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Preliminary Report on the Feasibility Study and Cost Benefit Analysis of Number Portability for Mobile Services in Hong Kong

1. The Office of the Telecommunications Authority (OFTA) has appointed the consultants, National Economic Research Associates (NERA), to conduct the feasibility study and cost benefit analysis of number portability for mobile services in Hong Kong.

2. NERA has now completed the attached preliminary report on the study. The document is now available on OFTA’s homepage at http://www.ofta.gov.hk.

3. NERA would like to solicit and consider further views and comments from the industry or interested parties on this preliminary report before producing a final report to OFTA before the end of March 1998. Any views or comments on this preliminary report should be made in writing to OFTA on or before 9 March 1998 to the following address either by fax or by Internet e-mail.

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4. OFTA will coordinate all the received comments and views and pass them to the consultants for consideration. After receiving the final report from the consultants, OFTA will consider the consultants' findings, conclusions and recommendations and decide whether number portability for mobile services should be introduced in Hong Kong.

5. It should be noted that all the findings and views given in the preliminary report are solely from the consultants and have not yet been accepted by OFTA.

Office of the Telecommunications Authority
21 February 1998
FEASIBILITY STUDY & COST BENEFIT ANALYSIS
OF NUMBER PORTABILITY
FOR MOBILE SERVICES
IN HONG KONG

A Preliminary Report for OFTA
Prepared by NERA and
Smith System Engineering

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EXECUTIVE SUMMARY

1) In December 1997, the Office of the Telecommunications Authority (OFTA) in Hong Kong commissioned National Economic Research Associates (NERA) and Smith System Engineering to conduct a feasibility study and a cost benefit analysis of mobile number portability. The main issues considered were:

   • technical options for MNP in Hong Kong;
   • costs of implementing MNP;
   • demand for, and estimates of, MNP;
   • options to recover the costs of portability.

2) Our final report will be provided to OFTA in March. The assumptions made in this report to determine the costs and benefits follow discussions we have had with the industry and other telecommunications experts. We recognise that these may need to be revised in the face of new information and would welcome any comments people may have on this preliminary report.

3) The mobile market in Hong Kong is currently very competitive. Eight mobile operators are operating eleven digital networks. By the end of 1997, there were over 2 million subscribers and the market shows signs of continued growth. We forecast that the penetration rate will grow to 60 per cent in 2007. OFTA believes that there is scope for future improvements. It considers the availability of number portability as essential for the further development of telecommunications in Hong Kong and for the delivery of enhanced benefits to consumers.

4) We reviewed the technical options for Hong Kong and believe that MNP could be introduced through call forwarding in 6-12 months. This would only be an interim solution.

5) In the medium to long term, MNP could be implemented through a distributed database solution with HKTC performing the look-up. This appears to be the most appropriate solution given that the vast majority of calls to and from mobile telephones pass through HKTC and HKTI’s networks. The existing infrastructure from the introduction of number portability in the fixed network would also help to expedite the introduction of MNP. Over time, other operators could provide the number translation services for themselves or other operators.

6) The costs of implementing mobile number portability vary according to the technical option and migration path chosen. Depending on the assumptions made, however, we estimate that the NPV of costs of MNP lies between HK $240 million and HK $450 million over 10 years. These estimates are based on information gained from interviews with operators and users in Hong Kong, relevant industry contacts,
Executive Summary

previous international studies and our knowledge of the telecommunications industry.

7) A wide range of consumers will benefit from the MNP in Hong Kong. Mobile subscribers will be able to switch operators and avoid the costs and inconvenience associated with a number change. Competition in the industry will be heightened as a barrier to switching is removed further benefiting residential and business users. Callers to mobile phone subscribers will be able to complete calls successfully in those cases where the subscriber has changed their mobile operator. We have captured these benefits in the following categories:

- Type 1 benefits which accrue to subscribers who retain their telephone number switching operator, and include:
  - cost savings from not having to change mobile number; and
  - cost savings from switching to more efficient operators.

- Type 2 benefits which are the efficiency improvements and any associated price reductions which result from increased competition;

- Type 3 benefits which are the savings as a result of there being fewer number changes.

8) There are also considerable benefits from the introduction of MNP. In total, the net present value of benefits ranges from HK$1,249 million, under our most pessimistic scenario, to over HK$1,467 million under our most optimistic scenario.

9) Our cost benefit analysis shows a clear net benefit to Hong Kong from the introduction of MNP. Even under our pessimistic scenario (where MNP is not implemented until January 2000, churn is low, and the rate of porting is low) we estimate a net benefit of around HK$1 billion in net present value terms over 10 years.

10) In determining how the costs of MNP should be recovered, we have drawn heavily on the principles developed by the TA for fixed network portability. Our reasoning is discussed in detail in Chapter 6 but can be summarised in the Table below.
## Allocating the costs of MNP

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1. INTRODUCTION

This preliminary report has been prepared by National Economic Research Associates (NERA) and Smith System Engineering (Smith) for the Office of the Telecommunications Authority (OFTA) in Hong Kong. This report is concerned with the introduction of mobile number portability for subscribers who move between mobile network operators in Hong Kong.

1.1. Terms Of Reference

The objectives of this consultancy were:

a) to identify all the possible technical options for the implementation of number portability on all mobile networks. The technical options should address the translation and routing mechanisms of ported mobile number calls amongst mobile networks, the four FTNS networks and HKTI's international network;

b) to assess the costs, short-term and long-term viability and risks of each of the technical options identified in paragraph (a) above;

c) to evaluate the direct and indirect benefits to be gained from the introduction of mobile number portability in Hong Kong;

d) to quantify the benefits identified under (c) as far as possible in order to arrive at the cost-benefit analysis for each technical option;

e) to make recommendations on the cost-recovery framework amongst mobile operators, FTNS operators and HKTI under each technical option; and

f) to make recommendations on the implementation plan for mobile number portability in Hong Kong.

1.2. Overview of Methodology

The cost-benefit analysis that we have carried out is described in more detail in Chapter 5 and Appendix 1. Here we provide an overview of the areas covered as part of the analysis, namely:

- specification of the base case;
- specification of the mobile number portability (MNP) case;
- identification and estimation of the benefits of MNP;
- estimation of the costs of MNP;
- treatment of costs and benefits from a national perspective;
- recovery of the costs of MNP.
1.2.1. The base case

In order to estimate the likely costs and benefits of introducing MNP, it was necessary first to specify a counterfactual case. In other words, to model what would happen in the mobile telecommunications market in the absence of MNP. This required forecasts to be made of market growth as well as changes in the market shares of the different types of mobile networks (GSM, PCS, TDMA and CDMA). These estimates were based on interviews with mobile network operators and consumer groups in Hong Kong and also drew on available market data.

