Final Report for Ofcom

Calculation of the costs of donor conveyance

20 July 2007

Our ref: 279-294

Analysys Consulting Limited
St Giles Court, 24 Castle Street
Cambridge, CB3 0AJ, UK
Tel: +44 (0)1223 460600
Fax: +44 (0)1223 460866
consulting@analysys.com
www.analysys.com

Calculation of the costs of donor conveyance

Final Report for Ofcom

Contents

1 Introduction

Mobile number portability (MNP) is an important feature in mobile markets as it allows customers to move between networks without the need to change their telephone numbers. Without MNP number changes are considered a barrier to proper competition. In the UK, the regulator mandated a change to the licence conditions of the mobile operators in early 1999 that required them to support a technical process for both administration of ported numbers and the technical routeing of calls for ported numbers.

The UK, unlike some markets, does not currently have a central database of ported mobile numbers, which means that calls are always routed to the network that was the original owner of the number, based on the national number group (NNG) which is the first five digits of the national format MSISDN (i.e. 07766).

Ofcom has been asked to resolve a dispute that relates to the donor conveyance charge (DCC) for ported-number call routeing and set-up. The DCC relates to the additional costs within the networks for handling a call to a ported number. Ofcom has asked Analysys to estimate the additional costs arising from a call to a ported number. This document describes:

- Section 2: the technical realisation of the call set-up process for ported number calls in the UK
- Section 3: the cost elements that are occupied in the process of delivering a call to a ported number
- Section 4: parameters, assumptions and calculations applied to Ofcom's 2G/3G MCT cost model in order to obtain the DCC cost estimates
- Section 5: results of the calculation
- Section 0: acronyms used in the report.

2 UK MNP

2.1 Original proposed solution

The original solution to UK MNP was agreed by a working group made up of several of the UK's fixed and mobile network operators, known as the PNO-IG (Public Network Operators, Implementation Group) which reported to Oftel at the time. The solution provided for a routeing scheme to set up calls to ported numbers without the need for a centrally managed ported number database. It also provided sufficient flexibility to the mobile networks so that they could continue to control call set-up in their own preferred way.

The following diagram provides an outline of the components of the original solution:

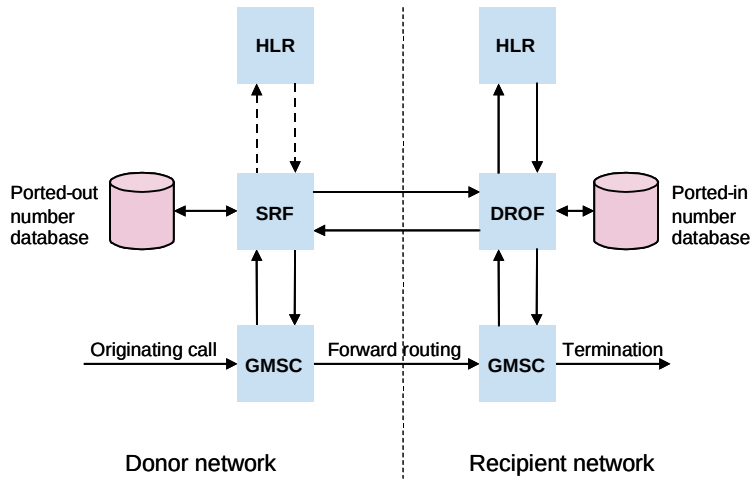

Exhibit 2.1:
Original solution architecture
[Source: Analysys]

- When a call is originated from a third-party network, it is routed to the owner of the NNG. This will be a GSM Gateway MSC that is responsible for interrogating the HLR

using a 'Send Routeing Information' MAP message (SRI). Under normal GSM call set-up operation, the HLR requests a 'roaming number' from the VLR and returns it to the G-MSC. The G-MSC uses that number to route the call to the visited MSC (where the subscriber is currently located).

- An additional signalling element (at the SS7 SCCP layer) is specified for UK MNP: the Signalling Routeing Function (SRF). This receives 'Send Routeing Information' requests and carries out a look-up against a database of all ported-out numbers. The ported-out database will have a record for each number that has been exported and will identify the recipient network. If a number is not in the ported-out database, the 'Send Routeing Information' request will be forwarded on to the HLR as normal.

