A SIMULATION TOOL FOR THE COMPARISON OF THE NUMBER PORTABILITY SOLUTIONS

by

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A SIMULATION TOOL FOR THE COMPARISON OF
THE NUMBER PORTABILITY SOLUTIONS

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ABSTRACT

A SIMULATION TOOL FOR THE COMPARISON OF THE NUMBER PORTABILITY SOLUTIONS

Number Portability is a very important instrument for competition in telecommunication sector. This study aims to investigate Number Portability and the solutions for constructing and managing Number Portability from the point of technical and economical aspects. Also, other applications of Number Portability in some countries have been examined. There are three types of Number Portability, which are Service Portability, Service Provider Portability, and Geographic Portability. This study has emphasized on Service Provider Portability. There are three types of Service Provider Portability which are non-Geographic Number Portability, Geographic Number Portability, and Mobile Number Portability. Nowadays, the solutions, which are used for Number Portability, are On-Switch solutions and Off-Switch solutions. On-Switch solutions consist of Onward Routing solution and Call Drop Back solution. Off-Switch solutions consist of Query on Release solution and All Call Query solution. A simulation tool was developed and applied to compare these four solutions. The results obtained from the simulation tool have been analyzed and evaluated.

Keywords: Number Portability, Number Portability Solutions, Simulation

ÖZET

NUMARA TAŞINABİLİRLİĞİ ÇÖZÜMLERİNİN KARŞILAŞTIRILMASI İÇİN SİMÜLASYON ARACI

Numara Taşınabilirliği, telekomünikasyon sektöründeki rekabeti artırıcı etkisinden dolayı öneme sahiptir. Bu çalışma Numara Taşınabilirliği kavramını ve Numara Taşınabilirliği'ni kurmada ve yönetmede kullanılan çözümleri ekonomik ve teknik açıdan incelemeyi ve karşılaştırmayı hedeflemektedir. Bu bağlamda bazı ülkelerdeki uygulamalar da incelenmiştir. Numara Taşınabilirliği'nin üç türü mevcuttur. Bunlar Coğrafi Taşınabilirlik, Servis Taşınabilirliği ve Servis Sağlayıcı Taşınabilirliği'dir. Bu çalışma Servis Sağlayıcı Taşınabilirliği üzerinde yoğunlaşmıştır. Servis Sağlayıcı Taşınabilirliği'nin üç türü mevcuttur. Bunlar, Coğrafi Olmayan Numara Taşınabilirliği, Coğrafi Numara Taşınabilirliği ve Mobil Numara Taşınabilirliği'dir. Günümüzde Numara Taşınabilirliği çözümleri On-Switch çözümler ve Off-Switch çözümler olarak ikiye ayrılmaktadır. On-Switch çözümler İleri Doğru Yönlendirme, Çağrı Geri Düşürme çözümlerinden oluşurlar. Off-Switch çözümler ise Bırakma Sorgulaması ve Tüm Çağrıların Sorgulanması çözümlerinden oluşmaktadır. Bu dört çözüm geliştirdiğimiz bir simülasyon aracı ile karşılaştırılmıştır. Simülasyon aracından elde edilen sonuçlar analiz edilmiş ve değerlendirilmiştir.

Anahtar Kelimeler: Numara Taşınabilirliği, Numara Taşınabilirliği Çözümleri, Simülasyon

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ACQ	All Call Query
CDB	Call Drop Back
COLP	Connected Line Identification Presentation
CRD	Central Reference Database
DB	Database
DN	Directory Number
DNO	Donor Network Operator
ETO	European Telecommunications Office
ETSI	The European Telecommunications Standards Institute
FCC	Federal Communications Commission
GMSC	Gateway Mobile Switching Center
HLR	Home Location Registry
IN	Intelligent Network
INTUG	International Telecommunication User Group
IOC	Inter-operator communications
ISDN	Integrated Services Digital Network
ITU	The International Telecommunication Union
LNP	Local Number Portability
LRN	Location Routing Number
LSMS	Local Service Management System
MNP	Mobile Number Portability
NANPA	North American Numbering Plan Authority
NP	Number Portability

OFCOM Office of Telecommunication (Britain)

ONO Originating Network Operator

OR Onward Routing

PSTN Public Switched Telephone Network

RNO Recipient Network Operator

QoR Query on Release

SCCP Signaling Connection Control Part Level

SMS Service Management System

SRF Signaling Relay Function

SS7 Signaling System No. 7

SSF Service Switching Function

SSP Service Switching Point

VMSC Visited Mobile Switching Center

1. INTRODUCTION

Number Portability is a subject of telecommunication sector and gains importance after liberalization of the sector. European Union makes Number Portability compulsory for the member states as in Universal Service Directive (2002/22/EC). Number Portability may be defined as migrating of a subscriber from one operator to another one without changing his/her telephone number [1]. Moreover, the subscriber can continue to benefit from the same services with this new operator without any interruption or corruption.

This issue is a great subject of choice from the view of subscribers. This application will decrease customer dependency to one operator and will increase competition [2]. In the same way, Number Portability will provide the subscribers with high quality but cheaper services. Moreover, this will cause in increasing of number of subscribers per line and number and amount of usage of services in telecommunication sector; so Number Portability will benefit to the sector, too [2].

Number Portability can be analyzed in three categories which are Service Provider Portability, Geographic Portability and Service Portability [1,2]. Service Provider Portability means a subscriber's changing his/her service provider without changing his/her phone number. Geographic Portability means a subscriber's changing his/her place without changing his/her phone number. Lastly, a subscriber's changing the services taken from the operator is called as Service Portability. For example, the subscriber's changing his/her PSTN (Public Switched Telephone Network) service to an ISDN (Integrated Services Digital Network) service is Service Portability.

Two factors are important for the success of the number porting applications which are the charges faced to the operators and subscribers and the easiness of number porting procedure and the length of timing used for porting the numbers. The best application in the Number Portability procedure is "one stop shopping" [3] by which the end user is in contact with only one operator in the number porting process. Service Provider

Portability, which was generally established to wire line networks in the primary applications, has been put into application in the mobile telephone network of developed countries.

Three developed countries USA, England and France took a long way in liberation of telecommunication industry. Also, these three countries are special from point of Number Portability and numbering plans. For instance, France is a good example for the closed-numbering plan while England is a good example for the open-numbering plan; however the numbering plan of USA is different from those two because it is an integrated plan including nearly 20 countries. Moreover, in US management of the numbering plan is on the response of an independent authority (North American Numbering Plan Authority-NANPA).

1.1. Research Problem

In some countries Number Portability applications became unsuccessful because of the high charges faced by the subscriber and operators. Other factors like easiness of number porting procedure and the length of timing used for porting the numbers are also important for the beneficial Number Portability.

In this thesis, a simulation tool has been designed to show the probable costs of number porting action and the differences between the applied solutions for the best benefit from Number Portability. Also, it is aimed to show the ways to overcome the problems other than charges like the length of porting time and the porting procedure.

1.2. Outline of Thesis

In this thesis, one of the most important subjects about telecommunication is analyzed. Number Portability is a new subject and started to be talked especially after countries' liberating telecommunication in 90's.

First section is an introduction for the thesis. In the second section, basic issues like definition of the Number Portability concept are given. In the third and fourth sections, basic types of Number Portability, which are Wireline Number Portability, Mobile

Number Portability, and Wireline-Mobile Number Portability are analyzed, respectively. In the fifth section, portability between the wired and mobile networks is described. In the sixth section, the effects of Number Portability are emphasized. The seventh section indicates country samples on Number Portability. Then, at the eighth, the simulation tool, which designed to compare the technical solutions for Number Portability, is described. Also, the analyses and evaluations about the simulation have been described at this section. Current situation about Number Portability in Turkey has been viewed in the ninth section. Lastly, the thesis is concluded and recommendations are stated.

2. NUMBER PORTABILITY

2.1. The Terminology

There are several terms which are introduced with NP. Some of the more common ones are as follows:

Entities

Network operator: an entity that operates a network in order to provide telecommunication services

Service provider: an entity that offers services to users involving the use of telecommunication services provided by network operators.

Party: the network operator and/or the service provider.

Donor network operator: the mobile network operator from which the mobile number was initially ported.

Recipient network operator: the mobile network operator to whom the mobile number is ported.

Donor service provider: the service provider from whom the mobile number was initially ported.

Recipient service provider: the service provider to whom the mobile number is ported.

Networks

Donor network: the initial mobile network where a mobile number was used before ever being ported.

Originating network: the network where the calling party is connected.

Recipient network: the mobile network where a mobile number is registered after being ported.

Transit network: a network that participates in a communication between two other networks.

Numbers

Directory Number: a number in the national numbering scheme that is allocated to a customer for a telecommunication service. The Directory Number is the number that is dialed by the users to reach the customer.

Routing Number: a specific number that is used by the networks to route the call. The routing number conveys information usable by the network.

Ported number: a number that has been subjected to number porting.

Number range holder: the entity responsible for the management of numbers within a particular range.

Numbering plan manager: the authority responsible for the management of numbers or number blocks within a national numbering plan.

2.2. What is Number Portability?

Number Portability may be defined as a subscriber's changing his/her address, operator or type of service without changing his/her telephone number [1].

Number Portability is applicable for the number categories defined in ITU-T E.164. E.164 is an ITU-T recommendation which defines the international public telecommunication numbering plan used in the PSTN and some other data networks [1]. Recommendation E.164.2 defines number format, forwarding of call and architecture of the network and talks about alternative applications for Number Portability [1]. These numbers are written with a prefix and can have a maximum of 15 digits.

To start a call the subscriber (caller) calls the other subscriber by just dialing his/her directory number without doing any extra operation or dialing extra number [4]. From the technical view the dialed number (ported) does not indicate enough information to find the right way for routing. In the Number Portability situation, the information, which will be used for routing the call, is collected by programming and database

searching on the telephone exchanges during forwarding action and in this way accessing to the end-user is succeeded.

Routing of calls to a ported number contains two steps (Figure 2.1). In the first step, the originating exchange, where the call is originated, analyzes the first numbers of the dialed number and then forwards the call to the serving exchange. In the second step, routing to the recipient network is done according to the routing number collected from the serving exchange. Routing number is a number which is used for the routing action of a ported number and ported number is the number to which porting action is processed [1,4].

If a subscriber ported his phone number from that operator to another or from that exchange to another exchange, only the routing number changes but the routing process stays same.

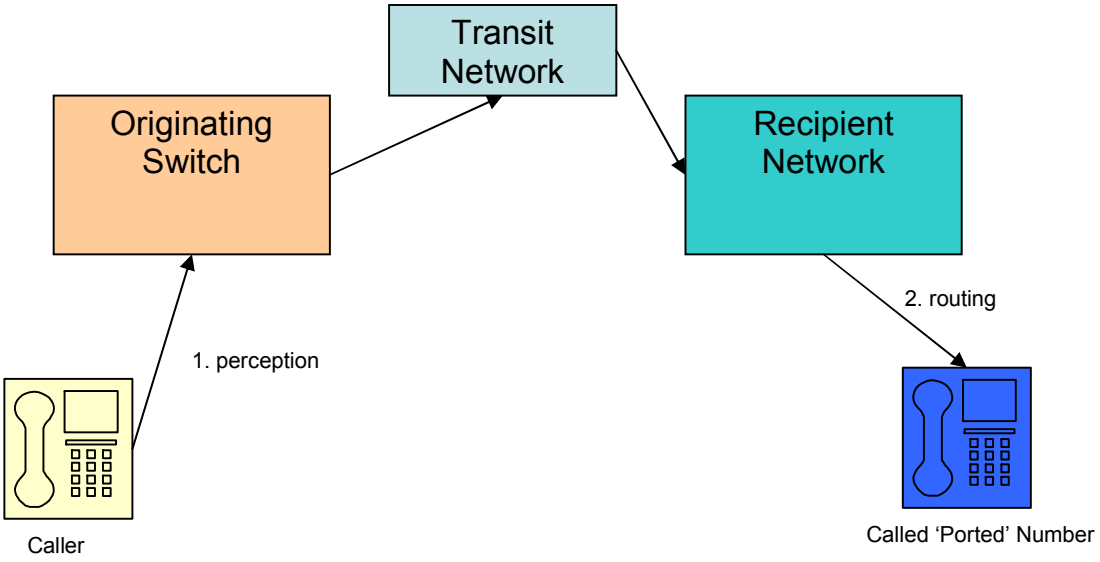

Figure 2.1. Routing of call to a ported number

The two steps mentioned in the previous paragraph also called as "perception" and "routing", respectively [5]. In the perception step, it is detected whether the number has been ported or not; and in the routing step it is detected whether the call is routed to the recipient network.

2.3. Advantages of Number Portability

The availability of Number Portability has been thought to bring substantial benefits to subscribers: lower price, greater choice, higher quality and a greater range of services. Number Portability would allow subscribers to take full advantage of the choices that will become available in a more competitive telecommunication market [6]. Moreover, civil society organizations related with telecommunication describe Number Portability as sine qua non of competition. For instance, INTUG (International Telecommunication User Group) points that when Number Portability is unavailable, the subscriber is forced to get service from one operator and barely could s/he change his/her service provider after s/he made some expenses and risk changing the phone number. In addition to this, INTUG states that even in telecom industry, where several operators act together, if Number Portability is not provided, we can not talk about development of a complete competition in this sector [6]. Competition in telecommunication is very important, especially from the point of presenting the services more qualified and cheaper. In the markets, where competition is developing newly, the legal mandatory operator has the biggest part of the market and in these types of markets the role of Number Portability is very important to enable new operators to compete in the market. Furthermore, in the saturated markets like wireline phone networks, the Number Portability should not be a barrier for the subscriber while changing his/her operator. To present telecommunication services cheaper and more qualified, rival operators and subscribers should have ability of choosing.

The advantage of Number Portability for the society is great; because the subscriber, who knows his/her telephone number will not change, can change his/her service provider with cheaper and more qualified one. On the other hand, the operator will not want to loose his/her customer and so it will try to make the current services better and try to present cheaper and more qualified services. As a result, Number Portability is an application that enables the subscribers with choices and causes the operators to present cheaper and more qualified services.

2.4. Three Types of Number Portability

There are three types of number portability [1]:

- Service Provider Portability
- Service Portability
- Geographic Portability

Service Provider Portability has three types according to the type of number used and the type of service:

- Portability of Geographical Numbers
- Portability of Non-geographical numbers
- Portability of Mobile Numbers

2.4.1. Service Provider Portability

Service Provider Portability is the ability of subscriber's changing his/her service provider without changing his/her telephone number [1]. Service Provider Portability is also called as Operator Portability. This type of portability has three subdivisions related with the type of service and telephone number:

- Portability of non-Geographic Numbers
- Geographic Number Portability
- Mobile Number Portability

Hence, Service Provider Portability is applicable for non-geographic and geographic numbers in the wired line network; and applicable for mobile numbers. ITU-T E.164 defines the numbers which are relevant for service provider portability. Service Provider Portability is applicable inside the boundaries of a country not between countries. The Service Portability of global service numbers is based on the agreements between countries and need an infrastructure which is able to handle Number Portability [4].

2.4.1.1. Portability of non-Geographic Numbers

This type of portability is portability of such types of numbers and services: shared cost services, free phone service (numbers start with 0800), telephone message services (the numbers start with 0900), personnel communication numbers [1]. Looking to the applied Number Portability studies, in general first studies of Number Portability have been applied to non-geographic numbers; because these services have been provided through intelligent networks and in this manner Number Portability has been established easily.

2.4.1.2. Geographic Number Portability

Geographic Number Portability is the portability of geographic numbers in the wireline networks [1]. Geographic Number Portability also called as Local Number Portability. In general, experimentations in Number Portability start with the initiative and request of the operator; and further tests are performed between operators. The results are put into work with the inclusion of real life situations involving subscribers.

