interfaces to perform the NPDB query. It could make the external NPDB complicated to deal with in a global environment.

Another alternative is to define a "common" interface supported by all NPDBs so that all the IP entities in IMS networks can use it. The good candidate to provide such a common interface is the ENUM/DNS[6],[7],[8] developed by the IETF(Internet Engineering Task Force). It transforms E.164 telephone numbers into domain names which represent the address of target service provider, based on the DNS delegation through NS records and NAPTR records to look up what services are available for a specific domain name. It is reliable, scalable and globally unified. And it is able to provide the NP capability only for the service where an E.164 telephone number is used to identify the end subscriber because the ENUM/DNS must use the E.164 telephone number as a primary key to look the destination's address up. To utilize the ENUM/DNS as an external NPDB in the IMS network, PSTN-oriented NP information also needs to be placed in it for the IMS networks to inter-work with the CS networks[9]. And also, the extension of parameters in the URI[10] is needed to carry the NP-related information in SIP. Figure 6 shows the handling case of the NP for the originating calls from the CS networks by the IMS. In that case, SIP needs to transport the NP-related information while the call is being routed to the gateways to the destination CS networks. There are three pieces of NP-related parameter which SIP must transport as follows.

- Directory number("dn")
- Routing number("rn")
- NPDB dip indicator("npdi")

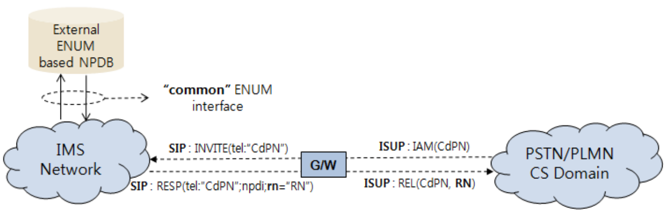

Figure 6. Concept of ENUM/DNS based NPDB interworking with CS network

The called directory number is for the terminating CS network switch to terminate the call and the routing number is to route a call to the destination CS network. The NPDB dip indicator is for the terminating CS network not to perform another NPDB dip. Figure 7 is the example of ENUM/DNS records using the tel or SIP URI extended for the NP.

Besides the basic ENUM/DNS standards, the commercial ENUM/DNS implementations for the industry-wide NP capability are already available in GSMA(GSM Association). The Carrier ENUM in the GSMA[11] is a framework to facilitate interoperable, carrier-scale solution to enable the routing and number translation service of global IP service based interconnect traffic

```
$ ORIGIN 7.6.5.4.3.2.1.e164.arpa.          * tel URI Case
NAPTR 10 100 "U" "E2U+pstn:tel"
"!^.*$!tel:+1-234-567;npdi!".rn=+7-654-321!".
```

```
$ ORIGIN 7.6.5.4.3.2.1.e164.arpa.          * SIP URI Case
NAPTR 10 100 "U" "E2U+pstn:tel"
"!^.*$!sip:+1-234-567;npdi!".rn=+7-654-321@operatorB.com;user=phone!!".
```

Figure 7. The example of ENUM/DNS Record with NP parameter

V. CONCLUSIONS

In this paper, we overviewed the four general NP schemes in legacy CS networks and considered the expected NP cases in IMS networks. After that, we discussed about the implementation issues to employ those general NP schemes into the IMS networks.

The ENUM/DNS is expected as a potential solution for the external DB based number portability solution in IMS networks by providing the reliable, scalable solution and the globally common interface. However, it is only appropriate for the service where an E.164 telephone number is used to identify the end subscriber.

The future work in this area will be about the more practical consideration on the deployment of the number portability in our commercial IMS network by using the solutions discussed in this paper. And we will do more research about the possible portability solution of URIs which does not use the E.164 telephone numbers and the optimized call flow in the ENUM/DNS based NP solution.

REFERENCES

[1] RFC 3482, "Number Portability in the Global Switched Telephone Network (GSTN): An Overview", IETF, 2003.
[2] ITU-T E.160, "Telephone Network and ISDN Operation, Numbering, Routing and Mobile Service", ITU-T, 1993.
[3] RFC 3261, "SIP: Session Initiation Protocol", IETF, 2002.
[4] RFC 3966, "The tel URI for Telephone Numbers", IETF, 2004.
[5] TS 23.228, "IP Multimedia Subsystem (IMS); Stage 2", 3GPP, 2009
[6] RFC 2916, "E.164 number and DNS", IETF, 2000
[7] RFC 3403, "Dynamic Delegation Discovery System (DDDS) Part Three: The Domain Name System (DNS) Database", IETF, 2002
[8] RFC 3761, "The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM)", IETF, 2004
[9] RFC 4769, "IANA Registration for an Enumservice Containing Public Switched Telephone Network (PSTN) Signaling Information", IETF, 2006
[10] RFC 4694, "Number Portability Parameters for the "tel" URI", IETF, 2006
[11] www.gsmworld.com/pathfinder