1.2.2. The MNP cases

If MNP is available, there will be more subscribers switching operators since subscribers require a lower level of savings to switch operators if they can retain their number and thus avoid the cost of a number change. Our modelling of the impact of MNP on switching decisions was largely informed by a user survey carried out by SOFRES of 1000 users of mobile phones in Hong Kong. Comparison of the base and MNP cases reveals the number of additional subscribers switching between operators because of the introduction of MNP.

1.2.3. Estimation of the benefits of MNP

Having established how many subscribers fall into the base case and MNP case scenarios, we used the survey results to estimate the benefits of MNP in general as well as the size of benefits available to different subscribers. These benefits were categorised into the following groups:

- **Type 1 benefits.** These are defined as the benefits which accrue to subscribers who retain their number when changing operators and included both the:
  - switching costs saved by those who would have switched even without MNP; and
  - the benefits of lower prices, better services etc for those who move as a result of MNP.

- **Type 2 benefits.** These are the efficiency improvements and any associated price reductions which result from increased competitive pressure. These accrue to mobile subscribers in general.

- **Type 3 benefits.** These are the other resource savings that arise from fewer number changes and include fewer misdialled calls and changes to information stored in customer equipment.

1.2.4. Estimation of the costs of MNP

The cost of number portability can be directly or indirectly associated with different parties according to whether work needs to be implemented by an individual operator, or whether
inefficiencies associated with the solution which lead to the cost are borne by the party. The parties to whom these costs have been associated are:

- **HKTC and HKTI:** the costs associated with these networks have been grouped together and separated from those costs associated with the alternative FNOs because several of the migration options require HKTC and HKTI to carry out changes to their networks independent of the other operators;

- **FNOs:** fixed network operators other than HKTC and HKTI;

**Mobile operators:** the costs associated with mobile operators will vary with factors such as number of customers, length of time in market and technology etc, but for the purpose of this study the operators have been grouped into small and large mobile operators dependent upon whether the operator had more than 100,000 subscribers in October 1997.

The costs incurred by customers can be divided into three types:

- **Type A customer costs:** are those incurred by mobile telephone users who would change network operator, even if MNP were not available. These costs are not therefore caused by MNP. In fact they are reduced by it (eg the need to inform friends is avoided) and these reductions in costs are treated as benefits (see Chapter 5);

- **Type B customer costs:** are those incurred by mobile telephone users who would not change network operator if MNP were not available. These include the costs of SIM cards, handset changes and other migration costs. These costs have been implicitly been netted out (ie treated as negative Type IB benefits) in Chapter 5.

- **Other customer costs:** are those borne by customers making calls to mobile telephones such as the extra dialling delay introduced by the MNP solutions.

In the discussion of the technical feasibility of the solutions and migration options, the number of realistic solutions to be considered in the medium-term has been reduced to a realistic sub-set of the options available. In the cost modelling work that has been carried out, these options have been examined in some detail to assess the cost of the solutions given realistic variations in the factors that affect these costs.

The number of implementation options available has been reduced to:

- call forwarding;
- call drop back;
- distributed database look up in the fixed network only;
The main migration options that have been considered, and for which detailed sensitivity

- immediate roll-out of off-switch solution with database look-up in HKTC's
- migration through call forwarding functionality to off-switch solution with

1. 5.
The purpose of the cost-benefit analysis is to establish whether MNP is likely to be discussed below:

   the aggregation of costs and benefits that accrue to different consumers and

   to another the effects are properly netted out;
   the appropriate discount rate.

consumers and producers it is necessary either to assume that monetary values are a true distribution, or to weight monetary costs and benefits according to the parties to whom and this is the line that has been followed in this study.

PMRS operator loses a subscriber to a competitor, it is necessary to look at the PMRS' loss subscribers with average (or below average) calling rates, therefore it might be assumed greater efficiency, newer technology etc. If so, the PMRS operators and other operators MNP and hence the net impact on profits would be zero.

necessary to deduct the profits that have been made by competitors had MNP not been

As the cost-benefit analysis is being undertaken from a national perspective, the discount
The chosen rate ought ideally to reflect the rate of social time preference and the
may well not be the same, but in practice the rate of 6 per cent is taken to serve both purposes.

1.2.6. Who bears the costs of MNP

A final important issue is that the way that the costs of MNP are recovered could affect the level of benefits. If all the costs were to be borne by the new entrants (the PCS operators in this case), they would need to be passed on to mobile users. This would affect the price differential they could offer and, as a result, the level of switching in the mobile market. In Chapter 5, we have drawn on the experience in the FTNS network in Hong Kong and elsewhere to recommend a method by which the costs of MNP can be recovered in an equitable and efficient manner.

1.3. Structure of the Report

The rest of this report is structured as follows:

- Chapter 2 provides an overview of the mobile telephony market in Hong Kong;
- Chapter 3 presents the range of technical options for MNP and explain the preferred method for its introduction;
- Chapter 4 estimates the costs of introducing MNP in Hong Kong;
- Chapter 5 discusses the survey of mobile phone users in Hong Kong and draw on those results to quantify the benefits of MNP;
- Chapter 6 identifies a variety of cost recovery principles and discuss their application to MNP in Hong Kong.

The report also contains three appendices. Appendix 1 discusses the future of Hong Kong's mobile telecommunications market in the absence of MNP and derives Base Case forecasts of mobile subscriber growth. Appendix 2 develops the subscriber switching model if MNP is introduced. Appendix 3 describes the telecommunications environment in Hong Kong including arrangements for interconnection between fixed telecommunications networks, mobile telecommunications operators and pager operators.
2. MOBILE SERVICES IN HONG KONG

2.1. Background

The telecommunications market in Hong Kong is one of the most competitive in the world. At present, there are four fixed network operators licensed to provide local telephony services. An agreement has recently been reached between HKTI and OFTA to introduce competition into the international services market by 1 January 1999.1

As at December 1997, there were eight mobile network operators with a combined total of eleven digital networks. The recent entry of six PCS licensees has heightened competition and increased the accessibility of mobile telephones. Indeed, by November 1997, almost 2 million people subscribed to a mobile telephone and the market is continuing to grow rapidly. Already, the penetration rate has reached 31 per cent and we forecast that this will grow to 50 per cent by the end of 2002 and 60 per cent in 2007.