The main reason for Number Portability under the initiative of operator is to provide the new operator to control its investment in the first steps of competition which has been started recently. The main reason of portability studies under the request of subscriber is to handle subscriber choice at a maximum level.

The starting time of the portability studies under the initiative of the operator is determined by the operator which has requested portability.

2.4.1.3. Mobile Number Portability

Mobile Number Portability is ability of the subscriber's changing his/her mobile network operator or service provider without any need to change his/her mobile phone number [1]. Since, Mobile Number Portability has a special place in telecom sector; it will be discussed further in section 4.

2.4.1.4. The Point of Regulation

When the three basic Number Portability types evaluated from the point of regulation, the most important subject (type) is Service Provider Portability [5]. Service Provider Portability must be under regulation to progress competition and to protect consumer

rights. However, mostly Service Portability and Geographic Number Portability studies are not regulated.

In the following part of this thesis, Number Portability has the same meaning with Service Provider Portability. The same situation can also be seen at the documents looking Number Portability from the point of regulation.

Geographic and non-geographic number portability, which are types of Service Provider Portability, are also defined as Wireline Number Portability in the literature, because they are applied to the wireline networks. In this manner, Service Provider Portability can be analyzed in two categories which are Wireline Number Portability and Mobile Number Portability. Moreover, this categorization is also feasible when Service Provider Portability is observed from the points of technical solutions and regulation.

2.4.2. Service Portability

Service Portability is the subscriber's changing the services he is taking without changing his/her phone number or service provider [1]. For instance; with Service Portability a subscriber can change his/her PSTN service to ISDN service.

Service Portability is not preferred in some countries, because the tariff information on the phone number is important. Especially, because the tariff information on non-geographic numbers is much related with the number and pricing the services is different; Geographic Number Portability is not applied to these types of numbers.

Service Portability is applicable for geographic numbers within the country but not applicable for numbers between countries and global service numbers. The reason why Service Portability is not applicable for global service is that these numbers are based on the codes allocated by ITU and indicate international identification about countries. Numbers are allocated based on the service it will provide; so changing the service without changing the number may become difficult or sometimes impossible.

2.4.3. Geographic Portability

Geographic Portability can be defined as a subscriber's changing his/her address without changing his/her phone number [1]. Geographic Portability is also called as address portability. In other words, Geographic Portability is only applied for geographical

numbers and provides the number staying the same (the porting may be in the area of the same exchange or to a different exchange area). ETSI (The European telecommunications Standards Institute) differentiates Geographic Portability to four [4]:

- In the same exchange area
- In the same numbering area
- In the same billing area
- Nation wide

However, there are limited applications of Number Portability. The general applications are portability of numbers in the same exchange area. Number Portability is not applicable for geographic numbers out of the country. Moreover, Number Portability is inapplicable for global service numbers, because those numbers do not have geographic specialties.

2.5. Number Administration and Routing

In NP, the main goal of routing is to divert the calls to the right network, central and subscriber. The number changed by NP is not enough for call divergence, so to route the call to the number, "routing information" shall be used. Routing information may be in the following formats [4].

2.5.1. Directory Number

In this structure; only directory number (subscriber's phonebook number) is used in routing calls. However, the same data is used before the number is ported. The advantage of this solution is not to affect the interface of the present network and not to need turning into a routing number.

The disadvantage is that it requires the usage of querying of all calls solution in this addressing system, because determination of the situation of the number (ported or not ported) is not done at the beginning, the forwarding number, which is sensible by all networks, is not assigned.

Knowing whether it is routed or not, the number is questioned in every networks and call is carried to the new call line. Because of not being assigned routing number to the subscriber whose number routed and only directory number is used, the network can not notice whether the number is routed. That's why all dialed calls (routed or not) have to be questioned.

2.5.2. Routing Number

In this structure, routing number is the only number which can travel among the networks. Directory number is not able to travel among the networks but it is turned into the routing number. Routing number is sufficient to reach the dialed subscriber. The advantage of this method is that there is no need any difference in signaling system and ability to use the present structure. Its disadvantage is that it requires an interrogation in the intelligent network or in the last transit network so as to get the information about directory number (COLP). This method causes insufficient usage of the number source, because for every ported number a routing number is constructed. In other words, a subscriber whose number is ported occupies a second number for routing process.

2.5.3. Separated Address

In separated address structure, directory number and routing number take two different places in signaling message. While routing number is using the routing function, directory number provides ending of call on the dialed side [4].

In this method, flouting number can be ITU-T E.164 or any other different number. In both situations, the routing number must be suitable for the plan in national numbering platform. The main reason of this is to prevent wrong routings using different signaling parameters with routing number and directory number. Disadvantage of this method is that routing number and director number are carried in different signaling parameters [1].

The usage of separated address shall be considered as a better long term method than the other methods because routing and directory numbers being carried separately. In this manner, future differences on the structures of the both addresses shall be handled

separately without affecting the other. Hence, ETSI suggests this method as a good long term solution [4].

2.5.4. Concatenated Address

In this format to route a call, subscriber (directory) number and routing number added to each other [1].

In Concatenated Address Format, routing number in front of the subscriber phone book number is used as a prefix (Figure 2.2).

Routing Number – RN	**Directory Number - DN**

Figure 2.2 Concatenated Address structure

The advantage of this method is that using number source is not needed. Also a new addressing system is not required because it is made by present structure of signaling system.

The disadvantage of it is that defining routing number suitable for numbers that is supported by centrals and signaling system, is a problem.

ETSI states concatenated address usage as a good solution for short term because it does not need any changes on signaling systems [4].

In this structure, routing number is the only number which can travel among the networks. Directory number is not able to travel among the networks but it is turned into the routing number. Routing number is sufficient to reach the dialed subscriber. The advantage of this method is that there is no need any difference in signaling system and ability to use the present structure. Its disadvantage is that it requires an interrogation in the intelligent network or in the last transit network so as to get the information about directory number (COLP). This method causes insufficient usage of the number source, because for every ported number a routing number is constructed. In other words, a subscriber whose number is ported occupies a second number for routing process.

2.5.5. Addressed Units in Call Routing

Only one or one of their combinations of the units given below can be addressed according to the structure of routing numbers [4].

Receiving network: In this method, routing number defines the network of the dialed number, but it also needs extra information, a directory number of the dialed (called) subscriber, to complete the routing. In this method, operators may not have wide information about configuration of the recipient network. But the bigness of the receiving network should be thought carefully in routing the call optimally [4]. Also, database questioning is needed in the recipient network to carry the call to routing number. Because, donor network is addressed by the routing number, it does not contain enough information for completing the call, made to the dialed subscriber. However, in the receiving network can contain thousands of subscribers according to the bigness of the network.

In this method, the directory number is needed for carrying the routing number to the correct subscriber, because the routing number delivers the call only to the receiving network.

Interconnection Point: In this method, routing number defines the next network's interface in the routing section. The directory number is required for completing the routing. Addressing interconnection point is not a correct solution in setting up and managing database, especially if there are a lot of operators.

ETSI does not suggest addressing the interconnection point. In this method routing number let the call go forward to interconnection point. In other words, it contains the information that supplies the routing number to connect to the dialed subscriber. So the directory number of the dialed subscriber is required for connecting to the subscriber though interconnection point.

Recipient Central: Routing number defines the recipient central to which the subscriber is belonged to. Directory number is required for completing the routing. The advantage of addressing the central is that it does not require database querying for completing the routing in this method. As the routing number defines central, the directory number of

the called subscriber, which is one of thousands subscribers, is needed for defining the dialed subscriber [4].

End Units: Routing number defines the subscriber reaching line. Routing number defines the subscriber whose number is carried. Addressing the subscriber with the routing number is a problem [4]. The reason is that a routing number must be used for each routed number. Also from financial point, an arrangement on to the subscriber connection will cost a lot, because it will cause a change in the routing records.

That is why ETSI suggests not using this method because of routing number is defining the dialed subscriber directly, using a routing number for each routed (carried) subscribers, and it will cause using the numbering source insufficiently. In other words, two numbers from numbering source have to be assigned to a subscriber, whose number is being routed [4].

Combined Units: Addressing, with routing number can be a combinations with any of the units explained above. An operator can choose the units that routing number addresses, in NP method. More than one method can be used together with taking care of the bigness (largeness) of the network, Interconnection point situation with the other networks and also its technology [4].

3. WIRELINE NUMBER PORTABILITY

Wireline Number Portability is the Service Provider Portability which is applied to geographic and non-geographic numbers [1].

3.1. Number Portability Solutions

NP solutions are examined under two categories based on the mechanism used to hold the numbers. The solutions are called as 'on-switch solutions' and 'Off-Switch solutions' [5]. In the on-switch solution, portability record of a number is hold at separate exchanges. However, in the Off-Switch solutions portability record of a number is hold at a central database and a local copy of this database is integrated to the related local exchanges for ease of management.

NP solutions are classified inside themselves as below:

- On-Switch solutions : Onward Routing, Call Drop Back
- Off-Switch solutions : Query on Release, All Call Query

3.1.1. On-Switch Solutions

In On-Switch solutions portability record of a number is hold at the donor network; accordingly calls to the ported number are firstly forwarded to the donor network. In On-Switch solutions there are onward routing and call drop back. In Figure 3.1, the forwarding procedure of a call to a ported number is shown[5].

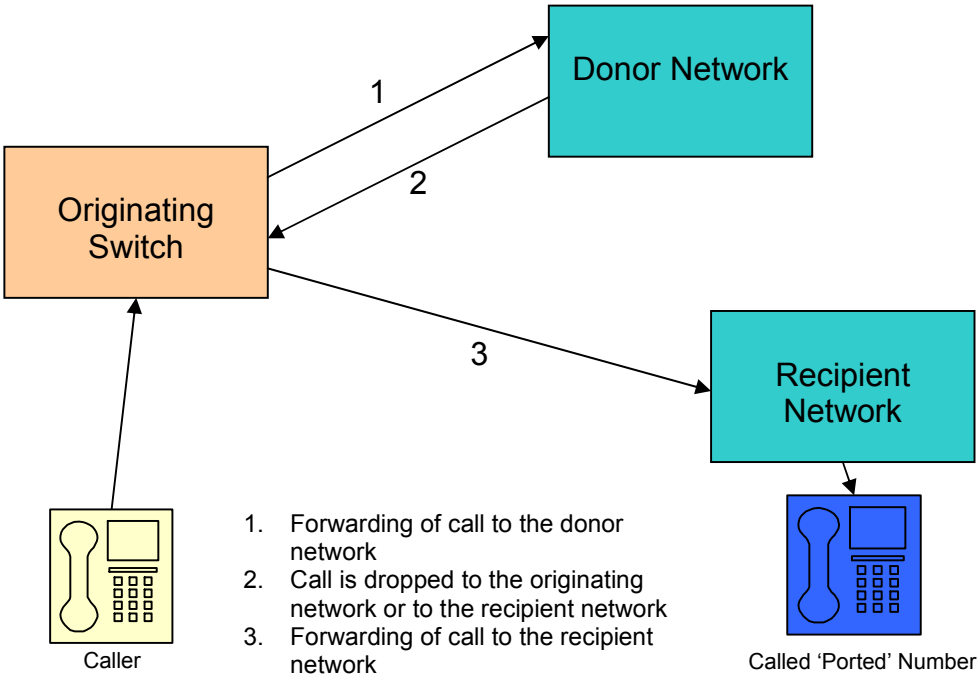

Figure 3.1 General view of On-Switch solutions

3.1.1.1. Onward Routing Solution

Onward routing solution is generally the first solution applied at NP studies [5]. With this solution, the call is firstly arrived at the donor network. The donor network searches its database and controls the called number whether it is a ported number or not. If the number is ported, then donor network searches its database and finds the forwarding number of the ported number and forwards the call to the new position (Figure 3.2). Here, only the donor network is holding the NP record.

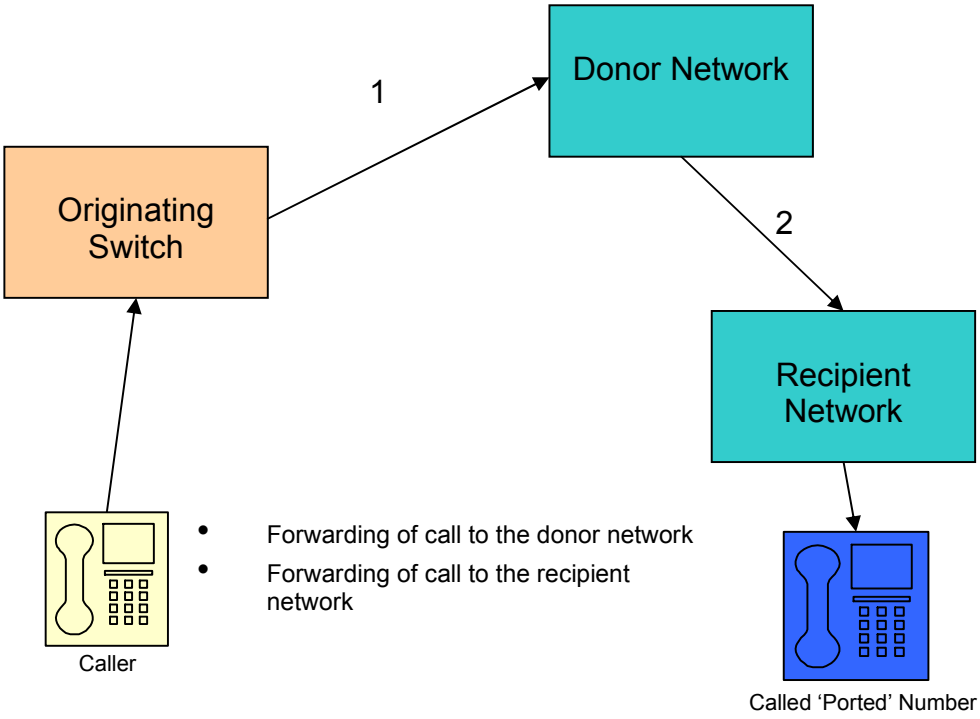

Figure 3.2 Onward Routing

There may be another alternative way for the call if there is a transit network between donor and recipient networks.

In this type of structure the donor network cancels the line of the subscriber, but does not erase the record of subscriber [1,5]. This record is used to forward the call to the recipient network. The recipient network establishes the line and creates a new record for the new subscriber. According to the used address and forwarding structure a routing number is allocated for the ported number.

3.1.1.2. Call Drop Back Solution

Call Drop Back solution is an advanced version of the Onward Routing solution (Figure 3.3). Donor network takes the call and detects whether this call is to a ported number; if so, the donor drops the call back, but the donor provides the NP information for that number and a message says that this number has been ported. This information and message are used by the transit or originating network to send the call to the new position [1,5].