- The mobile network owner of the SRF has a choice of whether to interrogate a Direct Routeing Override Function (DROF) in the recipient network or not. This allows an early HLR look-up to take place and the roaming number (for routeing to the subscribers Visited MSC) to be returned directly, or an IRN (Intermediate Routeing Number) to be used which can later be associated with the roaming number (effectively forcing the call to a particular gateway but not disclosing the subscriber's location). If the operator chooses not to interrogate the DROF, it can prefix the destination MSISDN with routeing digits that will force the call into the recipient network.

- The SRF returns the routeing number that will either be a prefixed MSISDN, an IRN or a GSM roaming number. It then forwards the call based on that routeing number.

- Upon receipt of the call, the G-MSC in the recipient network may either (i) strip the routeing prefix and request routeing information from the HLR, (ii) ask the DROF for the roaming number if it has one already, or (iii) ask the DROF to interrogate the HLR. The G-MSC then receives a roaming number that is used to forward the call to the visited MSC.

- Where the call originates on the same mobile network as a ported-in number, it is necessary to prevent 'tromboning' of the call (where it goes to the NNG network and then back again). It is the responsibility of the DROF to be aware of ported-in numbers

and MSCs should treat all originating calls to mobile destinations as potentially on-network.

- It was expected that the SRF and DROF would be combined into a single entity in each operator's network.

2.2 Non-circuit transactions

Other transactions that do not involve a traffic circuit are also present, for example SMS. SMS messages are carried over the SCCP signalling network only, without the allocation of a traffic circuit. In addition to the SRI message, it is necessary for the SRF to handle the 'Send Routeing for SM' message. In this case, there is no possibility for using IRNs or roaming numbers, all SMS messages are prefixed in the 'called party address' part of the message header.

2.3 Least effort implementation

The flexibility provided in the original PNO-IG solution, combined with reluctance to allow third parties to interrogate the HLR, tight timescales and penalties for non-compliance, meant that each of the UK mobile operators implemented solutions based on simple SRF prefixing only. The SRF identifies ported-out numbers and prefixes the MSISDN with a re-routeing code specific for the recipient network (of the form 44799*x*MSISDN where *x* is the identity of the recipient network). When the G-MSC receives a call to a prefixed number, it strips the prefix digits and sends an SRI request directly to the HLR.

The changes to existing functionality were therefore minimised to:

- a database of ported-out numbers
- a signalling solution that could recognise a ported-out number and respond to SRI with a prefixed MSISDN
- a G-MSC which could recognise a prefixed MSIDN and strip the prefix
- HLRs that could handle other networks' NNGs.

- MSCs that could re-route OLO NNGs to an external network if they were not known in the HLR.

This is the solution that is in place in the UK today, although the implementation of the ported-out database varies from operator to operator. There are two common implementations:

Solution A

The first implementation approach uses an SCCP/MAP signalling relay to intercept and forward SRI messages before they reach the HLR. This is the approach adopted by Ericsson (T-Mobile) in its FNR and Orange in the SLR. Other network vendors have similar schemes.

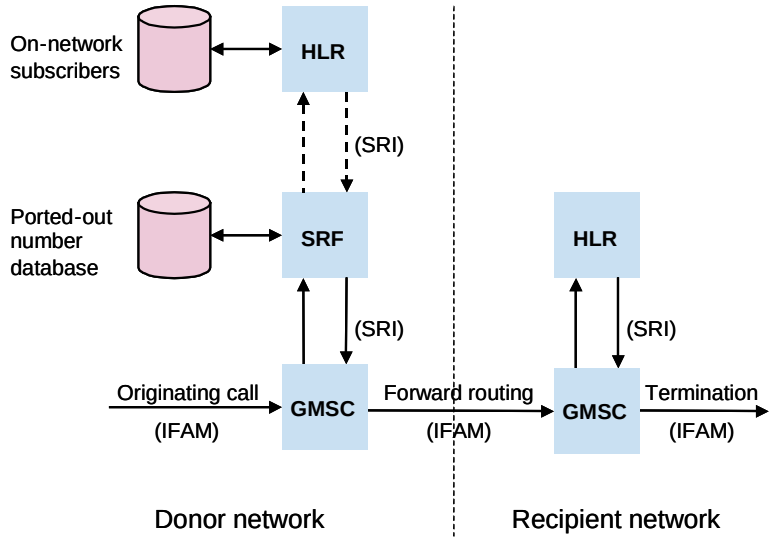

Exhibit 2.2:

Solution A [Source: Analysys]

Solution B

The second approach modifies the HLR so that it holds the ported-out database in addition to on-network numbers. Effectively the SRF is built into the HLR.