2.2. History of Mobile Communications in Hong Kong

Mobile services have been available in Hong Kong since 1984. The first mobile networks were analogue systems which typically used AMPS, TACS or ETACS standards. Hong Kong Telecom CSL, Hutchison and Pacific Link each operated an analogue network although all of these have been, or are in the process of being, phased out.

The first digital networks were introduced in 1993. The technology used in digital systems is generally considered superior to that used in analogue networks. In digital systems, audio sounds entering a mouthpiece are digitally coded and then used to modulate a series of short impulses that are transmitted between handsets and base stations. The advantages of digital systems include greater security than analogue systems (they are encrypted and can block communications from unauthorised handsets) and greater capacity than analogue systems using comparable bandwidths.

Digital systems can be operated using a number of standards. In Hong Kong, the standards used are GSM (operated by SmarTone, CSL, and Hutchison), TDMA (a cellular technology developed in the USA and operated by Pacific Link), and CDMA (operated by Hutchison).

In July 1996, OFTA awarded licences to six consortia to operate PCS networks. These networks are based on the DCS 1800 technology which is similar technology to the GSM standard but implemented at a higher frequency band. The licences were awarded to Hutchison (Everyday), Mandarin Communications (Sunday), New World PCS, P Plus Communications, Peoples Telephone, and Pacific Link.

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1 Subject to the necessary approvals of the Provisional Legislative Council and in return for an agreed compensation package from the Government, external service-based competition (such as International Simple Resale of voice services) will begin on 1 January 1999 and external telecommunications facilities-based competition (such as IDD service over cable and satellite facilities owned by service providers other than HKTI) will begin on 1 January 2000.
2.3. Number Portability for Mobile Services

The entry of the new PCS operators has led to a fall in prices and an increase in the range of choices available to mobile phone users. Despite the highly competitive market, the need for some level of regulation remains. Mobile operators, for example, are required to interconnect with HKTC, the dominant fixed network operator, in order to complete calls that do not originate or terminate on the mobile networks. The interconnect charges are regulated by OFTA. Spectrum constraints (which prevent additional entry into the market) also create a need for regulation and differentiate the mobile market from other markets.

OFTA, therefore, sees one of its key tasks as being the promotion of the development of a fair and competitive operating environment for the telecommunications industry in Hong Kong. The availability of number portability is considered by the TA as essential for the development of telecommunications in Hong Kong and for the delivery of enhanced benefits to consumers. Mobile number portability refers to the ability of users to retain their telephone numbers when changing operator. In the Consultation Paper on Number Portability for Mobile Services in Hong Kong OFTA stated that:

"With such a fast growing mobile customer base in Hong Kong and the choice of mobile networks available to customers, the TA believes that there would be some genuine demands and requirements from customers for mobile number portability."

Mobile operators in Hong Kong, however, have expressed mixed views about the introduction of MNP. The new PCS entrants were very supportive of MNP:

"The PCS operators unequivocally support the introduction and implementation of NP for mobile in Hong Kong. ... We believe that the presence and implementation of mobile NP would, as a direct result of such substantial savings to customers, remove one of the major barriers to full competition in mobile services in Hong Kong given the high percentage of mobile customers who are reluctant or unwilling to change operators if it would mean changing their mobile telephone numbers."

The more established mobile operators in Hong Kong were more sceptical about the need for MNP. Hutchison Telecommunications, for example, suggested that the introduction of MNP could generate a negative net benefit and might not be desirable for a number of reasons including the following:

- the very competitive nature of the mobile market;
- the low cost of subscribers switching numbers given that a large proportion of mobile subscribers are new; and
- subscribers in Hong Kong do not consider the inability to retain their number as a problem.
SmarTone also queried the need for MNP in Hong Kong. They stated that:

there are a few mobile operators. It has been widely recognised that with the 11 mobile networks and 8 mobile operators, Hong Kong is one of the most competitive on (i) whether further competition in Hong Kong resulted from number portability would be desirable and beneficial to the consumers as well as Hong Kong, (ii) for the benefits of Hong Kong, and (iii) the much heavier financial impact on the new mobile operators to implement number portability (and hence degrade their

One of the common themes emerging from the operators was that the TA should conduct comprehensive market research and undertake a cost benefit analysis to establish the

NERA and Smith to conduct the feasibility study and cost benefit analysis of mobile number portability for mobile services in Hong Kong. As part of this study, NERA explore their use and switching behaviour with mobile phones.

2. Fixed Network Number Portability in Hong Kong

Fixed number portability was implemented in Hong Kong in July 1995. For the first 18 agreement on the method for notifying all parties of ported numbers and installation and testing of hardware - a call-forwarding solution was used, before migrating to the current procedural and OSS changes to be made in conjunction with a relatively simple switching solution.

calls to subscribers porting into and out of the network respectively. Calls to numbers that have been ported from HKTC’s local switches are re-routed via the ICG using a gateway HKTC’s network, via the ICGs, cause a database look up to be performed using IN technology.

network operators’ networks.
2.5. International Experience with MNP

Although to date mobile number portability has only been introduced in Singapore, it is on the agenda to be introduced in other countries. This section summarises the state of play with MNP in Singapore, the UK, the Netherlands, New Zealand and the United States.

2.5.1. Singapore

Singapore become the first country to introduce mobile number portability when the mobile telecommunications market was partly liberalised in April 1997. The Telecommunications Authority of Singapore (TAS) adopted a phased approach to the implementation of MNP.
Call forwarding is to be used as the interim measure while operators determine the appropriate long term solution. The long term solution will, however, be based on the intelligent network platform which will be implemented when the technology is more mature.

The recovery of costs, at least for the interim solution, involves a charge to porting subscribers which was agreed by Singapore Telecom and MobileOne. The negotiations were facilitated by TAS. The decision whether to pass on the costs to end users will be a business decision. TAS has, however, agreed that a charge of S$8-10 per month is fair. As a result of the monthly charge, the number of subscribers who have ported is low (about one per cent of subscribers).

2.5.2. United Kingdom

MNP will be introduced in the UK by 1 January 1999. The decision to introduce MNP followed modifications to the licences of the four cellular mobile operators in order to require the Licensees to provide number portability to other mobile operators on a reciprocal basis.

The decision to modify the licences followed the findings of an economic evaluation of number portability in the UK mobile telephony market conducted by OVUM. The consultancy found that the net gain to the UK economy from the introduction of MNP would be £88 million (on a net present value basis). It went on to conclude that:

- the UK would be better off if number portability were introduced;
- OFTEL should therefore require mobile operators to introduce number portability; and
- number portability should be introduced as soon as is practicable.