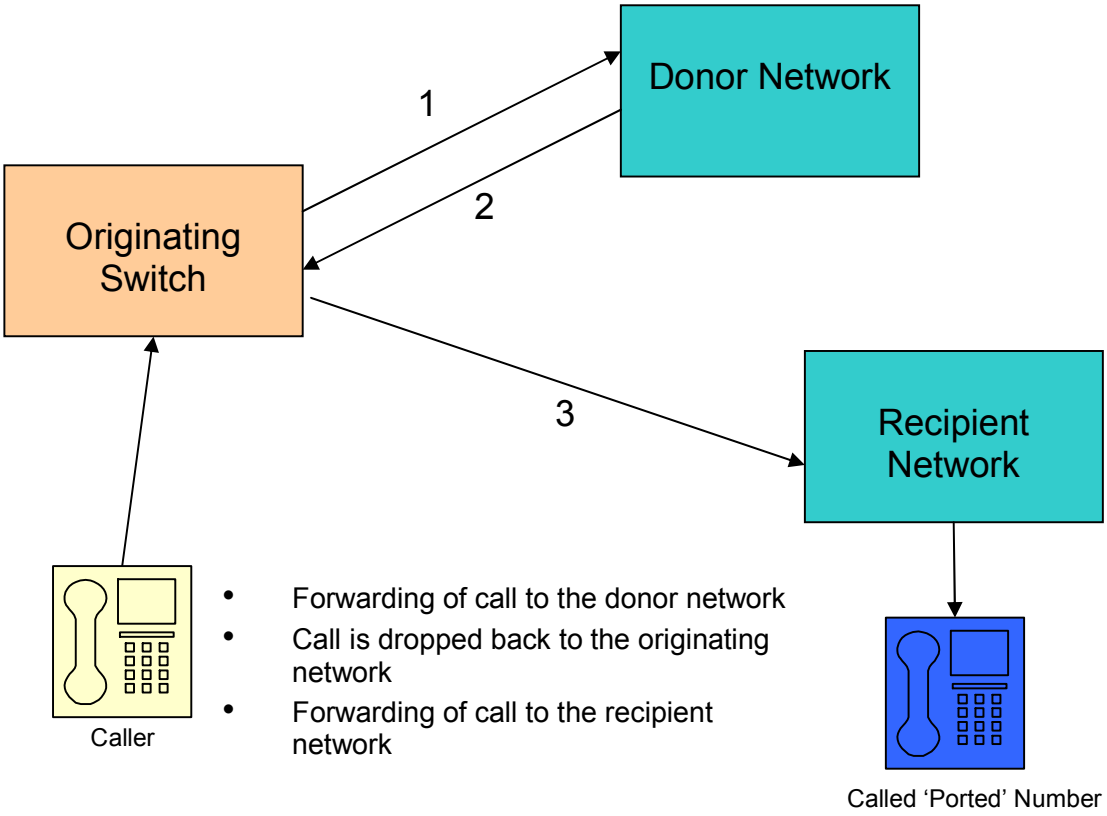

Figure 3.3 Call-Drop Back

As it seems in the figure, the donor network routes the call to the recipient network.

3.1.2. Off-Switch Solutions

In Off-Switch solutions, which is called 'intelligent network solutions' at the same time, the database is searched to detect whether the called number is ported, and if so the new position information is found in the database and call is forwarded. With the help of Off-Switch solutions the call is forwarded in an optimum way. The forwarding procedure of calls with Off-Switch solutions is shown in Figure 3.4.

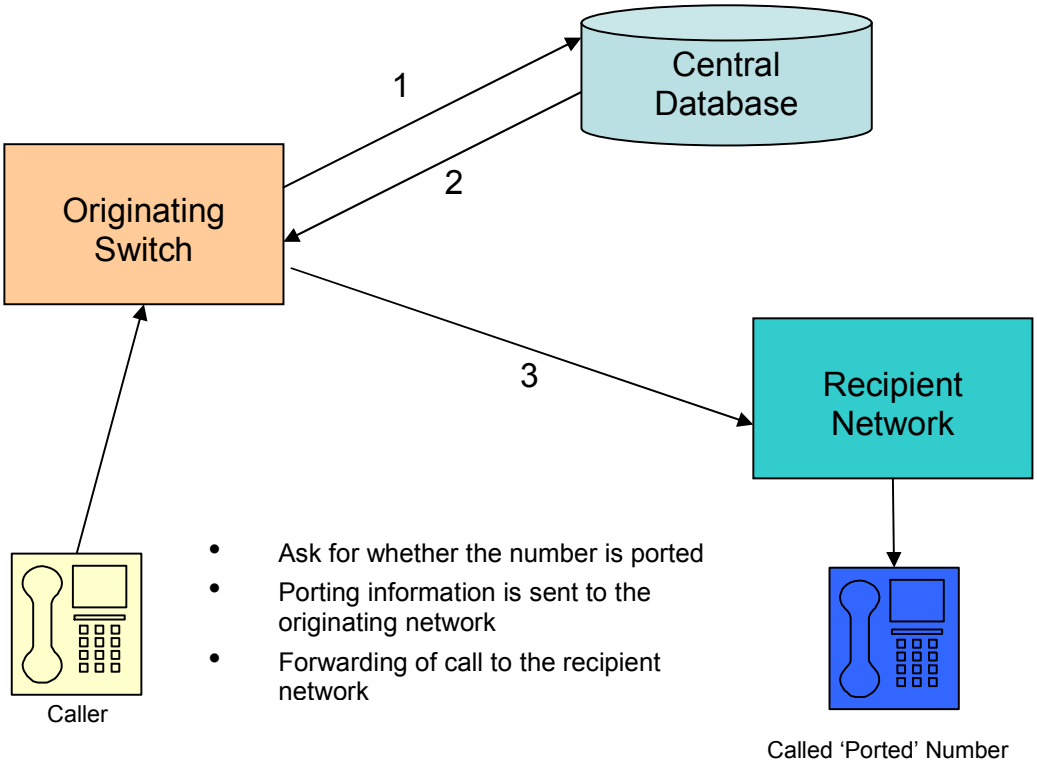

Figure 3.4 Off-Switch solutions

3.1.2.1. Query on Release Solution

In Query on Release solution, the donor network detects whether the called number is ported when it takes the call; and learns whether the previous network has the capability of 'Query on Release' and lastly sends the release message to the related network [5].

This message remarks that the number has been ported. With the help of this message, the related network searches the database and finds the porting information; then this network forwards the call to the recipient network and so to the subscriber. In this structure, the transit network has the ability of accessing to the database which holding NP information (Figure 3.5).

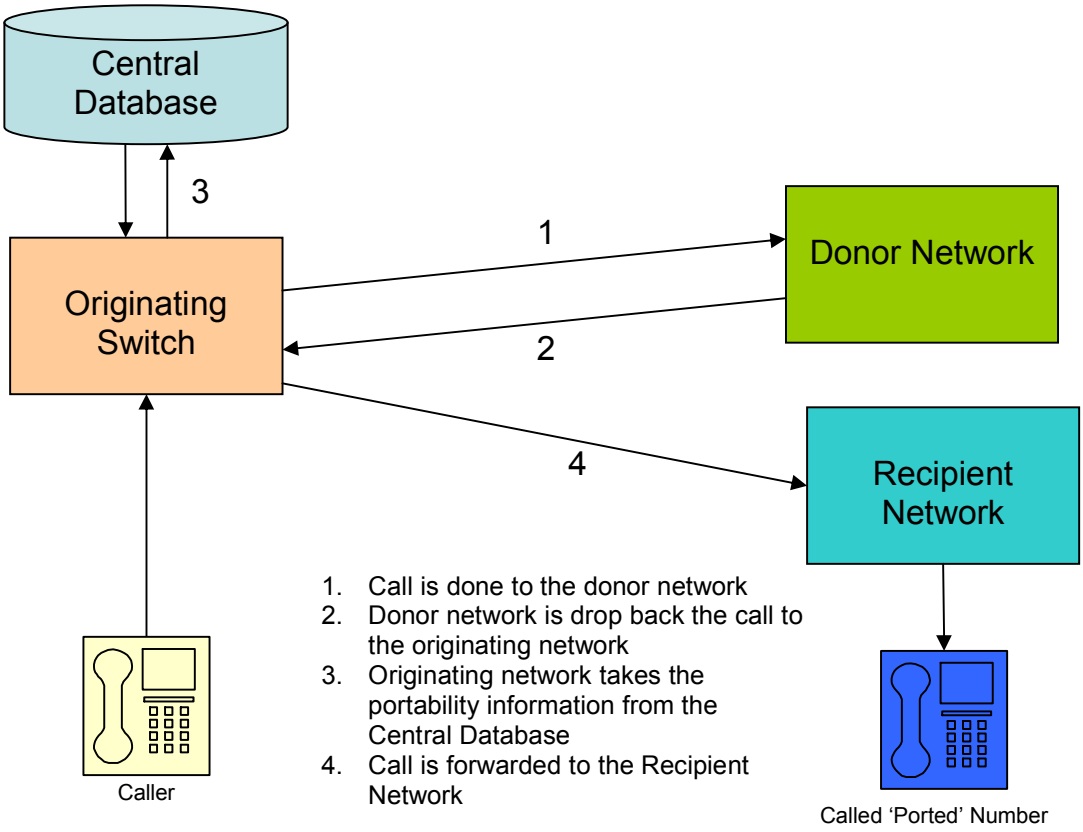

Figure 3.5 Query on Release solution

This solution seems as a combination of Call 'Drop Back solution' and 'intelligent network solutions'.

3.1.2.2. All Call Query Solution

In 'All Call Query solution', database search is done for every coming call-even that call is not to a ported number. If the call is to a ported number, then it is routed to the related network with the help of information taken from the database search. If the call is not to a ported number, then it is connected to the related subscriber [1].

In this structure, the originating network has access to NP database for the purpose of reaching data about the receiver network and the full address. In this way, the database search is executed once [5]. On the other hand, if one database search is not enough to find the real place of the ported number; more database search may be needed.

The most important advantage of this structure is that calls to a ported number are routed without entering to the donor network; and the disadvantage is that all calls are subject to database search which may cause time delay [4].

In the Figure 3.6, the schematic view of 'All Call Query' is shown [1]. As it seems, donor network is not related with the calling activity to the ported number. Database search is done by originating network or transit network.

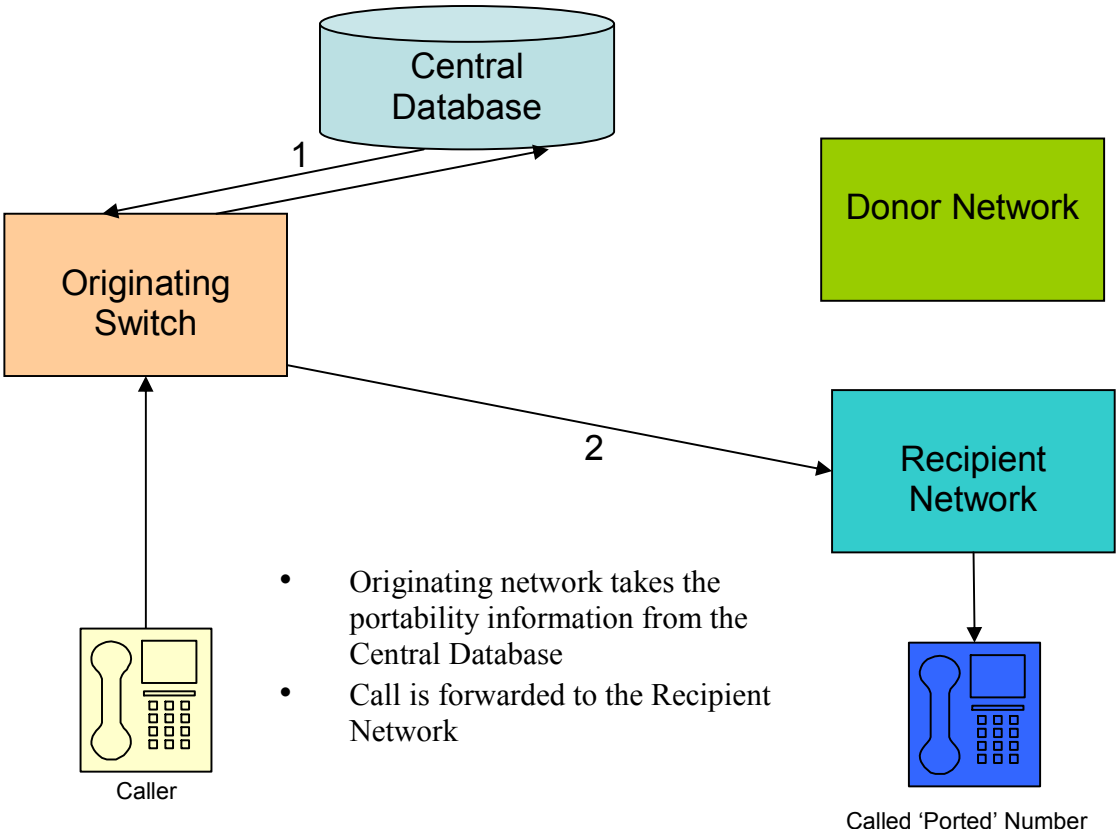

Figure 3.6 All Call Query solution

3.1.3. Comparison of Number Portability Solutions

For the systems which does not have Intelligent Networks 'Onward Routing solution' can seem as the best solution for NP; because the system can be established easier with this solution using present network architecture and technology than other solutions. However, the density of the traffic to the ported numbers becomes a very important factor at the efficiency of the system; because the calls to the ported number are routed form the donor network and this may busy the transmission network [4].

Intelligent Network solutions like All Call Query are long term solutions, which can be installed after Onward Routing. To make such an application, all of the administrators should make agreement mutually. Transferring from Onward Routing solution to All Call Query does not require any change, so both solutions can be used together [4].

Call Drop Back and Release solutions are best applicable for the situations that traffic of the routing numbers are not so heavy. Because of not routing over the donor network, transmission connections can be used efficiently. However, in these solutions, a database should be build up and network administrators should make agreement mutually. In Call Drop Back, in spite of not need a database, the donor network should save the routed number.

When country samples are investigated, it seems that On–switch solutions are used often. From the point of the view of the administrator, Off-Switch solutions have some advantages over the on-switch solutions [4]. Moreover, high cost of intelligent network and central, on switch solutions are preferred at first stage, then passing to intelligent network solution gradually.

When looking at the country applications, in France and England on switch solution for a long term, in Netherlands Off-Switch solution applied for a long term solution, and not using a transition solution. In Sweden and Finland, on switch solution is used as transition solution and intelligent network solutions are preferred as a long term solution. In Germany, more than one solution is used as parallel [8].

In a research made on European countries, it seems that on-switch solutions are cheap but for a few years of period, because of the insufficient usage of transmission and switching facilities, solution development and application expenses are very high [8]. Incumbent operators prefer On-Switch solutions generally because of the low cost. However, as parallel to the increasing number of routed number, routing and switching systems are used insufficiently, additional costs come up to high levels. Because of this reason, for a permanent and long term solution, intelligent network solutions are preferred.

3.2. Setting Up and Operating Number Portability

Setting up and operating of NP; it has got relations with many factors such as economical, technical and legal and defining the best system is so difficult and confusing, because the number of solution solutions is related with variations of networks [9]. For the benefits of the country, optimum solution is generally determined with the results of the studies by the committee (National Regulatory Authority, operators, producer and consumer companies).

Although the operators state the technical solution that they will use in their networks; the rules that all operators have to obey are determined by the National Regulatory Authority.

In the progress of forming the rules, called Functional specifications; to get benefit from the committees mentioned above are the position of general application. Because the rules that are determined, have to be running (operating) in the country's network. The issues on Functional Specifications will be taken charge of at the regulation level.

3.2.1. Determining the Solutions

Technical components of the solutions being used with the NP are gathered into three groups [4].

- Network establishment
- The method of porting the routing number
- Addressed unit with the routing number.

Network establishment means the technical substructure will be set up to apply the NP. They are the on-switch and Off-Switch solutions that were mentioned before. Onward Routing, All-Call Query, Query on Release, and Call-Drop Back.

Routing number indicates four alternatives which are concatenated address, separated address, routing number and only directory number.

The units, addressed with the routing number consist of 6 alternatives which are network end units, recipient network, interconnection points, recipient exchanges, only directory number.

The technical components that are explained above form a three dimension matrix structure and theoretically figures out 4x4x6 = 96 possible technical solutions. But theoretically 96 technical solutions may not be possible in practically for all. By the evaluations that ETSI does not suggest some solutions, NP solutions will decline. Table 3.1 indicates the solutions that ETSI suggests.