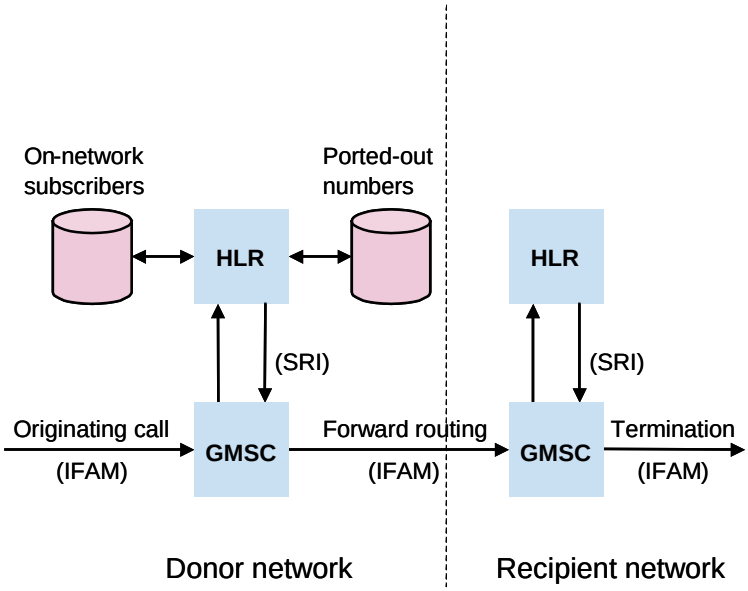

Exhibit 2.3:

Solution B [Source: Analysys]

2.4 Use of intelligent network

It is feasible for an intelligent network (IN) SCP to hold the database of ported-out numbers and there is nothing that would prevent this from being implemented in the UK. However, we are not aware of any specific implementations of UK MNP that use IN.

IN is implemented by setting triggers against particular numbers or number groups for either outgoing or incoming calls, or both. When a trigger fires, the switch interrogates an SCP to see if there should be any special call handling. In a GSM network, triggers are set at the subscriber level as part of the HLR subscription. This means that the relatively high cost of SCP interrogation can be avoided where it is unlikely to be needed.

One of the difficulties for using IN to implement UK MNP is that there is no HLR record for the ported-out subscriber and there will in any case be an HLR lookup which provides the opportunity to divert calls, etc.. The only way to implement UK MNP using IN is to configure all G-MSCs to trigger for all inbound calls before the HLR interrogation. As IN use grows, this may become feasible but it is likely to remain expensive relative to the approaches already described.

2.5 3G networks

At present, the call set-up process for 3G circuit calls is the same as GSM, so there are no differences required to this process. As IMS is rolled out, it is likely that the current process will stay in place for circuit-switched calls and IMS will handle portability separately for IP-based sessions.

3 Donor conveyance charge

The issue under debate is the cost to the donor network of handling calls for subscribers that have ported to a recipient network. This should include the cost of signalling and internal traffic carrying, but exclude interconnect or indirect transit charges which are settled outside of the DCC arrangement.

Using the ETSI GSM standards, a mobile terminated call is normally set up by an MSC as follows:

(1) The G-MSC processes the IFAM message

(2) A MAP signalling message is sent providing routing information from the G-MSC to the HLR (possibly via the SRF in some configurations)

(3) Another MAP signalling message is sent providing a roaming number from the HLR to the V-MSC

(4) The V-MSC processes the IFAM message

MAP signalling messages are then sent from:

(5) The V-MSC to the VLR to transfer information for the incoming call

(6) The V-MSC to the BSS to start processing the access request

(7) The BSS to the V-MSC to finish processing the access request

(8) The VLR to the V-MSC to complete the call.

When a donor-conveyed call arrives at a G-MSC, resources in that G-MSC are allocated to the call. In particular, the MSC must send a MAP signalling message (over an SCCP connection) to the device that has a database of ported-out numbers. That device may be a stand-alone platform or a function of the HLR. There is a likelihood that the G-MSC and the ported-out database will not be co-located and so there will be the possibility of a cost which results from the signalling link. After initial call set-up, resources are freed in the SRF/HLR but remain allocated in the MSC for the duration of the call.