Mobile number portability will be introduced using a signalling relay capability. Such a solution was seen as compatible with the evolving GSM environment, including supplementary services such as SMS.

2.5.3. The Netherlands

There are currently two operators offering a GSM service in the Netherlands PTT Telecom and Libertel. At least two more DCS-1800 licences will be issued in 1998.

In 1995, a preliminary study of number portability was commissioned by the Ministry of Transport, Public Works and Water Management. This study covered technical as well cost and profit issues. Following the study, the Ministry decided that mobile number portability should be implemented by 1 January 1999. The Dutch operators intend to provide mobile number portability by that date but are developing a proprietary solution to achieve it rather than waiting for the ETSI standard being developed within Europe.
2.5.4. New Zealand

New Zealand has one of the most deregulated telecommunications markets in the world. Decisions on numbering issues (including portability) are made by the Telecommunications Number Advisory Group (TNAG) which has been meeting for over five years. The interim solution will be based on call forwarding while the long term solution will be IN based although the timing of its introduction is uncertain.

2.5.5. United States

The First Report and Order on Reconsideration on Local Number Portability established that long-term number portability in the fixed network must be provided by all the LECs in the 100 largest MSAs according to a phased deployment schedule that began in the fourth quarter of 1997 and ends by 31 December 1998. Thereafter, for smaller cities, LECs must provide number portability within 6 months of a specific request by another telecommunications carrier.

The First Order also discussed a separate implementation schedule for Commercial Mobile Radio Services (CMRS) providers. Cellular, broadband PCS, and covered SMR carriers must have the capability of querying a number portability database, or make arrangements with other carriers to do these queries by 31 December 1998. Long-term mobile number portability must be implemented by 30 June 1999.

The FCC has not selected a particular architecture for long-term portability. Instead, the First Order establishes performance criteria that a LEC's long-term number portability architecture must meet. In particular, any long-term method must:

1) support existing network services, features, and capabilities;
2) efficiently use numbering resources;
3) not require end users to change their telecommunications numbers;
4) not require telecommunications carriers to rely on databases, other network facilities, or services provided by other telecommunications carriers in order to route calls to the proper termination point;
5) not result in unreasonable degradation in service quality or network reliability when implemented;
6) not result in any degradation in service quality when customers switch carriers;
7) not result in a carrier having a proprietary interest;
8) be able to accommodate location and service portability in the future; and

The FCC does support the decision of the industry to implement the Location Routing Number (LRN) method, as defined in the T1S1 document, ANSI T1.660-199x, American National Standards for Telecommunication Signalling System No. 7 (SS7) Call Completion to Portable Number.
9) have no significant adverse impact outside the areas where number portability is deployed.\footnote{FCC 1997 At http://www.fcc.gov/ccb/Nanc/numbport.html}
3. TECHNICAL IMPLEMENTATION OPTIONS

3.1. Background

This chapter discusses the technical options that have been considered as both short-term and long-term options for MNP in Hong Kong, including their feasibility, time frames for implementation, impact on supplementary services and operational systems and procedures.

The market for public mobile telephony in Hong Kong is characterised by a highly competitive environment, with eight separate operators maintaining twelve networks. The technologies represented are:

- GSM;
- PCS;
- IS-95 (CDMA);
- IS-136 (D-AMPS);
- TACS.

OFTA is interested in assessing the feasibility and cost of implementing MNP in Hong Kong in order to realise potential financial benefits. These include the removal of barriers to subscribers resulting from a change of service providers, as well as indirect benefits that accrue from increased competition resulting from lower tariffs. To this end, OFTA published a consultative paper in July 1997 outlining its plans for MNP, including a description of technical options that may be suitable, a suggested cost allocation framework and its intention of setting up an Industry Forum to study technical and implementation issues.

The result of this process showed that widespread support existed for the present feasibility and cost-benefit analysis study. The final report of this study is due to be published in March 1998, and the study will include a workshop at which an interim report will be circulated to interested parties. In the light of the findings, it is anticipated that OFTA may mandate the implementation of MNP in Hong Kong within prescribed timescales.

Throughout this document, the following definitions are used:

- donor operator/network: the operator/network that has lost the subscriber;
- recipient operator/network: the operator/network that has gained the subscriber;
- originating network: the network in which a call to a ported subscriber has been initiated.

The next section focuses on the selection criteria that will be used to assess the options.
3.2. **Option selection criteria**

This section discusses the criteria used to assess the implementation options in recommending a particular migration strategy to OFTA. The focus will be on the criteria used to compare each of the technical solutions and on the process by which OFTA can transpose the technical requirements for the solutions into a functional specification.

Two qualifications are in order. First, the responsibility for the ultimate migration strategy lies with OFTA, and will be affected by factors which fall beyond the scope of this study. Second, the scope of this study limited the degree of technical detail used to assess the costs of implementing each option and their technical implications. These issues are discussed in consultation with operators’ equipment manufacturers within the MNP forum proposed by OFTA. Nevertheless, in considering each of the technical options and each of the migration strategies, the overriding principles set out below will be taken into account. These are:

- technical feasibility;
- cost;
- migration and timescales;
- OSS impact;
- fixed mobile convergence;
- cost allocation compatibility; and
- mapping solutions onto requirement criteria.

3.2.1. **Technical feasibility**

While some of the solutions are infeasible as initial solutions, options for taking up these at a later stage will be considered. Particular risks associated with technically feasible solutions will be identified, such as threats to implementation timescales or quality of service.

Some of the solutions that are being considered are necessarily proprietary solutions due to the ground-breaking nature of MNP in Hong Kong. However, this study will attempt to assess whether such solutions are likely to be developed as standard solutions, thereby providing future security for their maintenance by manufacturers.

3.2.2. **Cost**

The set-up and recurrent costs of the most likely short and medium-term solutions and migration options are considered in the cost modelling section. Options identified as the most desirable are examined in closer detail through variations on a base case model. In addition, a less detailed analysis of other, less desirable solutions are modelled.

Due to the current volatility of the mobile market, it is difficult to predict how the Hong Kong network will develop in the long run. Therefore, the modelling work that has been carried out illustrates the worst-case, maximum-cost scenario.
3.2.3. Migration and timescales

Options are assessed according to their suitability as interim solutions while networks are developed towards the longer-term goals of providing network services and functionality in Hong Kong.

Estimates are made - by drawing on international experience in both the fixed and mobile arenas - of the shortest period in which the options could be implemented, given the goodwill and co-operation of all associated parties.