Table 3.1 Technical components in Number Portability

Components	**Solutions**	**Number of Alternatives**
Operating structure	Onward Routing, Call Drop Back, Query on Release, All Call Query	4
Routing number	Concatenated Address, separated Address ,Only directory number	3
Addressed units with the routing number	Recipient Central, Recipient Network Interconnection point , None (only when directory number is used)	4

According to the table 3.1, there are 48 kinds of applicable alternative solutions about NP [4].

The evaluation made above is concerned with the technical solutions; cost, administrative issues, and service have to be taken care for defining the best solution in the establishment of the NP.

The main issues that we must take care in establishment of NP are:

- Aimed time scale
- The features of the present network (Digitizing level, the existence of intelligent network platform, network structure)
- Interconnection structure (Number of connection points, interconnection level, transit areas)

- Applying measurement of NP (Number of lines that can be counted, general usage of the service and number of operators)

The effective and defining players on the issues mentioned above are national regulatory authority, legal mandatory authorities, new operators, and procedures.

Although the National Regulatory Authority does not take an active role in determining the technical solutions in general applications; it decides the rules (functional specifications) that the operators have to obey and application time scale.

Legal mandatory operators generally do not like NP Application. Bigness of the network and the using technology cause a high level cost in NP and this high level cost will be paid by leaving out a subscriber of its network. These are the main reasons for unwillingness. The role of legal mandatory operators is to improve suitable technical solutions for the rules that national regulatory authority defined and for the specifications and also to improve realistic and effective cost application.

Although the position of new operators seems same with legal mandatory operators, its application cost will be so less because of its network's being so small and modern and suitable for competition.

The role of producers, concerned with the NP, is to supply expert supporting and to improve suitable solutions and also to support it to be applied. When we look at the applications, it is seen that firstly on switch solutions are used, then Off-Switch solution are used because Off-Switch solutions are permanent and active.

Evaluation of ETSI, NP solution can change country to country or network to network [4]. There is not only one solution that can be suitable for all scenarios. But in the networks where the competition is being advanced, the best solution in the first step is Onward Routing because there will be a little demands in NP [9].

3.2.2. Operation

The most important difficulties faced with in NP are administration of the service and the procedures between the operators [4]. Therefore, improving fast and easy operating procedures for the end user is required.

These procedures consist of establishing NP, covering the demands, interference in the case of defection and invoicing.

The most common solution is one stop shopping that the subscribers contact only with the recipient operator to get the NP service. The reports and the documents that will be sent to the donor operator are prepared by the recipient operator.

So, setting the time of porting the number can be consisting of two ways. Doing the activation and deactivation operations on the stable time that the recipient and donor operators agree on or doing the activation in a few days after doing the deactivation.

The solution that will be applied is considered by the concerning operators but there is legal regulatory authority control on this solution.

3.3. Economical Aspects of Number Portability

The financial level of NP is considered importantly by even National Regulatory Authority and concerned operators. In many applications, less cost intermediate applications are preferred first because of high cost factors and then more active intelligent network solutions are used gradually.

3.3.1. The Categories of Costs of Number Portability

In a study made for European Commission, the cost items about NP can be classified in two groups; establishment cost and utilization cost [8].

Establishment cost can be classified in items.

System set up cost: setting up national central reference database and etc. These costs are on the systems that have to be established by all the operators concerned about NP.

Per-operator set-up costs: They are the costs of arranging allocating and invoicing of all the operators, and they are the costs of establishment of the system and the lines for reaching national database

Utilization cost items are given below:

Per-line set up: it is the cost to arrange the data of concerned subscriber in the donor network.

Additional carrying costs: It is an extra cost incurred as a result of processing and routing of a call to a ported number.

In the Table 3.2, the terms of solutions which were applied, the cost issues which can be considered under each cost item and the sides which were exposed to so-called cost are stated. As it can be seen from table that the cost level of system set up is concerned with the applications that are used [5].

Although the system set up cost in on-switch solutions is less than in Off-Switch solutions; additional carrying cost can be negligible in Off-Switch solutions, however in on-switch solutions additional carrying cost is in high levels.

In a study made by Europe Economics and Arcome SA, making samples about the cost of NP, some approximations are made about the cost levels [7]. In the sample, 1.000 local centrals (in ten different types) 100 transit centrals (in four different types) for legal mandatory operators and 20 local and 24 transit centrals in the same type for the new operators in this business are sampled. According to this study, when call-drop back is used, the system set up cost for the legal mandatory operator, is 57.7 million Euros and for new operator; it is 1.64 million Euros. When using off switch solution, the system set up cost for the legal mandatory operator is 56.5 million Euros and 8 million Euros for the new operator.

3.3.2. Cost Allocation Principles

System set up cost is collected for a year, on the basis of equal sharing or the stock rates of the operators in market. System set up cost per an operator is paid by the operator on the system and it is not generally shared.

Table 3.2 Costs involved in Number Portability applications

	On –Switch Solutions			Off-Switch Solutions		
	Costs Involved	Significance of Costs	Main Party Incurring Cost	Costs Involved	Significance of Costs	Main Party Incurring Cost
System Set-up Cost	• Software evaluation in switches, • Adaptation of information systems, • Creation of inter-operator service management tools and procedures, • Adaptation of maintenance and customer support procedures.	High Proportion of Total cost	The bulk of the costs will fall on the incumbent or donor network operator, although new entrants will also incur some costs.	• Set-up of intelligent network • Adaptation of information systems • Creation of inter-operator service • Management tools and procedures • Adaptation of maintenance and customer support-care procedures.	Significant proportion of total cost(higher than on-switch solutions)	High impact on all operators.
Per-Operator Set-up Cost	Initial programming of switches	Small proportion of total costs	Low impact on the mandatory operator as well as other originating and transiting operators.	• Initial programming of switches • Access to national NP Databases	Higher proportion of total costs than in on-switch solutions	Medium impact on all operators
Per-Line Set-up Cost	Modification of subscriber data	Very small	Medium for the mandatory and low for other operators.	Modification of subscriber data	Very small	Medium impact on the mandatory and low on other operators.
Additional Carrying Cost	Non-optimal routing of calls and Tromboning	Varies depending on technical solutions but can be quite high	High impact on the donor network operator and medium for others	Additional carrying cost for intelligent network query	Negligible	Very low impact on all call-originating operators.
Other Administration Costs	Allocation of non-geographic numbers	Negligible	Very low impact on the NRA	• Management of a national ported numbers database • Allocation of non-geographic numbers	Very small	Very low impact on the NRA

Sharing of utilization cost is often applied. There are some solutions given below are used to share extra carrying costs and per-line costs.

- The donor network should bear all costs.
- The recipient network should bear all costs.
- Sharing under arrangements: with proportions determined by national regulatory authority, the donor and recipient networks should share the costs.
- Sharing by agreement between operators: sharing costs between the related operators should be done by the help of accepted proportions and rules defined by the negotiations between related operators.
- The customer should bear his/her own costs.

It is very important that whether the application in sharing costs is symmetric or not.

Only if the operator that has the effective marketing power is responsible of providing the service of NP, it then should recover the costs from other operators. The mentioned costs are mentioned as inter-operator costs. In Table 3.3, inter-operator costs of some European countries are given [5].

In European Union, most authorities suggest that the set-up cost should be shared by all of the users, because this will improve liberalism and competition in the market. Those authorities also suggest that the subscriber should pay the usage cost, because taking the NP service depends on his/her option.

From the point of operators, whether the operator has the effective marketing power is also an important issue. System set-up costs are invoiced to the subscribers by the operator that has the effective marketing power [5]. However, the mentioned costs are under the control of National Regulatory Authority. This situation is not valid for the operators that do not have the effective marketing power and those operators define the prices on their behalf.

Table 3.3 Samples of Existing Inter-Operator Charges for NP

Costs	Finland	France	Germany	Netherlands	UK
Cost Per-Line	140 Euros (one-off)	15 Euros	No charge	9 euros	6 – 8 Euros
Cost Per-Operator	4 euros per month	520 Euros	No charges	No charges	No charges
Additional Carrying Cost	0.004 Euro per call 0.007 Euros per min.	0.007 – 0.009 Euro per min.	No charges	Subject to commercial negotiation	No charges

It seems that per line administration costs in 4 of 5 EU Member States are passed on to the other operator (Table 3.3) [5]. However in Germany the NRA, Reg TP, has ruled that a charge on costumers could deter them from exercising their right to change operators while retaining their telephone number.

The additional carrying costs have emerged as the cost category most likely to cause difficulties in Member States. Those member states that have chosen Onward Routing solution that creates significant additional carrying costs and have allowed their donor network operator to pass on these costs to the recipient network operator (such as France and Finland) have experienced a low take-up of NP. In Ireland, additional carrying cost is charged by the originating network. The mentioned operator is free to charge the cost from the subscribers.

For it is difficult to get it from the concerned sides by allocating and invoicing costs, ODTR's opinion is to find an average cost and if the invoicing cost is more than that cost, it is a way of not invoicing the cost till the profit is made.

Table 3.4 indicates Cost Sharing Model suggested by Europe Economics & Arcome SA [5].

Table 3.4 Recommended Sharing Models for Cost Allocation

Costs	Recommended Sharing Model
Set-up Costs	All operators should bear their own set-up costs by themselves. The effective operator of the market (legal mandatory operator) should be able to reflect these costs to the subscribers under the control of the national regulatory authority.
Utilization Costs • Additional Carrying Costs • Per-line Administration Costs	When practicable to do so, additional carrying costs should be charged by donor network operator to call originating operator. However, as the donor operator is generally the legal mandatory operator, sharing model should not obstruct the legal mandatory operator of setting-up a more effective model. Per-Line Administration costs should be passed on by the donor network operator to the recipient network operator; but the mentioned cost should be cost oriented not impede the competition.

3.4. The Regulation Principles for Number Portability

In NP, National Regulatory Authority's main goal is to support the effective competition that will be applied technical, administrative and financial solutions and to supply its being applicable. In this manner, the missions of the National Regulatory Authority are summarized below:

- To manage National Central Reference Database.
- To improve functional specifications for NP and to define the time scales.
- To define the cost-allocation issues by evaluating the effects of technical solutions that will be applied by the operators.

3.4.1. Central Reference Database

Constructing independent National Central Reference Database is an important subject, when talking about the Off-Switch solutions. This database holds the portability information of the networks. Here, the important point is that the national database is not responsible for forwarding the call; but it provides the portability information to the operator which is responsible for forwarding the call.

When looking up from the financial/management dimension of this database, management of the database should be operated by an independent company or institution. The mentioned company/institution is detected after an adjudication done by the National Regulatory Authority. The company/intuition selected by the NRA will be responsible for all activities of the database. The construction and management costs of the database are compensated by the operators according to the one of the solutions: sharing equally and sharing according to the portions in the market. Sharing equally is an optimal solution for the legal mandatory operator, but not for the small operator. However, sharing according to the portions in the market is good for the small operator, but not for the legal mandatory operator.

3.4.2. Functional Specifications

Functional Specifications; technical and functional scale of NP consist of the general rules that operators have to obey and the general rules that will supply the effective number usage.

The issues in Functional Specifications are reported technically by ETSI. In this report general responsibilities of operators/service providers about NP are given below [4]:

As a reciprocity principal, the recipient network should act like as a donor network. The solutions used by the operator should be under control of itself, but the operator should conform with the below principals:

- Service provider should provide a voice message if the call is wrong.
- Service provider is responsible for its customer. However, the procedures between the donor-recipient operators should be defined to provide the answer to the subscriber just in time.

- The information needed for accounting should be provided between operators.

For Wireline NP, ETSI set the responsibilities below [4]:

The Originating Network : If operator selection is present, the responsibility for NP is at the operator network. Here, the mentioned network is the originating network.

Transit Network : Transit Network is network which carries the call between two networks. Transit Network may work also as a service host network. The reciprocities of transit network, while it is not a service host, are:

- If the previous network adds the routing number, transit network takes the call to the recipient network.
- If the previous network does not add the routing number, transit network takes the call to the donor network.

Donor Network : The donor network has not a special duty at the times it does not work as a host network.

Recipient Network : Responsibility of the recipient network is to route the call to the subscriber.

Service Provider Network : Service Provide Network is responsible for detection of the number whether ported or not, detection of the routing number after interrogating of the database, addition of routing number, forwarding the call to the recipient network.

The National Regulatory Authority should make the operators conform to the principals of ETSI above. These specifications are performed by most of the countries.

3.4.3. The Regulation of Cost Allocation

The National Regulatory Authority is much concerned with the sharing of costs, which is related with the technical solutions. Consequently, the National Regulatory Authority should work with the operators while selecting the technical solutions. The main responsibility of the authority is to select the best solution which is advantageous for the entire operators, equally [5].

The most important matter about the cost sharing is that the cost sharing solution should not block the operator selecting a more effective solution.

4. MOBILE NUMBER PORTABILITY

Mobile Number Portability (MNP) is a customer's changing his/her mobile network operator and/or service provider while retaining his/her E.164 number [1]. The solutions of the NP used on Digital Mobile Telephony Networks and related aspects are mentioned in this section.

4.1. Technical Aspects of Mobile Number Portability

Technical solutions adopted should meet the criteria of fairness, openness, feasibility and simplicity. The National Regulatory Authorities are responsible to make sure that the criteria are fulfilled.

In discussing technical solutions for the MNP, it is useful to make a distinction between "Call-Related Functions" and "non-Call-Related Functions" (Table 4.1). The call-related functions are the functions which are used to establish a call to a mobile terminal; the non-called related function are the functions which are involved to provide services such as SMS (Short Message Service) which are not directly linked to a call. The table which shows the solutions about the functions mentioned of NP is as below:

Table 4.1 Mobile Number Portability Solutions

Solutions For Call Related Functions	Solutions For non-Call Related Functions
• Intelligent Network(IN) based solutions • Signaling Relay Functions(SRF) based solutions	Signaling Relay Functions(SRF)

Since solutions based on Intelligent Network and Signaling Relay Functions are the standardized solutions, in non call-related functions only Signal Relay functions are used, in call-related functions the network functions and one of these solutions related to the equipments used is chosen.

4.1.1. Porting of Call-Related Functions

4.1.1.1. Solutions Based on Intelligent Network

Establishment of a call can not be based on the simple digit analysis of the called subscriber number which is ported. This type of analysis is only points to the donor network. Therefore, the goal that lies behind this solution is to obtain the routing information by interrogating the database. The mentioned interrogation may be performed in the originating network, a transit network, or in the donor network. In the Figure 4.1, it seems that the call is routed to the donor network that performs the NP Interrogation [8].

When the signaling message used to set up the call and containing the called party number reaches the GMSC of the donor network a interrogation to the IN NP Database is triggered (Figure 4.1). If the number has been ported the result of this database dip is the routing number (B) used to route the call to the recipient network.