Since a donor-conveyed call is routed to the recipient network after the second of the eight steps described above, only steps (1) and (2) incur cost for the donor network in handling donor-conveyed calls. All of these stages are displayed below in Exhibit 3.1, with those relevant to the costs underlying the DCC highlighted in red.

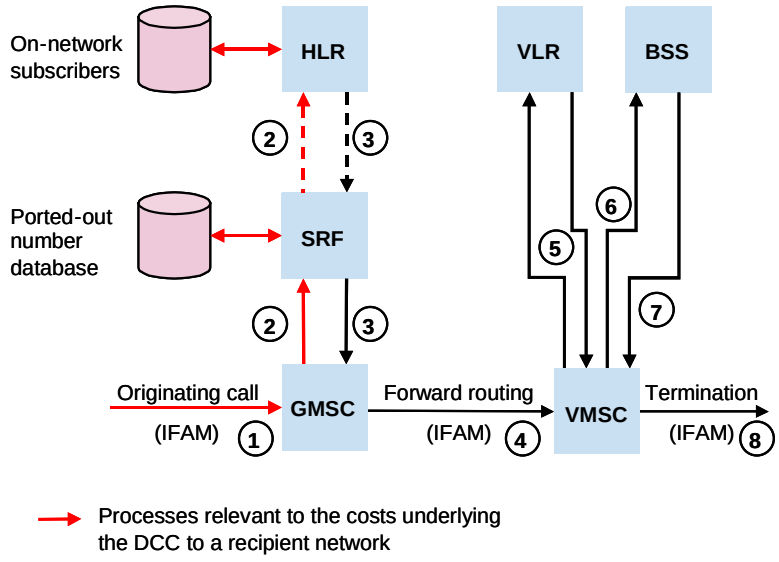

Exhibit 3.1: *Processes required to set up a call in a network according to the ETSI GSM standards [Source: Analysys]*

3.1 Cost elements

There are principally two aspects of the DCC that should be considered for modelling: the initial set-up transactions and the cost of holding the call up in the G-MSC. When the donor conveyed call reaches the recipient network G-MSC, it will strip off the routeing prefix and subsequently treat the call as a conventional incoming minute of traffic. The

activity of removing the prefix for such calls is unlikely to incur any material additional cost components in the recipient network, therefore we consider recipient network costs to be negligible.

Donor network call set-up costs

1. MSC IFAM handling (signalling)
2. SCCP transactions between the G-MSC and the HLR/SRF, including bandwidth and signalling transit switching charges
3. The cost of operating the SRF (or the proportion of the physical platform allocated to this function)
4. Operation of the ported-out database and the costs of the look-up transaction

Donor network duration-based costs

5. Allocation of call handling resources in the MSC and interconnect switches (if separate)
6. Use of internal signalling for ISUP call handling (i.e. between an interconnect switch and the G-MSC).

4 Parameters, assumptions and calculations applied to Ofcom's 2G/3G MCT cost model

Ofcom's 2G/3G MCT cost model provides a breakdown of average per-minute costs for incoming and outgoing voice services, according to a categorisation of various radio, transmission and switching elements. The relevant unit cost base in the released version of the model is the combined 2G/3G operators since ported-out calls and the DCC are statistically most likely to be related to these operators. Switching costs are independent of radio frequency therefore identical for 900MHz or 1800MHz operators.

Exhibit 4.1 below shows cost components of DCC related to termination and origination.

Activity for a ported-out call	*Mobile termination*	*Mobile origination*
1. MSC IFAM handling (signalling)	Yes – part of an incoming call attempt	
2. SCCP transactions between the G-MSC and the HLR/SRF, including bandwidth and signalling transit switching charges	Yes – part of an incoming call attempt (SCCP costs) plus HLR	
3. The cost of operating the SRF (or the proportion of the physical platform allocated to this function)	This cost element is specific to donor conveyance	
4. Operation of the ported-out database and the costs of the look-up transaction	This cost element is specific to donor conveyance	
5. Allocation of call handling resources in the MSC and interconnect switches (if separate)	No – a DCC call is switched directly to the POI and on to the recipient network. There is no mobility management performed during the DCC call handling	
6. Use of internal signalling for ISUP call handling (i.e. between an interconnect switch and the G-MSC)	Yes – from the POI to the G-MSC	Yes – from the G-MSC to the outgoing POI