3.2.4. OSS impact

Any special impact that the solutions may have on the Operational Support Systems (OSS) will be considered. A general discussion of the impact of MNP on OSS is provided in a later section of this chapter.

3.2.5. Fixed mobile convergence

An important long-term goal of most national networks is fixed-mobile convergence. Consequently, each feasible solution is assessed in the light of such an environment.

3.2.6. Cost allocation compatibility

The solutions will also be judged on the ease by which the cost-allocation principles may be applied. These issues are considered in more detail in the treatment of cost-allocation recommendations.

3.2.7. Mapping solutions onto requirements criteria

The role of OFTA in the implementation of MNP is to facilitate a solution that is both feasible and acceptable to associated parties without limiting the implementation choices faced by a given operator.

In mandating any form of number portability, a National Regulatory Authority must initially decide the scope of the requirements. Next, it must develop a set of functional specifications which define the requirements needed to implement number portability, taking into account the cost allocation criteria discussed in detail above. This should include:

- mobile-to-mobile service provider porting only (not fixed-to-mobile);
- digital-to-digital technologies only (not analogue technologies).

The functional specification must define the way in which telephone calls to and from ported numbers are routed between networks, but may also encompass other aspects associated with the porting process, such as operational procedures for the interchange of customer information and the rules for the synchronisation of a central database. The
amount of detail required in the functional specification will be influenced strongly by factors such as the exact regulatory conditions within the network and the status of the national network. In practice, the solutions that are then implemented by individual operators may vary significantly depending on factors such as the size of the networks, the likely number of customers wanting to port in or out of the networks and the interconnection arrangements between the networks.

Examples of such variations in the way in which number portability may be implemented, remaining within the boundaries of national requirements criteria, are:

- in the UK, BT (the incumbent) uses a drop-back mechanism to reduce the cost of completing calls to former customers that have ported to other networks. The necessity for this procedure is a consequence of BT’s two-tier network, and does not need to be implemented in its competitors’ networks;
- in Hong Kong, HKTC uses a combination of on-switch database look ups and central look ups at ICGs to implement fixed number portability. Should economic and operational conditions dictate, the use of originating switch central database look-up would be equally valid within the current requirements criteria.

In considering the various options below, assumptions have had to be made concerning the way in which the operators are likely to implement the solutions, and are documented accordingly.

Several of the options involve a database look-up, either locally at a switch, with reference to a database unique to an operator’s network (a distributed database), or with reference to a central database, accessible - on-line or off-line - to all operators. Each of these options may be implemented in a variety of ways ranging from developing standard switch software, to housing of the database at the SCP point of an IN architecture.

This area of technology is under rapid development at present, but for each option, several implementation methods are possible, as demonstrated in Hong Kong by the different ways in which a database look-up solution has been implemented by each of the fixed operators.

The final format of a solution implemented by an operator will depend on a variety of factors including the number of switches, performance required and available technology. These options will therefore be referred to simply as ‘database look-up’ methods, and more detailed implementation architectures will be considered in calculating the costs of the methods in section 4. For further cost modelling, it has been assumed that the current rules for the fixed solution will be adhered to.

### 3.3. Operational support systems (OSS)

The impact of MNP on the OSS of the fixed and mobile operators is still under investigation and will be discussed in the final version of the report.
3.4. On-switch solutions

On-switch solutions are those in which information concerning the whereabouts of ported subscribers is held on the switch in the donor network to which they were originally connected. Inevitably the routing of calls to such subscribers is inefficient, and so these solutions can only be considered as interim solutions pending more efficient off-switch solutions.

This section discusses the on-switch solutions. The basis for options identified in the consultation paper published by OFTA are supplemented by several other options identified by the study team. For each option, the method is identified, the suitability of the method according to the selection criteria outlined in section 4 considered and a summary of the advantages and risks identified.

3.4.1. Call forwarding - mobile-network look-up (OFTA option 2)

From the point of view of the switching architecture, call forwarding is the simplest option, requiring minimal modifications to the switching equipment. The option is illustrated in Figure 3.1.

![Figure 3.1 Call forwarding solution](image)

Calls are routed through the fixed and mobile networks in the usual way though, in reality, the majority of calls will pass through HKTC’s network during the proposed time for the utilisation of a call forwarding solution.
Should a subscriber subsequently port to a second recipient operator, the unconditional call forward set on the donor operator's switch will be adjusted to point to the new recipient operator's switch, and the other operator would drop out of the operational handling of such calls.

Solutions based on call forwarding-type schemes have been achieved in a variety of ways in fixed solutions in different countries, each solution being a trade-off of development effort required to achieve more efficient use of switch resources. For mobile number portability it is assumed that the forward would be achieved using a standard unconditional call forward divert, which would tie up an extra port on the switch for the duration of the call, and utilise corresponding processor resources. Should development of an alternative solution be deemed worthwhile, it will be likely that the overall cost of the development, less the savings in reduced resource consumption, will make this assumption a worst case.

Several variants on the format of the call forwarding scheme, including the use of second dummy numbers, the addition of routing prefixes, or the definition of a new numbering space - sometimes referred to as routing numbers - have been considered in many countries both for fixed and for mobile number portability. It has been assumed that in Hong Kong the formats of the forwarded number would be consistent with the Gateway Numbers used in the fixed interim solution, that is either:

- Gateway number = Network Identifier (3 digits) + Directory Number (8 digits);
- or
- Gateway number = Network Number (9 or 10 digits).

Numbering space in Hong Kong has been reserved for both formats.

3.4.1.1. Technical feasibility

The implementation of a call forwarding solution in Hong Kong would be technically straightforward, and a similar solution was used as an interim for the introduction of fixed number portability. A number of factors should be considered, however.

By allowing calls to be completed to the donor GMSC and then be rerouted to the destination switch, resources such as switch processing and switching capacity, as well as trunk traffic and signalling capability are consumed. As the number of calls to ported numbers increases, this increase in capacity demand may have implications for the ability of the mobile operators' and HKTC's networks to supply this extra capacity.

The costs associated with the tromboning of calls between the FNOs' networks and the donor operator comprise both the inherent cost of handling the extra traffic at the donor GMSC, the cost of utilising interconnection capacity between operators other than HKTC, as well as the additional interconnection charges that are paid to HKTC. Detailed modelling of these extra costs is carried out in section 4.
In order for CLI to be handled correctly, arrangement must be made in the recipient operator’s network for all outgoing calls to present the DN of the subscriber. This can be achieved by means of insertion of the number string in the relevant part of the outgoing SS7 messages.