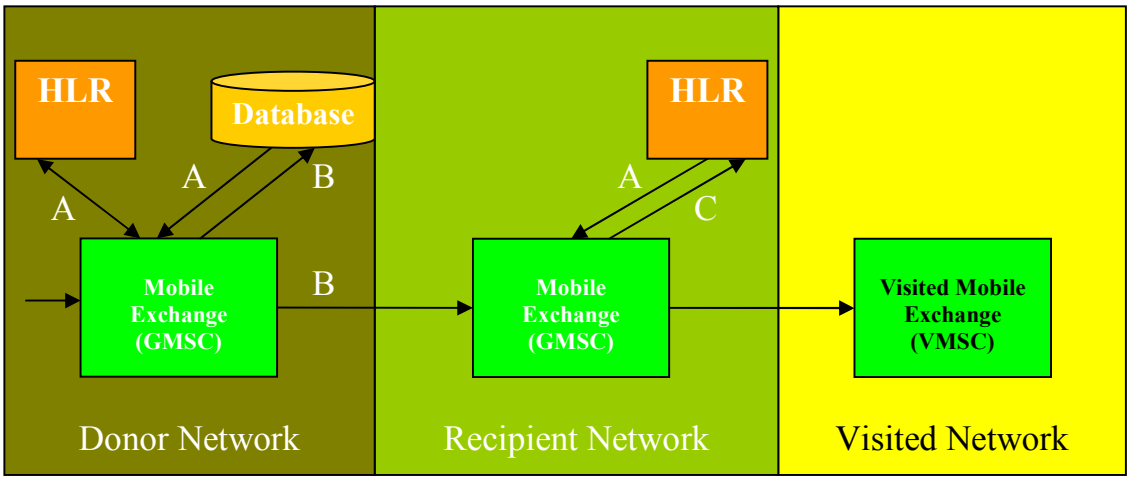

Figure 4.1 Forwarding the call with IN solution

Here,

A : Dialed Number

B : Routing Number

C : Mobile Subscriber Routing Number

GMSC : Gateway Mobile Switching Center

VMSC : Visited Mobile Switching Center

4.1.1.2. Signaling Relay Function

Signaling Relay Function includes re-routing capabilities provided by the signaling system at the Signaling Connection Control Part Level (Figure 4.2). In other words, The SCCP is used in signaling system. The SRF (Signaling Relay Function) interrogates the set-up messages used to route the call, performs the portability checks and returns routing information to the GMSC or relays the message to the Home Location Registry (HLR). This can be done by either the originating or the donor network.

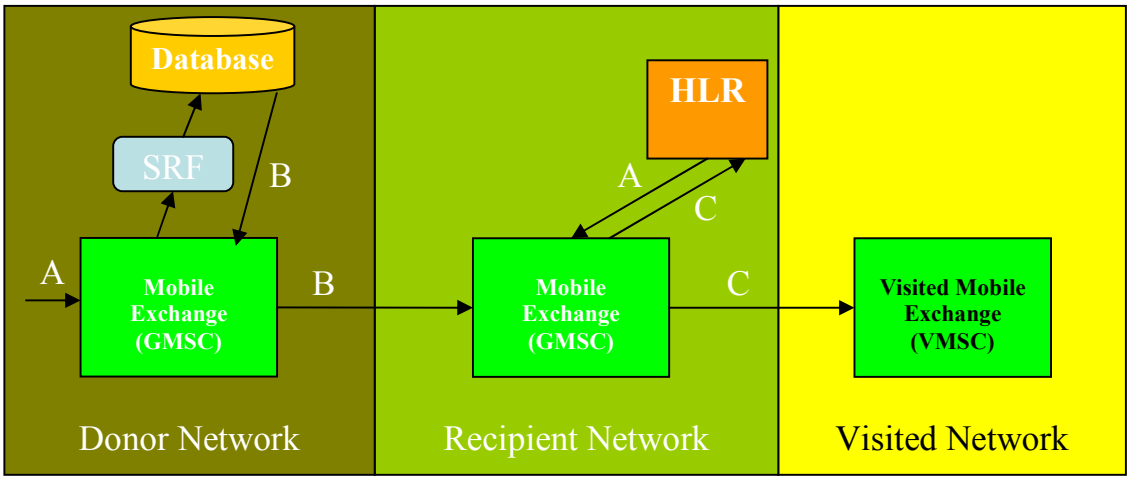

Figure 4.2 Signaling Relay Function in Donor Network

When the "set-up message" (A) reaches the GMSC a routing enquiry is sent to the SRF, analyzing the called number, determines whether the number has been ported to another network as in IN solutions (Figure 4.2). If the number has been ported; either the SRF can determine and return a routing number (B) to recipient network or it sends a message to the SRF function of the recipient network. Then, the GMSC interrogates the HLR to obtain the Mobile Subscriber Routing Number (C) used to identify the current physical Location of the called party.

4.1.2. Porting of Non-Call Related Functions

In MNP, non Call-Related Functions like SMS are also quite essential. In Mobile Number Portability, these services should also be delivered safely to the right service network. In MNP based technical solutions; non-call-related functions like SMS should also be used when the number has been ported.

4.1.2.1. Signaling Relay Function

Signaling Relay Function is used to port the non-Call Related Functions (Figure 4.3). As is the case, when the SMS is sent, it is routed to the SRF of the donor network by the SMS-GMSC. In this example showed in the Figure 4.3, the subscriber or dialed number (A) is on roaming, so the information sent from SRF of the donor network to the SRF of the recipient network is forwarded by the recipient network to the HLR to find the physical position of the subscriber. The result of the database dip in HLR (B) is the VMSC of the roaming number that is returned to SMS-GMSC. Finally, SMS is sent from SMS-GMSC to the VMSC [8].

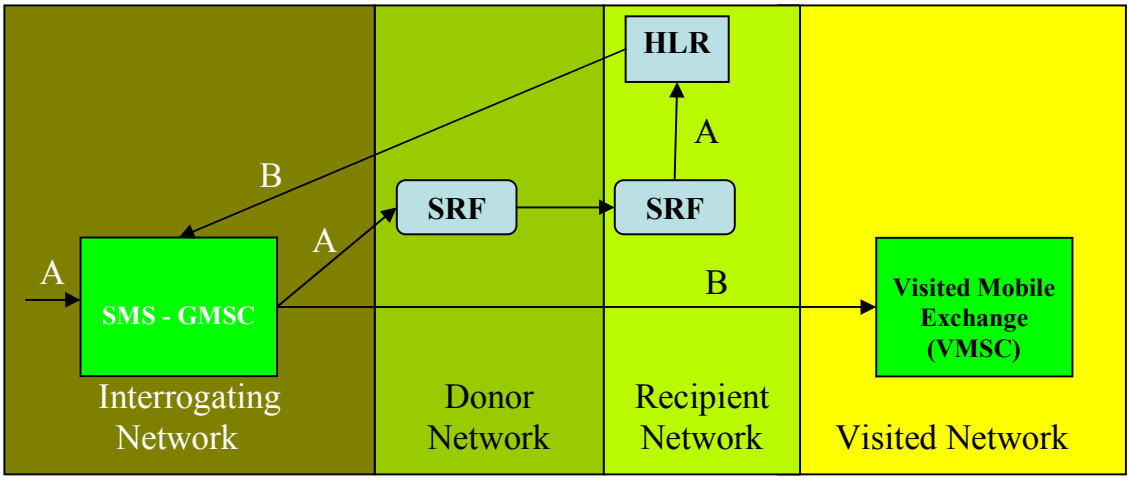

Figure 4.3 SRF solution for non-Call Related Functions

4.2. Setting Up and Operating Mobile Number Portability

4.2.1. Determining the Technical Solutions

In MNP, both solutions require some enhancement to the routing mechanism and consequently to the signaling system. However, the biggest advantage of the solution based on Signaling Relay Function is that it mostly uses the present functions of the mobile network and therefore the additional investment is more limited than the Intelligent Network solutions [8]. At the same time Signaling Relay Function based solutions are considered as a simpler and easier solution. In addition, the capability of providing MNP is offered at the SCCP level and this situation implies that any future enhancements or changes taking place at the Application Level will not interfere with the solutions for MNP.

Because, SRF is the only function applied on non-call-related functions, applying this to the call-related functions, on the other hand, will make it easy to run the system. With the growing convergence of wireline and mobile services, the large presence of IN based services, IN solutions are expected in the next few years to be increasingly used.

On the other hand, IN may represent a disadvantage in terms of cost. However, considering the benefits of intelligent Network based solutions, it will not be wrong to say that it compensates the costs fast anyway.

4.2.2. Operation

The most important difficulties faced with in MNP are the administration of the service and the procedures between the operators [4] as in Wireline NP. In addition to this, mechanisms to properly route a call to a ported number considering both call-related functions and non call-related functions is an important factor for operation.

Improving fast and easy operating procedures for the end user is required. These procedures consist of establishing MNP, covering the demands, interference in the case of defection and invoicing.

The most common solution is one stop shopping that the subscribers contact only with the recipient operator to get the MNP service. The reports and the documents that will be sent to the donor operator are prepared by the recipient operator. The process should be automated. A system for the automatic porting and synchronization of operators' switching and operational support systems should be developed.

So, setting the time of porting the number can be consisting of two ways. Doing the activation and deactivation operations on the stable time that the recipient and donor operators agree on or doing the activation in a few hours after doing the deactivation.

4.3. Economical Aspects of Mobile Number Portability

4.3.1. Categories of Cost of Mobile Number Portability

Costs involved in MNP are categorized under three headings.

- The system set-up costs
- The administrative costs
- The additional carrying costs

The system set-up costs are the incremental costs needed to establish MNP provisions in networks and support systems. The administration costs are the per-line set-up costs appeared in the porting of numbers. The additional carrying costs are the additional carrying costs of MNP for individual calls. Details of these costs will be described in detail later in section 8.1

4.3.2. Cost Allocation Principles

The dimensions of costs involved in Mobile Number-Portability may vary from the current network system, customer traffic to the technical solution applied. But there are generally accepted, basic principles. In a study made by ETO (European Telecommunications Office), 6 basic principles which are also being applied by Ofcom are described below [8]:

- Cost Causation : Cost allocation should have strong regard to whose actions cause additional costs to be incurred.
- Cost minimization : Those who are in a position to affect the level of the costs have strong incentives to minimize costs. Such as limiting the proportion of an operator's costs which can be passed to other or to regulate the charges and only allow certain amount of the big operator's costs pass to other operator.
- Distribution of Benefits : Cost allocation should recognize that ported numbers are not the only beneficiaries of MNP. Benefits from MNP are also accrued to callers and to other users in general.

- Effective Competition : Cost allocation mechanism should promote competition. For example, the costs which the donor operator can pass to the recipient operator should be limited. The price which can be charged to the customer ported his/her number, should be minimized.
- Reciprocity and Symmetry : MNP is required to be offered in both directions.
- Practicability : Cost allocation should be easy to implement. This might include each operator bearing its own costs or treating MNP cost in exactly the same way as other interconnect charges, perhaps just negotiating a lower interconnect charge for calls carried to the ported number.

The six principles of cost allocation described are not always straight forward. When, look at the applications, it seems that each operator bears its own system set-up costs. On the other hand, administrative costs of recipient network are compensated by the donor network and donor network reflects the cost to the subscriber only once. However, the extra carrying cost is generally considered with interconnection and in disagreement, the sharing solution is determined by the National Regulatory Authority [8].

4.4. Regulation Dimension

Cooperation of parties is a necessity to find a feasible technical solution in MNP. The parties consist of such mobile operators, National Regulatory Authority, legal mandatory operator, service providers.

ETO proposes for the National Regulatory Authorities about MNP are as the followings [8]:

- MNP should be introduced immediately
- Operators should be careful about:

  Consumer's procedure should be simple.

  Porting procedure and costs of it should be informed to customers. The procedure should be based on 'one-stop shopping'
- Customers should be informed about the reasons of inabilities to port their numbers and the duration.

- The Process Duration for MNP should not be long for the customer to get this service.
- Operators should take precautions against the trouble customers will face in porting action, in order to keep it at minimum level.
- A Database for MNP registry should be set up by each operator or a central database should be set up and an independent company should provide the safety.
- For technical solutions to MNP, National Regulatory Authority should not be supportive but should provide a fair, open, practical, and simple application.

5. NUMBER PORTABILITY BETWEEN WIRELINE AND MOBILE SERVICES

Wireline-Mobile Service Portability enables a subscriber to move between wireline and mobile services without changing his/her E.164 number and service provider [8]. From a customer's point of view, an integrated service package one terminal, one number and one bill are very attractive. Today, there are terminals available that can be used both as a mobile phone and a cordless wireline phone at home.

There are obstacles to set up wireline-mobile Service Portability due to the existence of technical and regulatory barriers. Considering technically, that there are not standardized solutions at present is an important barrier. The current difference between the prices of mobile calls combined with the need for tariff transparency represents, in short term, important barriers to Wireline-to-Mobile Service Portability [8].

6. EFFECTS OF NUMBER PORTABILITY

Short term effect on Numbering Plan of NP shows itself as the number has the identity of the service provider [10]. Assignment of geographic numbers is done as blocks to operators; therefore, any customer may affect the system when he/she wants to port his/her number. Because of the ported number, the amount of the numbers assigned to the operator not only decreases but also it will be impossible to get information from the ported number about the operator [10].

The Effect of NP to the National Numbering Plan is, after 5 years and over, disorders in the structure of numbers. For example, Service Portability means losing service information on the number, and Geographic Portability applied on national content means losing geographic information.

ETO's evaluation for long term in Service Provider Portability is that portability of wireline-mobile services will be possible. One point that should be concerned for portability to this and other services is that how much operators will care about the information that numbers carries. In other words, the tariff that the number carries and preservation of Service Portability have precedence application of service and Geographic Portability can be limited to preserve relevant information [10].

Since Geographic Portability that –will be applied to national level- will be able to be obtained by having the open numbering plan changed to closed one, geographic information and tariff are the matters that need to be concerned carefully on the consumer's point of view.

In the applications of Service Portability, the subscriber may be informed about the service and tariff information through voice messages or written messages if the phone has screen. On the other hand, the subscriber is not able to be informed about the service and tariff information, and then the Service Portability may be limited.

Forwarding numbers and the place they are occupying are another important issue of NP should be careful when making numbering plans. ETO's evaluation points out that NP

will affect the number allocations in the long term; therefore the institutions responsible from numbering will select way of allocating numbers to the subscribers directly (individual number allocation). Individual number allocation is an applicable solution for special tariff services and personal numbers; but allocation of geographic and mobile numbers to the subscriber directly is not applicable.

7. COUNTRY SAMPLES ON NUMBER PORTABILITY

Three developed countries USA, England and France took a long way in liberation of telecommunication industry. Also, these three countries are special from point of NP and numbering plans. For instance, France is a good example for closed-numbering plan while England is a good example for open-numbering plan; however the numbering plan of USA is different from those two because it is an integrated plan indicating nearly 23 countries. Moreover, in US management of numbering plan is on the response of an independent authority (North American Numbering Plan Authority-NANPA).

In France, NP service on wire line network started in January 1998. Technical solution used for geographical numbers is Onward Routing. According to France Telecom, transition to a more effective way of solution is based on the number of subscribers benefited from NP [5]. France Telecom wait a few years for NP of the non-geographic numbers and finally MNP was implemented in Metropolitan France on 30 June 2003 following long discussions with players, and with mobile operators and consumer associations in particular. The choices made at that time took into account long-term objectives such as efficiency and consumer protection but also included more short-term considerations, such as the need to avoid delaying the launch of portability [11].

In England, first application of NP was done in April 1996 for geographic numbers (only for wired network subscriber phones). Primarily, NP application was a condition added to the license of British Telecom; subsequently added to the licenses of other operators [12]. NP for non-geographic telephones (different from mobile ones) was established in 1997. Lastly, in 1999 NP for mobile phones established. Nowadays; NP is applicable for geographic, non-geographic and mobile numbers in England [13].

Primary applications of NP in England were restricted with numbers assigned by the operator (number blocks). This application was changed by Oftel (now Ofcom) in 23rd of 1999 as subscriber has the ability of getting NP service when he requests. Meanwhile,

the approach of Ofcom to NP service is “a service that must be provided to all subscribers by the operators [10].

In England, the current allocation of costs associated with portability is done with cost sharing solution. 1995 Monopolies and Mergers Commission (MMC) recommendations derived this principle which has since been supported by industry. This principle applies to both geographic and non-geographic numbers. Given that this principle was supported by industry and has worked under the current NP regime, Ofcom considers that it should continue to be applied to the new portability regime [14].