***Exhibit 4.1**: Cost components of DCC related to termination and origination [Source: Analysys]*

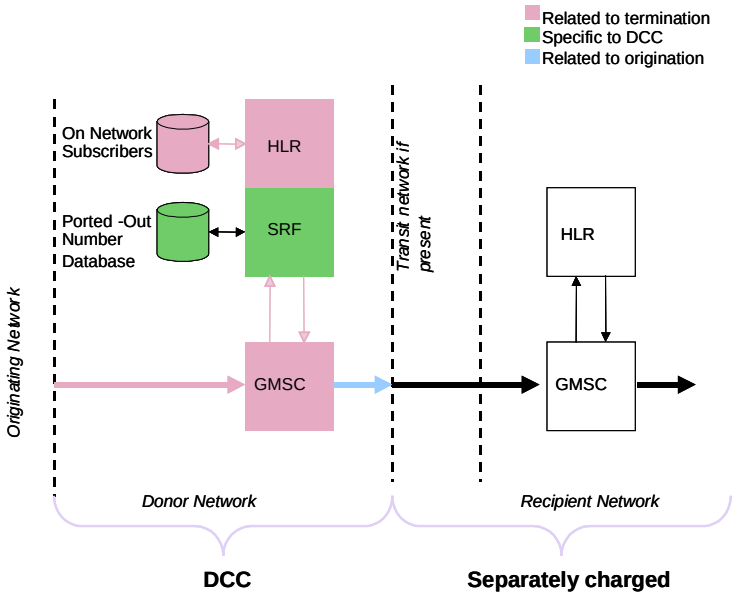

Exhibit 4.2:

DCC components

[Source: Analysys]

The 2G/3G MCT cost model contains the following relevant network elements:

- 2G MSC (processor, software, interconnect interface, support plant)
- 2G MSC ports (BSC facing, MSC facing, interconnect facing)
- 3G MSC (MSCS, Media Gateway, interconnect interface, support plant)
- 3G MSC ports (RNC facing, MSC facing, interconnect facing)
- switching site (building, site lease)
- HLR
- 2G network management system
- 3G network management system.

There are three issues relating to the calculation of DCC costs:

- signalling infrastructure is not explicitly modelled (STP, signalling links, etc.)
- MNP infrastructure is not explicitly modelled (SFR, database, etc.)
- the HLR is modelled as a single unit, allocated to subscribers, but exogenously recovered from received voice traffic.

We assume, based on our knowledge of how the model has been built up, that signalling infrastructure – particularly for call set-up processing – is implicitly included in the MSC cost element. Given that MNP infrastructure is closely related to the HLR – in some instances, integral to it – then we assume that within the cost model, MNP infrastructure costs are captured within the HLR cost element. The allocation of the HLR cost to subscribers however, should not affect the calculation of DCC costs, since the purpose is to calculate the costs of a donor-conveyed call – which can be considered a small proportion of total traffic – rather than to de-average and re-allocate the unit costs within the cost model to separately distinguish the service costs of non-ported and donor-conveyed calls.

Therefore, the costs of the HLR are expressed on a per-minute basis, in order to estimate the HLR costs of a donor conveyed call (i.e. the SRF part of the HLR which returns the MSISDN prefix, rather than interrogates the HLR to "Send Routeing Information".

4.1 DCC routeing factors

Based on the information gathered above, we have made the following routeing factor estimates for a ported-out call.