Incoming calls to the ported subscriber will have presented to them both the CLI of the originating caller, as well as that of the DN itself. For applications that rely on the use of this information, minor changes may need to be made to ensure that the appropriate field is selected.

Inbound calls from outside Hong Kong, via HKTI’s network to numbers that have been ported could, in principle, cause problems with the operators’ call accounting process. This is because the service charge that is delivered to the mobile operators by HKTI for calls terminating in their network would be paid to the donor network, and the subsequent call forward leg of the call would appear to the recipient operator as an ordinary call. The recipient operator would therefore be unaware of the latent revenue to be collected for the call from the donor operator.

This problem was overcome during the period in which a similar call forwarding interim solution was in place for fixed number portability by routing such calls along dedicated inter-operator routes. It is unlikely, however, that the traffic over the multitudinous routes between all of the mobile operators could justify the expense of such dedicated routes, and therefore modifications would have to be made to the mobile operators’ billing systems to screen such calls and make appropriate adjustments to the inter-operator accounts.

The operation of the SMS system has not yet been fully specified as part of the GSM standard and, consequently, many variations on its implementation exist throughout the world. In Hong Kong, the main use for SMS is for network operators to offer information delivery value-added services (VAS) to their customers, and very little MO traffic is generated. Under the call forwarding solution, MO SMS messages to ported subscribers might not be able to be completed. The VAS would continue to work, however, because messages to mobiles registered on the recipient network could be identified using the IMSI address of the ported number, which is unique to the new SIM card issued when the subscriber ports.

Whilst the call forwarding solution is in place, the call forwarding capacity of the mobile operators’ GMSCs, extra processing capacity and user ports will be reserved for the duration of calls to ported customers. This may require the operators to invest in extra capacity, but once a medium-term solution is in place, this capacity would be released for use by new customers.

Mobile operators that have direct interconnection between their networks would be able to forward calls to customers ported between their networks via the interconnecting leased lines, and thereby avoid incurring additional interconnection charges to be paid to HKTC.
3.4.1.2. Timescales and migration

A similar solution has been implemented in Singapore within the last six months, and so, coupled with the experience already gained in Hong Kong in number portability, roll out in similar timescales should be realistic. The timescales are most likely to be determined by the changes that need to be made to the OSSs.

We have assumed that such a solution could be rolled out in 6 to 12 months.

3.4.1.3. OSS impact

As part of the cost allocation principles developed as part of this study, the charges made by HKTC for the extra interconnection costs incurred for the tromboning of calls between HKTC's network and the donor operator are passed on to the recipient network. The billing systems of the mobile networks must be modified accordingly and procedures defined for the exchange of this billing information, and settling of accounts.

In addition, the revenue for calls originating outside the Hong Kong SAR would need to be screened and passed onto the recipient operator, and the billing systems of the mobile operators would need to be adapted accordingly.

3.4.1.4. Fixed mobile convergence

This solution is necessarily an interim solution and, though in principle an extension of a solution used to implement number portability, would not be used in the long-term.

3.4.1.5. Cost allocation compatibility

The solution requires little or no modifications to be made to the systems of FNOs, and so all set-up costs are borne by the mobile operators.

Additional conveyance costs would be particularly acute, were the take-up of porting services to be high, and would strongly depend on the timing of migration options and the take up rate of number portability. This is explored more thoroughly in section 4.

On-going costs include overheads associated with the use of facilities on the donor operator's GMSC which are controlled by the donor operator. The additional interconnection charges paid to HKTC are outside the donor operator's realm of control and should be passed onto the beneficiary of the porting traffic, namely, the recipient operator. This is discussed further in section 6.

3.4.1.6. Summary of advantages

- Easy to implement, requiring few, if any, changes to the mobile switches.
- Able to be quickly rolled out using procedures similar to those already in existence.
• Good compatibility with CDMA/D-AMPS systems, as call forwarding would be implemented using the call forwarding features of these switches.

• There is no requirement for the fixed operators to make modifications to their look-up databases.

3.4.1.7. Summary of risks

• Some operators claim that problems would be encountered with the handling of CLI information, used to provide CLIP. It would appear, however, that these fears are unfounded and that, with minor modifications, these problems may be overcome for calls to and from ported numbers.

• Operators have expressed concern that the solution is likely to overload the call forwarding capacity of their networks, perhaps necessitating the deployment of extra capacity.

• SMS messages cannot be forwarded in this way, though in Hong Kong, the operators' SMS-Cs are not interconnected, which limits the usefulness of SMS, and so this is less of a problem anyway.

• International calls terminating at a mobile telephone that has been ported within Hong Kong will not be able to be traced by the recipient operator's billing system so that HKTI can be billed accordingly. Similar problems were encountered during the operation of the interim fixed solution, and were overcome by trapping the calls and routing them along separate trunks.

• HKTC has expressed concerns that it may not be able to support the additional capacity demanded of its network in the event of heavy take up number portability leading to a surge in interconnection service demands. HKTC has stated that it may require up to 18 months to implement such capacity.

• Calls forwarded to a recipient's switch rely on the integrity of the donor's network for the grade of service offered to its customers. This threat to network integrity could be backed up by service level agreements, but remains an implicit danger for a network porting in customers.

• Introduces additional dialling delay.

3.4.2. Call drop-back
This solution, illustrated in Figure 3.2, was not considered by OFTA in its discussion paper.

![Figure 3.2: Call drop back](image)

The solution is superimposed onto the call forwarding solution identified above, and is most likely to be rolled out only when this simpler solution has been running for some period of time and is stable.

The initial signalling exchange to set up calls is intercepted by the donor exchange, and sufficient information returned to the originating exchange in order for the call to be completed to the recipient operator's network, thereby significantly reducing the tromboning of calls into the donor network.

### 3.4.2.1 Technical feasibility

A proprietary version of call drop back has been implemented in HKTC's network as part of its fixed number portability solution in order to improve internal routing of calls within the network.

A similar technique is used in the UK fixed networks to reduce tromboning between tandem and local level switches.

For both solutions, however, dropback is not achieved across a point of interconnection between two networks, as would be required here, and world-wide operators have misgivings about using such a solution because of its implications for the billing for such services. Call dropback functionality is not a standard ITU-T SS7 function.
Development of such functionality would require agreement concerning the commercial and technical issues as well as development effort from the manufacturers of all switches used in the Hong Kong network.

3.4.2.2. Timescales and migration

Manufacturers do not offer call drop back functionality as a standard feature on switches and this would need to be developed as a proprietary solution. The time to agree and develop a solution between the various manufacturers is likely to be at least twelve months.