The current cost sharing principles and those Ofcom beliefs should be applied to the new portability regime are set out in the proposed license modification, and are [14]:

- Charges shall be based on fully allocated costs of providing portability or incremental costs (if that is what BT’s charges are based on) unless the old and new Operators shall have agreed another cost basis, or the Director shall have determined, following an application by either or both Operators, that another cost basis should be used.
- The old operator shall make no charge in relation to its System Set-Up Costs.
- Subject to the other cost allocation principles outlined in the license the new Operator shall pay charges based on the reasonable costs incurred by the old Operator in providing portability with respect to each number or block of numbers.
- The old Operator shall make no specific charge based on Additional Carrying Costs.

In USA, Telecommunication Act of 1996 has designated the local operators with giving NP service under the regulation of FCC. Related with this act, FCC has made a regulation that forced all local operators in the 100 metropolitan areas have to build databases enabling NP in June 1996. In the first applications of NP, consumers with wire line phones have been able to switch from one local operator to another while at the same location without having to change their phone numbers. But, this NP situation was limited within the local area (Local Number Portability-LNP) that if a subscriber is

moving from one geographic area to another, he may not be able to port the wire line number [15].

In November 2003, wireless operators began porting wireless numbers in the 100 metropolitan areas and after this number porting between wire line and wireless operators started, too. Lastly, in May 2004 Wireless Number Portability became available for the markets outside the 100 metropolitan areas.

After local number porting action a charge named Local Number Portability End User Charge is faced by the subscriber. This is a wireline, monthly charge through which telecommunication companies may recover certain costs of providing local Number Portability service. Recoverable costs include the costs of physically upgrading, creating new facilities or improving the existing wireless network, and performing the ongoing functions associated with providing local number portability. The FCC determined that telecommunications companies may recover certain costs of providing Local Number Portability through a monthly charge on their customers' invoices [15].

From the point on Wireless Number Portability the FCC does not regulate the rates of wireless service providers because the wireless industry is very competitive. In most areas, consumers have many service provider and plan options available. Competition brings the lowest prices for consumers. Operators are allowed to charge a fee to recover their "porting" costs. Operators may or may not choose to charge a fee, and their fees may vary. If they do charge specific fees, the fees cannot exceed their porting costs. Even if operators decide to charge for wireless LNP, they may not refuse to port a number because a consumer has not paid a porting fee. In addition to this, some operators may choose to pay the old operator's costs of porting for the benefit of their new customers [15].

8. SIMULATION TOOL FOR THE COMPARISON OF THE NUMBER PORTABILITY SOLUTIONS

It is aimed to compare the four solutions on cost basis, used in Number Portability, through a simulation tool. These four methods are Onward Routing, Call Drop Back, Query on Release, and All Call Query. The simulation tool has been developed in Microsoft .NET with C# programming language. An ordinary computer which has Microsoft .Net framework installed is enough to run this tool.

The simulation tool consists of two parts. The first part, which is named as Cost Simulation, is for assessing the costs of NP. The second part, which is named as Call Simulation, is for showing the effect of NP on the cost of a call.

8.1. Structure and Definitions of Cost Simulation Tool

In Cost Simulation Tool, it is aimed to estimate the total cost of NP application. Total Cost indicates Set-Up Costs, Per-Line Costs and On-Going Costs. The structure of Cost Simulation tool is as in Figure 8.1[5].

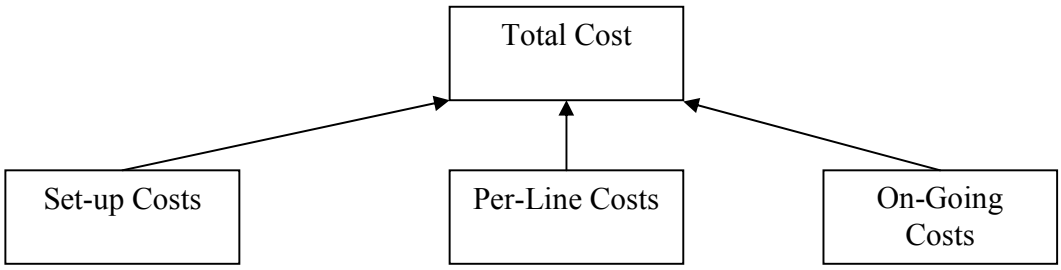

Figure 8.1 Structure of Cost Simulation Tool

Here;

Set-Up Costs	: the one-off set-up and other costs.
Per-Line Administration Costs	: costs associated with subscribers porting.
On-Going Costs	: continuous costs.

These three cost types are relevant both for On-Switch and Off-Switch solutions. However, items of these costs show difference based on the solution selected. The cost types and items are described in detail in section 8.1.1, 8.1.2 and 8.1.3.

8.1.1. Set-Up Costs

Set-Up Costs include the database costs and the costs of upgrading software. These costs are incurred for establishing the relevant capacity to provide portability in a network and between networks. Set-Up Cost items / Sub-items and brief descriptions of them are listed below [5].

Software Development Cost : The development costs are one-off costs, and related with the current switch type. Therefore, they will depend on the Donor Network Operator's characteristics. The items of software development costs are listed and briefly described in the Table 8.1.

Software Deployment Cost : Software deployment cost is all of the costs of the activities that make a software development available for use. The software deployment costs and the cost of license rights are incurred per switch. The software deployment costs could be integrated in a global network evolution plan (part of a major release). Therefore, they may not systematically be part of costs incurred by NP. The items of software deployment costs are listed and briefly described in the Table 8.2.

Licensing Cost : Licensing cost is the licensing costs of the software established to the network. The licensing costs could be integrated in a global network evolution plan (part of a major release). Therefore, they may not systematically be part of costs incurred by NP.

In On-Switch solutions Licensing Costs of software development for each local and transit switch are incurred by the operator. In Off-Switch solutions licensing cost of SSF function + IN trigger software development for each transit switch and licensing cost of Call-Drop Back optimization of each local and transit switch are incurred by the operator.

Table 8.1 Software Development Cost Items

Items	Brief Description	NP Solution
Transparent call forwarding	The cost incurred by the operator for upgrading the software on the switches to forward calls from DNO.	On-Switch
Call drop-back	The cost incurred by the operator for upgrading the software on the transit switches for call drop back optimization.	On-Switch
customer care and billing system	The cost incurred by operator for creation of new types of subscribers and billing rules, distinction between initial and current local loop	On-Switch Off-Switch
inter-operator billing system	The cost incurred by operator for creation of billing for NP activation service, new conveyance tariff for calls to ported numbers.	On-Switch Off-Switch
IN trigger in transit switches	The cost incurred by operator to add a new IN service trigger in the transit switches	Off-Switch
Development of IN NP service	The cost incurred by operator for Development of IN NP service	Off-Switch
Drop-back (query on release)	The cost incurred by the operator for upgrading the software on the local and transit switches for query on release optimization.	Off-Switch
Extension of manageable number blocks	The cost incurred by the recipient operator for extension of manageable number blocks	On-Switch Off-Switch
administration of NP requests	The cost incurred by the operator to interface with the national database for the administration of NP requests	Off-Switch
download of routing information	The cost incurred by the operator to interface with the national database for downloading of routing information	Off-Switch

Table 8.2 Software Deployment Cost Items

Items	Brief Description	NP Solution
adaptation of information systems	The cost incurred by the operator for the adaptation of information systems (the customer care and billing systems)	On-Switch Off-Switch
initial programming of routing tables	The Cost incurred by the operator for the analysis and routing of the routing prefix (es) of a RNO must be introduced in the local and transit switches of DNO (in Off-Switch solutions only transit switches).	On-Switch Off-Switch
Deployment of IN trigger and SSF	The cost incurred by the operator for deployment of IN trigger and SSF in transit switches	Off-Switch
Deployment of Drop-back	The Cost incurred by the operator for deployment of drop-back optimization in local and transit switches.	Off-Switch

8.1.2. Per-Line Costs

Per-line costs are the administrative and technical costs incurred by the request for activation of number portability for a particular customer line. They depend on many criteria. The Per-Line Administration costs will be assessed as whole, since it is very difficult to evaluate each sub-item separately. Per-Line Administration Cost is one-off cost and should not exceed the standard line activation cost.

8.1.3. On-Going Costs

On-going Costs include cost of management of non-geographic numbers (On-Switch solutions) and cost of IN system & database administration and maintenance (Off-Switch). On-Going costs are continuous and mostly incurred by the NRA, but cost of IN system administration and maintenance is incurred by the operator. The big part of these costs is the salaries paid to the people working (engineers, etc.)

8.2. Structure and Definitions of Call Simulation Tool

In Call Simulation Tool, it is aimed to estimate the cost of a call to a ported number. An operator can behave in three different forms. First one is Originating Network Operator (ONO) where the call originates. The second one is Donor Network Operator (DNO) from where the number is ported. The third one is Recipient Network Operator (RNO) to where the number is ported.

The Call Simulation consists of three parts first of which is main entry screen, the second one is operator entry screen and the third one is report screen. Graphical report part is programmed with the help of a library downloaded from www.dotnetcharting.com. The items of these three parts of Call Simulation are listed and briefly described in the Table 8.3, Table 8.4 and Table 8.5, respectively.

Table 8.3 Main Entry Screen Items

Items	**Brief Description**
Number of Call	Total number of calls that will be done to ported numbers.
Portability Solution	Portability solution that will be used at the calling action.
Call Duration	Duration of a call to a ported number
DB Search Fee	Cost of interrogations to the central database at Off-Switch solutions
Call Duration Increment	Interval of call duration increment is entered here in minutes. For time being, it is not used; but this is not an obstacle for working of the simulation as wanted.
Call Duration Increment Counter	Number of the intervals of call duration increment. For time being, it is not used; but this is not an obstacle for working of the simulation as wanted.

Table 8.4 Operator Entry Screen Items

Items	Brief Description
Operator Name	Name of the operator
Subscriber Number	Number of the subscribers of the operator in millions
Call Start Up	Fee for call start up per minute
Call Termination	Fee for call termination taken by the operator from the originating operator per minute
Fee per Minute	Base fee invoiced to the subscriber of originating network per minute
Search fee	If the operator is a DNO and the portability solution is Call-Drop Back or QoR; it may take a search fee from the ONO
Area Code	Code of geographic area or mobile operator
Interconnection Fee	If there is an interconnection over the operator, that operator takes an interconnection fee per minute
Operator Type	The role of the operator at that situation as Originating, Donor, or Recipient

Table 8.5 Report Screen Items

Items	Brief Description
Total Call	Total number of calls during period of a day
Total Call Duration	Total duration of calls during period of a day
Total Call Fee	Total call fee of calls during period of a day
CallFeePerCall	Fee of a call
CallFeePerMinute	Fee of a call per minute

8.3. How the Cost Simulation Tool Works

After selecting Cost Simulation from the menu, Cost Simulation starts. Firstly, Main Definitions Screen comes (Figure 8.2). Here, the basic inputs are entered. The requested duration for simulating the cost is entered into Simulation Duration. Then, the names of the operators are entered under Name and initial subscriber numbers are entered under the Initial Line Number in millions. After that, yearly subscriber changes should be

entered through Edit for each operator one by one. At any phase of Cost Simulation, Reset Definitions can be selected to reset the simulation.

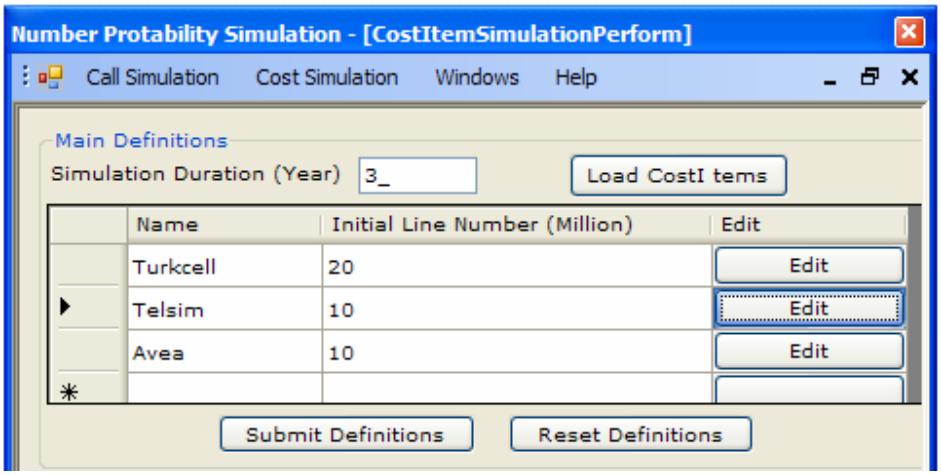

Figure 8.2 Main Definitions Screen

Once the Edit is selected, the Operator Line Number Change History screen is opened (Figure 8.3). At this point, it is noticed that the number of the years is same with the simulation duration as expected. For each year, three values entered. First value, which is named as New Subscription Percent, is for the total percent of new subscriptions to this operator. Second value, which is named as Lost Subscription Percent, is for the total percent of closed or ported numbers from this operator. Third value, which is named as Ported Subscription Percent, is for total percent of ported numbers to this operator.

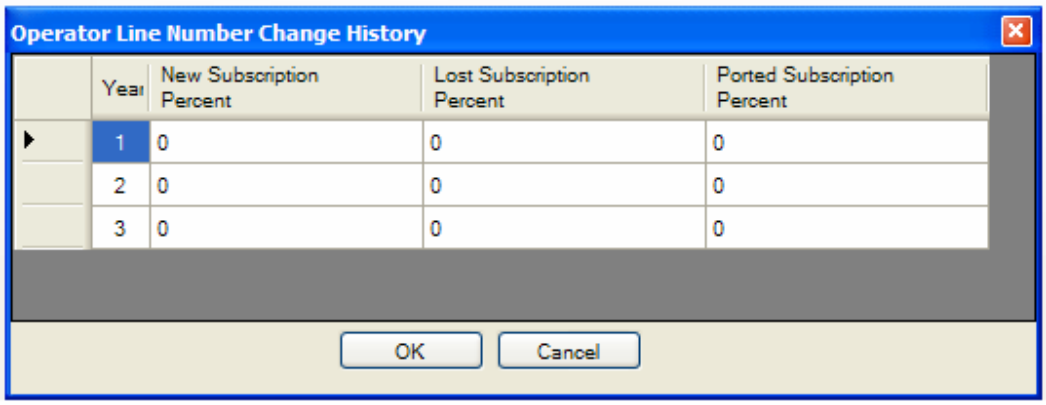

Figure 8.3 Operator Line Number Change History screen

After the values for each year are entered, this screen is confirmed and returned to the Main Definitions screen. Afterwards, Load Cost Items is selected that is for loading the

XML. This XML file includes the cost items and values for them. Lastly, to confirm and to access the main part of the simulation, Submit Definitions is selected.

In the Cost Items screen, cost items are listed horizontally (Figure 8.4). Under each item, there are sub-items of that item. Here, these items are transferred from the XML file. Furthermore, in order to make it easier to use simulation, values of items can be transferred from the XML file. In spite of this, the values could be entered manually by hand. Summation of costs of sub-items gives the cost of the item. Moreover, summation of the items gives the total cost for the related portability solution.

The quantity of the sub-item times the unit cost of sub-item gives the cost of the sub-item. As it is mentioned before in the section 8.1, cost items may be incurred by operator or by the NRA. Therefore, in the simulation the party responsible for the related cost of sub-item is selected for each cost item. If NRA is selected as the responsible party for payment, the color of the cost of the item becomes green and if operator is responsible party for payment, the color of the cost of the item becomes blue.

Costs vary according to their payment type. The cost can be one-off cost that means payment is done once; or the cost can be variant that means it changes according to the number of the ported numbers; or the cost can be annual that means payment calculated on a yearly basis. If cost type of item is variant, the cost of this item equals number of the ported numbers times the unit cost. If cost type of the item is annual, the cost of the item equals duration year times the unit cost. In the graphical report of the Cost Simulation, the annual type costs can be seen yearly.