Network cost element	*2G tern'n*	*2G orig'n*	*3G term'n*	*3G origi'n*	*2G DCC*	*3G DCC*
2G MSC: processor [A]	274 725	83 488			¼ × 274 725	
2G MSC: software [A]	274 725	83 488			¼ × 274 725	
2G MSC: I/C interface [B]	274 725	83 488			274 725 + 83 488	
2G MSC: support plant [A]	274 725	83 488			¼ × 274 725	
2G MSC ports: BSC facing [C]	1	1			0	
2G MSC ports: MSC facing [C]	1	0.5			0	
2G MSC ports: I/C facing [D]	1	1			½ × (1 + 1)	
3G MSC: MSCS [A]			315 259	95 806		¼ × 315 259
3G MSC: Media Gateway [A]			315 259	95 806		¼ × 315 259
3G MSC: I/C interface [B]			315 259	95 806		315 259 + 95 806
3G MSC: support plant [A]			315 259	95 806		¼ × 315 259
3G MSC ports: RNC facing [C]			1	1		0
3G MSC ports: MSC facing [C]			1	0.5		0
3G MSC ports: I/C facing [D]			1	1		½ × (1 + 1)
Switching site: building [F]	1	1	1	1	¼	¼
Switching site: lease [F]	1	1	1	1	¼	¼
HLR [E]	exog	none	exog	none	10% x exog	10% x exog
2G NMS [F]	1	1			¼	
3G NMS [F]			1	1		¼

Exhibit 4.3: *Termination, origination and estimated DCC routeing factors [Source: Ofcom model, Analysys]*

A. A donor-conveyed call only employs the first two (of eight) stages involved in processing an incoming call, as explained in Section 3. Therefore, we estimate that a donor-conveyed call uses the MSC 25% compared to an average incoming call

B. A ported-out call utilises the interconnect interface both on inbound and outbound to the recipient operator

C. A ported-out call does not interact with radio facing equipment or traverse the inter-MSC network

D. A ported-out call utilises the interconnect interface both on inbound and outbound to the recipient operator. A factor of ½ is applied to reflect refinements to the dimensioning of MSC ports necessary to accurately estimate costs at a more granular level than was used in the MCT model.

E. It is estimated that the cost of the SRF and ported-out database is small compared to the cost of the HLR (when expressed on a per-call minute basis, relative to the exogenous per-minute cost of the HLR.

F. Switching facilities and network management are required for ported-out calls, however these assets are related to the operation of the entire switching, transmission and radio network, whereas a donor-conveyed call only uses limited equipment in the switching layer of the network.

5 Results

An additional module to the MCT cost model has been constructed to produce benchmarks for the efficient DCC unit costs. The application of our assumptions to the 2G/3G model unit cost base results in a best estimate of the cost of donor conveyance in the donor network. Exhibit 5.1 illustrates the best estimates of the 2G and 3G conveyance charges for a 2G/3G combined operator, under a medium demand scenario.

Pence per minute	*2G DCC*	*3G DCC*
MSC costs	0.187	0.087
Switch site, building and lease	0.006	0.005
SRF (proportion of HLR)	0.013	0.013
NMS	0.009	0.001
Total cost per minute (real 06/07)	**0.215**	**0.106**
Expressed in nominal terms	0.221	0.108
Traffic weight	83%	17%
Weighted average DCC	**0.201**	

Exhibit 5.1: *Calculation of estimated average DCC in 2007/08 [Source: Analysys]*

6 Glossary

BSC	Base Station Controller
BSS	Base Station Subsystem
DCC	Donor Conveyance Charge
DROF	Direct Routeing Override Function
ETSI	European Telecommunications Standards Institute
FNR	Flexible Number Register (proprietary Ericsson)
G-MSC	Gateway MSC
GSM	Global System for Mobile communication
HLR	Home Location Register
I/C	Interconnect
IFAM	Initial and Final Address Message (ISUP message)
IMS	IP Multimedia Sub-system
IN	Intelligent Network
IRN	Intermediate Routeing Number
ISUP	ISDN User Part (ITU-T standard)
MAP	Mobile Application Part (ETSI standard 09.02)
MNP	Mobile Number Portability
MSC	Mobile services Switching Centre
MSCS	MSC Server
MSISDN	Mobile Station Integrated Services Digital Network
NNG	National Number Group
NMS	Network Management Software
OLO	Other Licensed Operator
PNO-IG	Public Network Operators, Implementation Group
POI	Point of interconnection
RNC	Radio Network Controller

SCCP	Signalling Connection Control Part (ITU-T standard)
SCP	Signalling Control Point
SLR	Service Location Register (proprietary Orange)
SMS	Short Message Service
SRF	Signalling Relay Function
SRI	Send Routeing Information (MAP message)
SS7	Signalling System No. 7 (specified by the ITU-T)
STP	Signalling Transfer Point
VLR	Visitor Location Register
V-MSC	Visited MSC