Furthermore, roll-out of the functionality at the same time as the implementation of number portability would be a risky strategy, and so it is likely that the roll-out would be staggered to be at least six months after the roll-out of the call forwarding solution. It is desirable that the call forwarding solution be in place in Hong Kong for as short a period as possible in order to avoid potentially expensive additional conveyance costs, preferably 6 to 12 months at longest, and so the risk and development effort involved with the implementation of such a proprietary would be unreasonable. The magnitude of these additional conveyance costs are investigated in more detail as part of the cost modelling.

3.4.2.3. OSS impact

There would be no additional impact on the OSSs of the operators’ except if it were agreed that the additional signalling and processing overhead associated with dropping back of calls were to be accounted for between operators. The elimination of call tromboning would obviate the need for the billing systems of the donor and recipient operators to transfer the additional interconnection costs.

3.4.2.4. Fixed mobile convergence

This solution is necessarily an interim solution, and though in principle an extension of a solution used to implement number portability, would not be used in the long-term.

3.4.2.5. Cost allocation compatibility

The development of this solution would require proprietary development work to be carried out which may not be adopted in other countries. Therefore, it is likely significant investment by switch manufacturers will be required, both for the fixed switches, and the mobile switches. Manufacturers are unlikely to want to invest in a proprietary solution, meaning that development costs would fall to the operators.

Subsequent routing of calls would be more efficient, however, reducing the on-going costs of the solution leading to significantly reduced additional conveyance costs.

The application of the cost allocation principles would be identical to that for the simple call forwarding solution, with the exception that accounting for the additional interconnection costs would not be required.
3.4.2.6. **Summary of advantages**

- There is no requirement for the fixed operators to make modifications to their lookup databases.

- The additional interconnection costs will be reduced relative to a call forwarding solution and there would no longer need to be accounting for additional interconnection charges to HKTC between donor and recipient networks.

- The solution would reduce the load on the HKTC network.

3.4.2.7. **Summary of risks**

- At first sight this solution appears to be particularly suited to the HK scenario as most calls are routed outwards from the central star hub of HKTC's network. This would, however, be a proprietary solution requiring drop back across a POI, and may not be adopted as a standard implementation.

- The solution is strongly dependent on fixed operators, as the switches in these networks would need to implement drop back on all switches.

- It is unlikely that a 'big-bang' approach would be sensible, it being best to roll out the call forwarding solutions first to shake out technical and operational problems before implementing the drop back feature at a later stage.

- The impact on supplementary services is not clear at this stage.

- CDMA and D-AMPS manufacturers would also have to develop drop back functionality for single networks, or else additional tromboning would be incurred.

- Introduces additional dialling delay.

3.5. **Off-switch solutions**

Off-switch solutions are those in which information concerning the whereabouts of ported subscribers is held at a location other than the donor network switch to which they were originally connected. Generally, information concerning the new location of the subscriber is exchanged between network operators and held on a database for real-time reference. This ability to route calls to the ported subscriber at an earlier point in the call chain allows considerable savings to be made in the cost of the call.

This section discusses the off-switch solutions. The basis for options identified in the consultation paper published by OFTA are supplemented by several other options.
identified by the study team. For each option, the method is identified, the suitability of the method according to the selection criteria outlined above is considered and a summary of the advantages and risks identified.

The method of maintaining the national database can be divided into two categories: central and distributed. The central database is maintained by a single central organisation, and referred to by all operators. The distributed database functions by each operator maintaining its own copy of the database, updated by information concerning individual porting actions, and compared with the other databases periodically; this is the current situation for the maintenance of the FNO databases.

The following sections discuss

- the benefits of each of these arrangements;
- the mobile-network look-up solution;
- the fixed-network look-up solution;
- the all-network look-up solution;
- signal relay-based solutions developed in the UK and Netherlands; and
- the North American solution.

3.5.1. Database options

3.5.1.1. Distributed database

The current database synchronisation arrangements in place for the fixed number portability solution in Hong Kong are in the form of a distributed database. Each operator maintains copies of the national database updated by reports of individual porting actions. These reports are distributed via the AD system and cause each of the four operators' databases to be updated. The databases are then routinely audited against one another every month.

A similar arrangement, or extension of the current arrangement could be used for the implementation of mobile number portability. If the national network were to move towards all operators carrying out their own database look-ups, however, synchronisation of 11 or separate databases may become increasingly resource intensive.

The advantages of the distributed database are:

- In Hong Kong, arrangements for a distributed database between at least the fixed operators are already in place.

The disadvantages of the distributed database include:
3.5.1.2. **Central database**

The central database would be maintained by a single central organisation which may be OFTA, HKTC or other third-party. The responsibility of this body would be to technically and operationally maintain the database ensuring that the information held within the database is accurate, and updated where necessary, whilst providing a level of availability appropriate to a telecomm network. In the event of corruption, however, of the data, the donor network operator would be responsible for data concerning number ranges allocated to them.

The database would need to be replicated for resilience, though the specification of the database would not need to be as stringent as the real-time reference databases used by individual operators.

The central database would be installed as an addition to the existing infrastructure associated with the distributed database, because each operator will need to maintain at least one local copy of the database for real-time interrogation.

The central database is likely to contain more information than the DN to NN mapping pairs required by the telecommunications networks in real-time, however, which would more easily facilitate the maintenance of the database.

Copies of the central database would be down-loaded into the non-real time systems of the individual operators at regular intervals, or notification of individual porting events could be passed to the operators to allow them to maintain synchronisation of their databases with the central database between more formal downloads of the whole database. One or more copies of this database are then likely to be held for real-time interrogation by individual operators' switches.

In Hong Kong, the implementation of a central database would be an adjunct to the functionality provided by the present system, providing potentially improved and secure operational performance. Even so HKTC would still be required to adapt its database look up fixed number portability solution to the requirements for MNP.

The central database carries with it the advantage that:

- an accurate central copy of the national database is maintained for reference by all other operators;

while disadvantages encompass:
The funding for setting up and maintaining a central database must be agreed between operators.

In the absence of technical reasons, there is little financial incentive for operators to invest in such a facility.

Commercial problems concerning the ownership of the equipment and data would need to be resolved.

If corruption occurs, re-synchronising the database to the information held by the donor networks would be difficult.

There would be security implications for a database that is accessible from multiple parties.