For each cost item, a minimum unit cost, a maximum unit cost and an expected unit cost can be entered. The maximum and minimum unit costs are the costs found or posed by other researchers or institutions. On the other hand, the expected unit costs are the costs expected by the researcher.

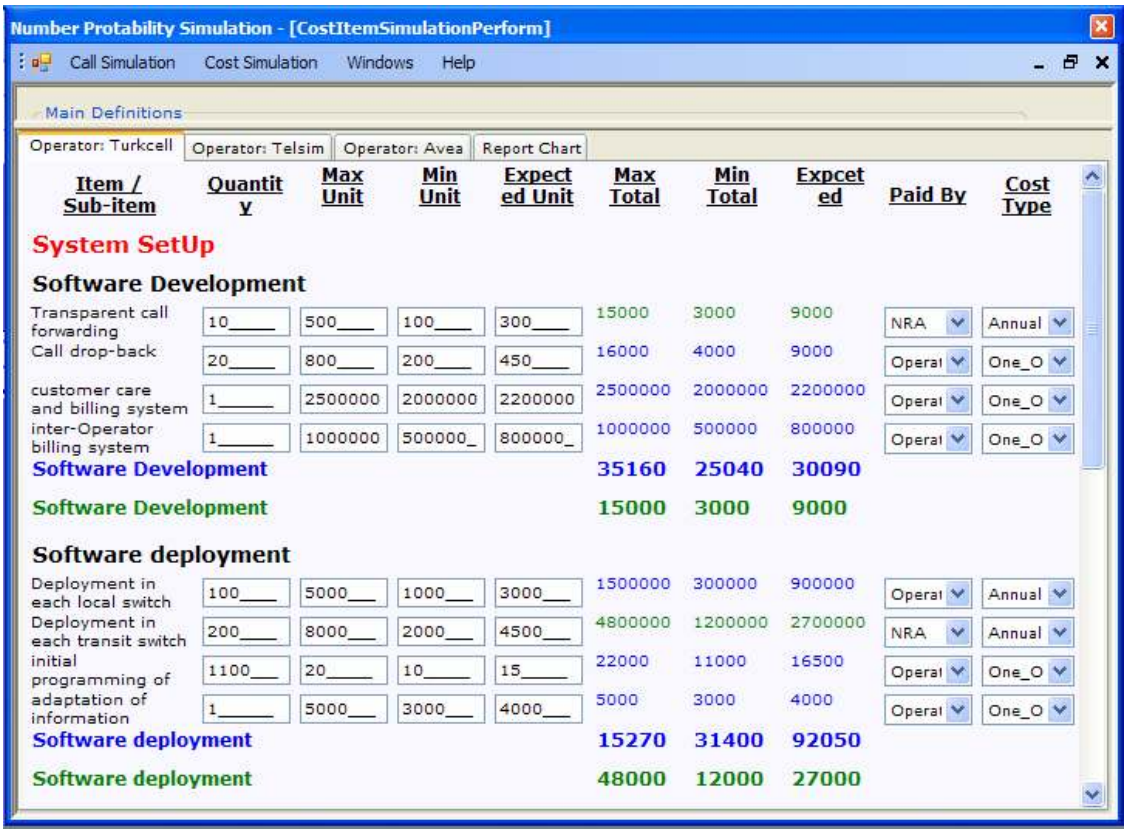

Figure 8.4 Cost Items screen

8.4. How the Call Simulation Tool Works

After selecting Call Simulation from the menu, Call Simulation starts. Firstly, Main Entry Screen comes (Figure 8.5). Here, basic and common preferences are entered under Basic Preferences part. Then, operator definitions could be entered through the Operator part in the middle or through selecting the Add Operator command below the Operator part. Before running the simulation, the values should be entered and different operators should be assigned as ONO, DNO, or RNO. Afterwards, Central DB name and DB Search Fee is entered. The information about central DB is relevant while simulating Off-Switch solutions.

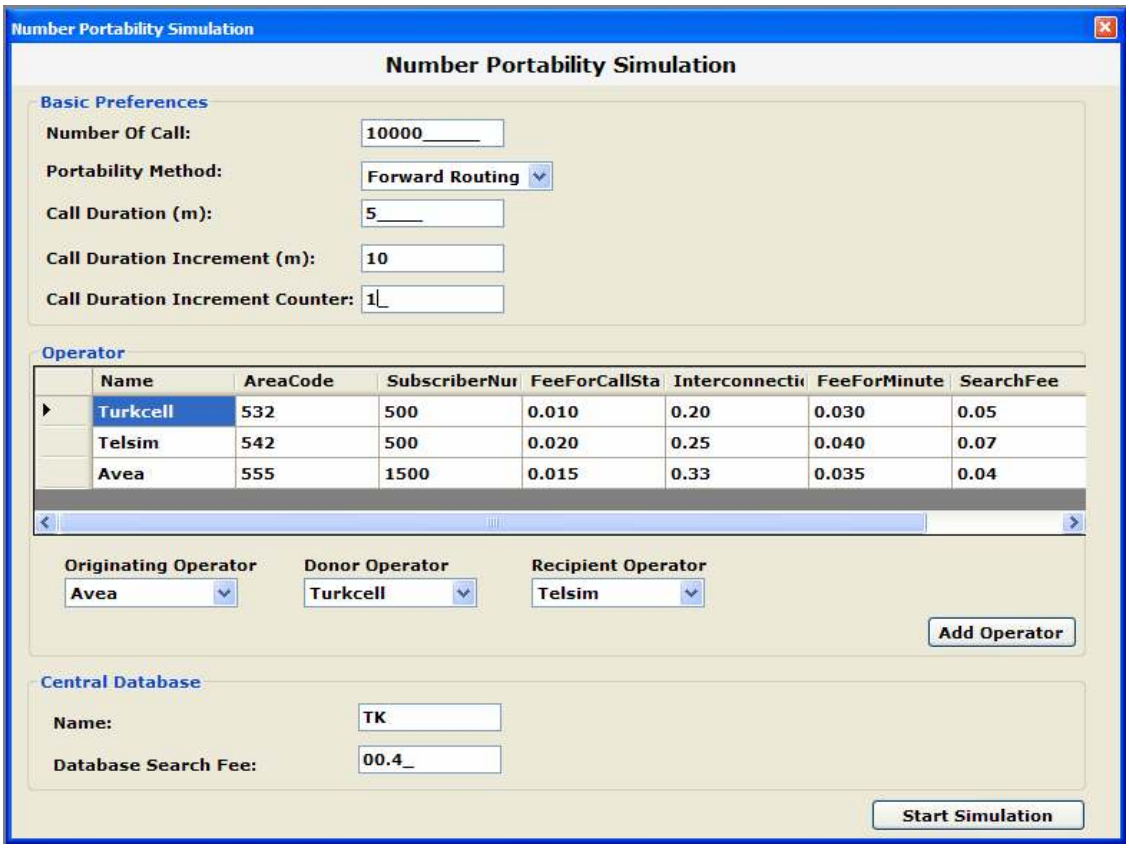

Figure 8.5 Main Entry Screen of Call Simulation Tool

By selecting Add Operator, information about operators can be entered (Figure 8.6).

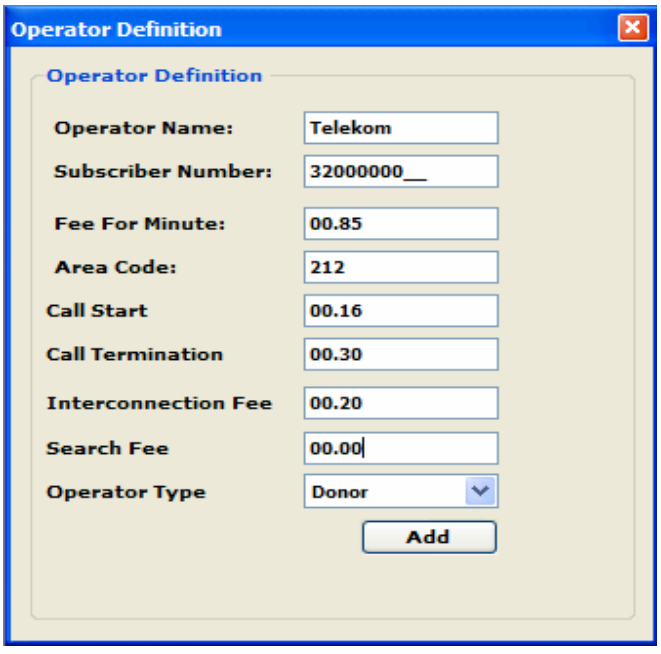

Figure 8.6 Operator Definitions Screen of Call Simulation Tool

8.5. Results Derived from the Cost Simulation Tool

8.5.1. Values Entered

With the help of the Cost Simulation, a comparison can be made between On-Switch and Off-Switch solutions after entering the required parameters. These parameters can be entered through interactive user entry or automatically through an XML file. Assumptions are made about the size and nature of the networks of the different operators.

An incumbent local loop operator having a network of 1000 local switches (10 different types) and 100 transit switches (4 different types). A new entrant operator (with its own access network) having a network made of 20 local switches (1 type) and 2 transit switches (1 type).

In an example application the following cost inputs are entered to the simulation, respectively (Table 8.6, Table 8.7, Table 8.8, and Table 8.9). In this example, maximum and minimum values are in Euro and gathered from a study of Europe Economics & ARCOME SA [5]. Expected values are the values of the researcher.

Firstly; simulation runs On-Switch solutions for which two XML inputs are submitted to the simulation; one for the incumbent operator and one for the small or new entrant operator. Then, operator line number history values, which affect the per-line costs, entered on the basis of the expected values of the researcher for incumbent operator and new entrant operator, respectively (Table 8.10, Table 8.11).

Secondly, simulation runs Off-Switch solutions for which two XML inputs are submitted to the simulation; one for the incumbent operator and one for the small or new entrant operator. Then, operator line number history values in the tables are entered (Table 8.10, Table 8.11).

Simulation duration is 5 years for all example applications. Initial number of subscribers is 20 million for the incumbent operator and 4 million for the new entrant operator.

Table 8.6 On-Switch solutions costs incurred by incumbent operator in the simulation tool

Item / Sub-item	Qty.	Maximum Unit Cost	Minimum	Expected	Paid By	Cost Type
System Set-Up Costs						
Software development						
Transparent call forwarding	10	350.000	250.000	200.000	operator	One_Off
Call drop-back	14	350.000	250.000	300.000	operator	One_Off
customer care and billing system	1	2.200.000	800.000	2.000.000	operator	One_Off
inter-operator billing system	1	800.000	300.000	500.000	operator	One_Off
Software deployment						
Deployment in each local switch	1.000	5.000	1.000	3.000	operator	One_Off
Deployment in each transit switch	100	5.000	1.000	3.000	operator	One_Off
adaptation of information systems	1	5.000	1.000	3.000	operator	One_Off
initial programming of routing tables	1.100	5	15	10	operator	One_Off
Licensing						
Licensing in each local switch	1.000	30.000	10.000	20.000	operator	One_Off
Licensing in each transit switch	100	15.000	10.000	5.000	operator	One_Off
Per-Line						
Per-Line Administration	1*	20	10	15	operator	Variant
On-going						
Management of non-geographic numbers	1**	100.000	80.000	40.000	NRA	Annual

1* : it changes according to the number of the ported numbers

1** : it changes on a yearly basis

Table 8.7 On-Switch solutions costs incurred by new entrant small operator in the simulation tool

Item / Sub-item	Qty.	Maximum Unit Cost	Minimum Unit Cost	Expected Unit Cost	Paid By	Cost Type
System Set-Up Costs						
Software development						
Transparent call forwarding	1	350.000	250.000	200.000	operator	One_Off
Call drop-back	2	350.000	250.000	300.000	operator	One_Off
customer care and billing system	1	2.200.000	800.000	2.000.000	operator	One_Off
inter-operator billing system	1	800.000	300.000	500.000	operator	One_Off
Software deployment						
Deployment in each local switch	20	5.000	1.000	3.000	operator	One_Off
Deployment in each transit switch	2	5.000	1.000	3.000	operator	One_Off
adaptation of information systems	1	5.000	1.000	3.000	operator	One_Off
initial programming of routing tables	22	5	15	10	operator	One_Off
Licensing						
Licensing in each local switch	20	30.000	10.000	20.000	operator	One_Off
Licensing in each transit switch	2	15.000	10.000	5.000	operator	One_Off
Per-Line						
Per-Line Administration	1*	20	10	15	operator	Variant
On-going						
Management of non-geographic numbers	1**	100.000	80.000	40.000	NRA	Annual

1* : it changes according to the number of the ported numbers

1** : it changes on a yearly basis

Table 8.8 Off-Switch solutions costs incurred by incumbent operator in the simulation tool

Item / Sub-item	Qty.	Max. Unit Cost	Min. Unit Cost	Expected Unit Cost	Paid By	Cost Type
System Set-Up Costs						
Equipment investment						
IN Platform and SMS	1	6.000.000	3.000.000	5.000.000	operator	One_Off
National Ported Number Database	14	1.500.000	1.000.000	1.500.000	NRA	One_Off
Software Development						
IN trigger in transit switches	4	2.000.000	1.000.000	1.500.000	operator	One_Off
Development of IN service	1	2.000.000	1.000.000	1.500.000	operator	One_Off
Drop-back (query on release)	14	3.000.000	2.000.000	2.500.000	operator	One_Off
Ext. nb of number blocks	4	200.000	100.000	150.000	operator	One_Off
Customer care and billing system	1	2.000.000	1.000.000	1.500.000	operator	One_Off
Inter-operator billing system	1	800.000	500.000	800.000	operator	One_Off
Administration of NP request	1	300.000	100.000	200.000	operator	One_Off
Downloading routing information	1	150.000	100.000	125.000	operator	One_Off
Software deployment						
Deployment IN trigger and SSF	100	5.000	3.000	4.000	operator	One_Off
Deployment drop-back	1.100	5.000	3.000	4.000	operator	One_Off
Initial programming of routing tables	1.100	15	5	10	operator	One_Off
Adaptation of information systems	1	5.000	1.000	3.000	operator	One_Off
Licensing						
SSF function + IN trigger	100	300.000	200.000	250.000	operator	One_Off
Drop-back	1.100	8.000	7.000	5.000	operator	One_Off
Per-Line						
Per-Line Administration	1*	20	10	15	operator	Variant
On-going						
Administration and maintenance	1**	300.000	200.000	250.000	NRA	Annual
Maintaining and operating the IN system	1**	300.000	200.000	250.000	Operator	Annual

1* : it changes according to the number of the ported numbers

1** : it changes on a yearly basis

Table 8.9 Off-Switch solutions costs incurred by new entrant small operator in the simulation tool

Item / Sub-item	Qty.	Max. Unit Cost	Min. Unit Cost	Expected Unit Cost	Paid By	Cost Type
System Set-Up Costs						
Equipment investment						
IN Platform and SMS	1	6.000.000	3.000.000	5.000.000	operator	One_Off
National Ported Number Database	1	1.500.000	1.000.000	1.500.000	NRA	One_Off
Software Development						
IN trigger in transit switches	1	2.000.000	1.000.000	1.500.000	operator	One_Off
Development of IN service	1	2.000.000	1.000.000	1.500.000	operator	One_Off
Drop-back (query on release)	2	3.000.000	2.000.000	2.500.000	operator	One_Off
Ext. nb of number blocks	1	200.000	100.000	150.000	operator	One_Off
Customer care and billing system	1	2.000.000	1.000.000	1.500.000	operator	One_Off
Inter-operator billing system	1	800.000	500.000	800.000	operator	One_Off
Administration of NP request	1	300.000	100.000	200.000	operator	One_Off
Downloading routing information	1	150.000	100.000	125.000	operator	One_Off
Software deployment						
Deployment IN trigger and SSF	2	5.000	3.000	4.000	operator	One_Off
Deployment drop-back	22	5.000	3.000	4.000	operator	One_Off
Initial programming of routing tables	22	15	5	10	operator	One_Off
Adaptation of information systems	1	5.000	1.000	3.000	operator	One_Off
Licensing						
SSF function + IN trigger	2	300.000	200.000	250.000	operator	One_Off
Drop-back	22	8.000	7.000	5.000	operator	One_Off
Per-Line						
Per-Line Administration	1*	20	10	15	operator	Variant
On-going						
Administration and maintenance	1**	300.000	200.000	250.000	NRA	Annual
Maintaining and operating the IN system	1**	300.000	200.000	250.000	Operator	Annual

1* : it changes according to the number of the ported numbers

1** : it changes on a yearly basis

Table 8.10 Subscriber (Number) changes for incumbent operator in yearly basis

Year	New Subscription	Lost Number	Ported Number
	Percent	Percent	Percent
1	5	15	3
2	4	15	2
3	5	10	4
4	10	5	5
5	10	3	8

Table 8.11 Subscriber (Number) changes for new entrant operator in yearly basis

Year	New Subscription	Lost Number	Ported Number
	Percent	Percent	Percent
1	20	4	15
2	15	5	10
3	10	5	5
4	5	4	3
5	4	3	2

8.5.2. Reports and Results

In the cost simulation tool, report output is consisting of a bar chart and a text report. While using On-Switch solution the new entrant operator's system set-up cost (max: 4.795.330 €, min: 2.083.110 €, expected: 3.889.220) represent 10 per cent of the incumbent operator's system set-up cost (max: 48.421.500 €, min: 18.706.500 €, expected: 34.014.000 €). However, NRAs should assess whether the costs may differ from the levels indicated above based on the correction factors that the software deployment costs can be integrated in a global network evolution plan and the license rights also can be integrated in a global system license plan. Therefore, they may not be separately identifiable or part of costs incurred in implementing NP.

While using Off-Switch solution, the new entrant operator's system set-up costs represent 17 per cent of the incumbent operator's system set-up costs, higher than with an On-Switch solution.

Per-Line Cost is counted with the number of ported numbers and unit cost which is same for all solutions.

On-Going Costs are same for the new entrant operator and the incumbent operator within Off-Switch solutions. There are no On-Going costs for operators within On-Switch solutions. However; the On-Going cost incurred by NRA within Off-Switch solutions is three times higher than within On-Switch solutions.

Off-Switch solutions are more costly than On-Switch solutions and the difference is especially large for a new entrant local loop operator, since the initial minimum investment in an Off-Switch solution is higher. Also, the costs incurred by NRA are six times higher with Off-Switch solutions than On-Switch solutions.

While the incumbent operator probably already has IN functions in his network for other services than NP, the incumbent operator may not have IN systems at that time to implement NP. The benefit, of course, of investing in an IN platform is that an operator is able to provide a variety of other value-added services.

NRAs should assess whether cost may differ from the levels indicated above based on the some correction factors. For instance; the magnitude of Off-Switch investments depends on whether the solution is All Call Query or Query on Release. The first one will require higher IN query capacity, the second one generates a much lower amount of queries but requires software developments in the switches. As well, the operator may also prefer (if they are allowed to) to use the IN service of another operator, especially if they are a small regional operator. In practice, this solution will consist of delivering the traffic for call termination, and will lead to higher interconnection costs [5].

8.6. Results Derived from the Call Simulation Tool

8.6.1. Values Entered

With the help of the Call Simulation, a comparison can be made between the four solutions after entering the required parameters. These parameters can be entered through interactive user entry to Main Entry Screen and Operator Entry Screen. For instance, in an example application the following inputs are entered to the Main Entry

Screen and Operator Entry Screen (Figure 8.7). Here, the unit of fees is in YTL (New Turkish Lira) and the unit of duration is in minute.

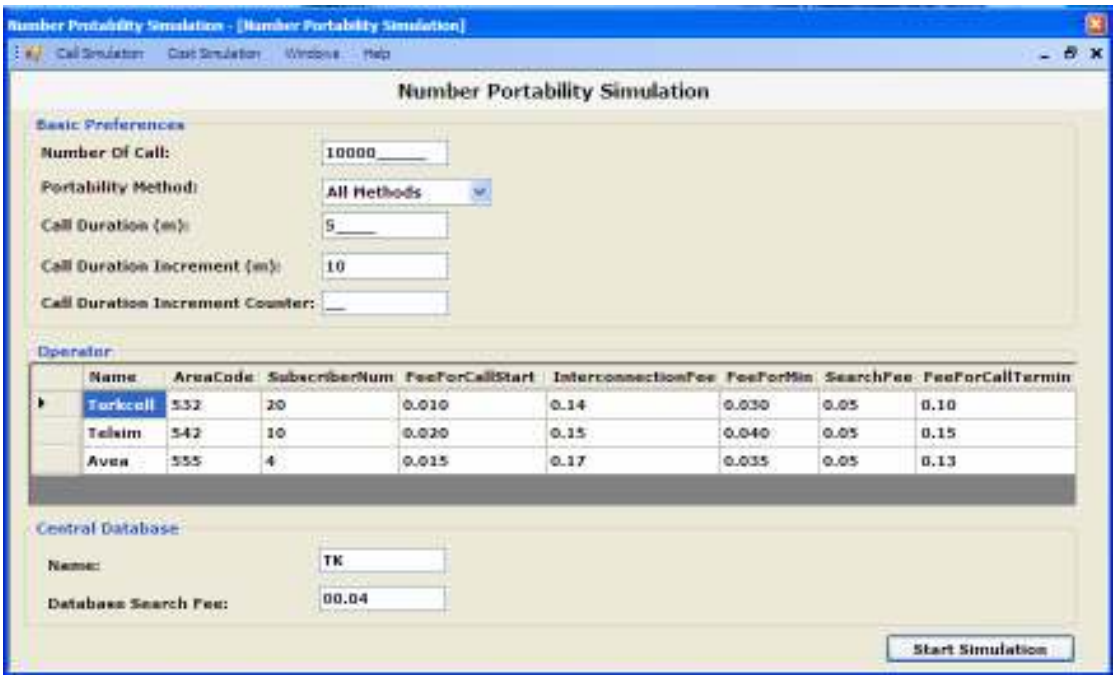

Figure 8.7 Values entered to the Call Simulation Tool

8.6.2. Reports and Results

Total Call Fee, Call Fee per Call and Call Fee per Minute are significant for the research, since the Call Simulation aims to estimate the cost of a call to a ported number. Firstly, the result call fee for each solution is calculated as in the Table 8.12 and then other calculations are done on the basis of Total Call Fee and duration. Output is consisting of a bar chart and a text report.

The bar chart report of the simulation indicates two sub-charts. The first sub-chart report is the 'summations' report which represents the summation values (entities indicating the word 'total') about the solutions (Figure 8.8). The second one for the entities representing the average values (entities indicating the word 'per') is called as 'averages'. The green series are for Onward Routing, the yellow series are for Call-Drop Back, the red series are for Query-on-Release and the blue series are for All-Call Query solutions.

Table 8.12 Calculation of fee of a call

Solution	Result Fee
Onward Routing	TerminationFee (Recipient) + InterconnectionFee (Donor)*dura. + FeeForMinute (Originating)*dura.
Call Drop Back	TerminationFee (Recipient) + Search on Donor (Donor) + FeeForMinute (Originating)*dura.
Query on Release	TerminationFee (Recipient) + Search on Donor (Donor) + Search at Central Database + FeeForMinute (Originating)*dura.
All Call Query	TerminationFee (Recipient)*dura. + Search at Central Database + FeeForMinute (Originating)*dura.

In the example application, TotalCall and TotalDuration entities are same for all of the solutions; since the total call and total call duration assigned to all of the solutions is same (Figure 8.8, Figure 8.9). Conversely, an important difference is shown when looking at TotalCallFee and CallFeePerCall. Here, Onward Routing has the highest fee rate. The important reason for this is the additional carrying fee of DNO. Call-Drop Back has lower fee rate; since the ONO is not responsible for paying interconnection fee to DNO. However, ONO may pay a search fee to DNO before drop-back action as in this example.

All of the calls to ported numbers in Off-Switch solutions are subjected to Central Reference Database interrogation; this causes additional fee for the calls. In spite of this, the lowest call fee rate is observed in All Call Query solution. With Query on Release solution call fee rate is a little higher than with ACQ, since with QoR solution the path of a call to a ported number passes beyond the donor operator and the Central Reference Database. Hence, ONO may pay a search fee to DNO before drop-back action as in this example.

There is an important point that the most of the transactions in Off-Switch solutions are between the originating operator and the central database. However, in On-Switch solutions an important part of the transactions goes through the donor operator. So, the donor operator continues to become busy with the ported number that is another disadvantage of On-Switch solutions.

Total Call Fee, Call Fee per Call and Call Fee per Minute for Onward Routing solution have the highest rate; since the donor operator takes additional fees such as additional carrying costs. The lowest Total Call Fee, Call Fee per Call and Call Fee per Minute are shown on the All-Call Query solution, because the fee of interrogating the Central Database is the only additional fee when this solution is used.

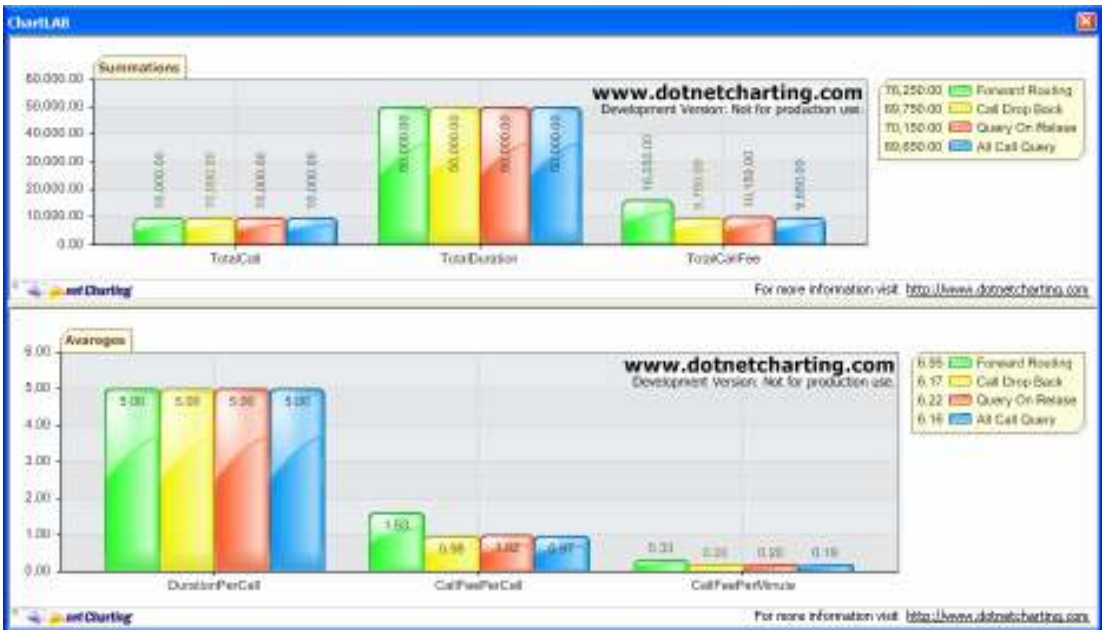

Figure 8.8 The graphical report for Call Simulation Tool

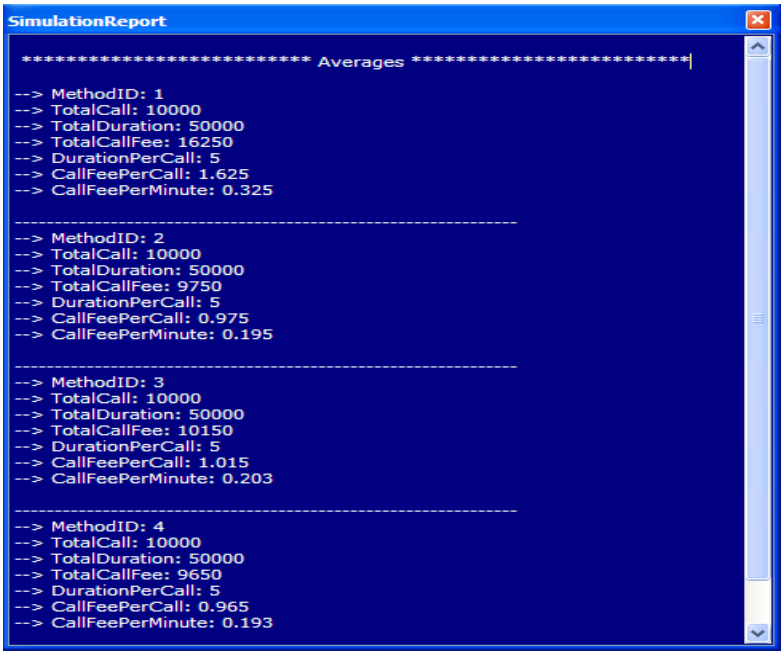

Figure 8.9 The text report for Call Simulation Tool

9. CURRENT SITUATION IN TURKEY

In Turkey, there is no NP implementation yet. However, regulations about NP are prepared by Telecommunication Authority and shall become law in the first quarter of 2007. Then, TA will construct a Central Reference Database and will be responsible of managing this database. Number Portability will probably start at least six months later after construction of the CRD.

By looking the results of those countries applied NP, with the implementation of NP subscribers will be able to change their telephone operator or physical location or type of service without changing their telephone numbers on PSTN/mobile networks. Thus, NP will make contribution to improving of the competition in the telecommunications market.

Basically, the scope of studies on NP will include preparation of ordinance and application procedures in this regard. According to EU Universal Service Directive (2002/22/EC), NP should be applied on PSTN/mobile networks. In that respect, to implement NP on public telephone networks considering the priorities to be determined, studies covering technical solutions, cost allocation solutions etc. should be performed.

10. CONCLUSION AND SUGGESTIONS

With the implementation of NP, subscribers will be able to change their telephone operator or physical location or type of service without changing their telephone numbers. NP has been thought to bring substantial benefits to subscribers: lower price, greater choice, higher quality and a greater range of services. Thus, NP will make contribution to improve the choices in a more competitive telecommunication market.

In the thesis, three types of NP have been explained. These are Wireline Number Portability, Mobile Number Portability and Wireline-Mobile Number Portability. The four technical solutions to establish NP are explained and compared in theory. Then, they have been compared through a simulation tool designed according to the theory explained. Simulation tool has provided comparison of the technical solutions for a variety of parameters.

According to the results of the cost simulation tool, Off-Switch solutions are more costly than On-Switch solutions and the difference is especially large for a new entrant operator, since the initial minimum investment in an Off-Switch solution is higher. Also, the costs incurred by NRA are higher with Off-Switch solutions than On-Switch solutions.

According to the results of the call simulation tool, call fee rates with Off-Switch solutions are lower than with On-Switch solutions. Additionally, the busyness of the network is higher with On-Switch solutions.

On-Switch solutions can be used as short-term solution, since the adaptation of present network and numbering structure to On-Switch solutions is easier and cheaper. Even, the adaptation to Off-Switch solutions is not easy and cheap as On-Switch solutions and requires Intelligent Networks; investing an IN platform provides operator with a variety of other value-added services and easier number management. Therefore; Off-Switch solutions can be used as long-term solutions.

Implementation of NP for Turkey will probably be done until the end of 2007. Firstly, a CRD will be constructed and operators will use that database to access or enter information about ported numbers. They will not be able to use CRD for querying the called number. After implementation of NP, Turkey should select Off-Switch solutions as long term solutions.

The simulation tool should be revised and improved. With the current state, simulation tool meets the needed comparison between NP solutions; however with the help of more parameters entered, the results will be more accurate and helpful for all.

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