3.5.2. Mobile-network look up (OFTA option 2)

Option two in OFTA's consultation paper includes routing to ported numbers being carried out by the mobile operators. In theory, this could be achieved by using a central database look up technique, though in reality no better results could be achieved than using call forwarding as the majority of calls – those initiating from HKTC's or HKTI's network – would trombone into the donor network operator's network for the duration of the call.

This solution is unlikely to be seriously considered, as calls to subscribers that have ported away from a network would still be inefficiently routed into and out of the donor network causing tromboning of calls, and incurring the same penalties that are encountered by a call forwarding solution. Secondly, as yet relatively few calls are mobile to mobile, and there exist few direct interconnection links between mobile networks, and so calls would need to be routed via the fixed network anyway.

3.5.3. External database – fixed-network look up (OFTA option 3)

3.5.3.1. Method

This option requires the fixed operators to perform the necessary number translation functions for calls to ported mobile customers as an expansion of their existing duties for the routing of calls to ported fixed numbers. The option is illustrated in Figure 3.3, which demonstrates worst-case routing scenarios.

Furthermore, mobile-to-mobile calls would strictly be caused to be routed via the fixed network, even if a direct point of interconnection exists between the two networks. It is likely in these circumstances that calls that would more efficiently be routed through this POI would be intercepted and passed this way, achieving all that is required by option one: all-operator look up.
This option involves expansion of the capacity of HKTC database look-up system. Currently 95% of calls pass through HKTC network, and so such a solution is likely to be efficient — at least in the short-term.

### Technical feasibility

In principle, extension of the FNO fixed number portability solution should be straightforward by extending the range of numbers that cause a database interrogation to be carried out. The practical and operational impacts of expanding the capacity of HKT networks is less easy to assess, though in principle developing the extra performance capability (both size of database and number of dips per second required) is possible. HKT have suggested that the current solution may need to be significantly redesigned, and a study into this possibility would need to be carried out as a matter of urgency.

Scaling the other FNOs' solutions should be more straightforward as they are based on central IN solutions.

### Timescales and Migration

The timescales for the extension of this functionality is difficult to assess until the exact solution is known. Taking the worst-case scenario that the solution would need to be redesigned from scratch, we believe that such a solution could be rolled out in 12-18 months, though if the solution were to be a migration from a call forwarding solution, a
further 6 months may have to be added to this estimate to reflect the diversion of resources away from its development, and migration activities that would have to take place.

3.5.3.4. OSS Impact

No additional impacts have been identified of this solution on the OSSs.

3.5.3.5. Fixed mobile convergence

The solution offers ideal scope for full mobile-fixed convergence allowing mobile numbers in principle to be ported to fixed numbers and vice versa.

3.5.3.6. Cost allocation compatibility

This solution achieves close to optimum routing of calls to ported numbers, though this is only actually achieved when all originating switches are capable of database look up. For the basis of our calculations, we have assumed that this is so, as it is not clear when a full IN solution roll out is likely to be achieved, particularly as international services have not yet been liberalised.

HKTC would need to fund expansion of its database look-up capacity, and has stated that it believes that it has no obligations for the funding of such solutions.

3.5.3.7. Summary of advantages

- This solution is functionally almost identical to the current fixed solution.
- No immediate development work would be required in the mobile switched networks.
- Close to optimal call routing achieved.
- The solution provides a good basis for fixed-mobile convergence.
- The solution should be fully compatible with most none TCAP supplementary services, as the calls are routed in the most efficient way.
- The solution would be compatible with CDMA/D-AMPS systems as most of the modifications are made exclusively in the fixed networks.

3.5.3.8. Summary of Risks
HKTC have expressed concern that large upgrading of its central look up equipment would necessitate fundamental redesign and implementation of this equipment, which it would be unhappy to fund. Pending the resolution of its current grievances with OFTA over cost allocation for the fixed solution, this could cause a bottleneck.

The database needs to accept changes from 11 fixed and mobile operators increasing the danger of errors being introduced. Suitable operational procedures would need to be devised to minimise this risk.

This implementation is dependent entirely on the fixed operators, making cost allocation rules complex.

The solution would be potentially a non-standard implementation.

Introduces additional dialling delay.

3.5.4. External database – all-operator look up (OFTA option 1)

3.5.4.1. Method

This method is illustrated in Figure 3.4.
The principle behind the solution is that each party should carry out number translation in its own network where necessary, so that no calls are routed to an inappropriate POI. In reality, this would be achieved in a variety of ways by individual operators, in the same way that the fixed number portability solution has been implemented in different ways by the fixed network operators.

In practice, this is a solution on an almost continuum of solutions from option three (fixed network look up only) to a full IN solution whereby all originating calls cause a database look up at the original exchange. In considering this solution therefore, the study will be considering a particular point in the potential development path of the MNP solution, and it will be assumed that all operators implement the solution in the same way that HKTC has implemented fixed number portability.

3.5.4.2. Technical feasibility

Implementation of database look up in the mobile networks would necessitate a proprietary solution, or investment in technology. Several of the operators have already invested in such technology and it is possible that such a solution could be based on this platform. The operators may have reservations about using this platform for such a basic network function, as later development work on the platform could threaten the integrity of the whole of the operator’s network. In which case the operators would need to invest in additional IN hardware.
3.5.4.3. **Timescales and Migration**

As described above, it would be inappropriate to mandate that all operators implement a database look up solution, as for the current interconnection situation, few calls would benefit from being routed within the mobile network as they need to pass through the fixed network anyway. Instead, such functionality should be adapted by individual operators when the commercial conditions are favourable. Therefore it is impossible to estimate when this condition will be achieved, though in principle it could be achieved under similar time scales to that required for the roll out in the fixed network ie 12-18 months.

3.5.4.4. **OSS Impact**

No additional impacts have been identified of this solution on the OSSs.

3.5.4.5. **Fixed mobile convergence**

The solution offers ideal scope for full mobile-fixed convergence allowing mobile numbers in principle to be ported to fixed numbers and vice versa.

3.5.4.6. **Cost allocation compatibility**

This option requires expansion of the fixed network central look-up routing capacity, and development of mobile switches leading to implementation of central look-up routing functionality. It is unlikely that this would be appropriate as an immediate solution, rather as a step along the migration path. If this is technically preferable at some stage, however, the cost allocation principles adopted should ensure that its implementation is encouraged.

This is the ultimate solution, allowing all calls to be routed along the optimum path. The cost of setting up look-up functionality in the mobile network is unlikely to be initially justified, however, though the operators should be encouraged to move towards this solution when traffic levels and interconnection makes this appropriate.

This solution would most likely be implemented by the mobile operators initially using on-switch solutions to perform the on net look up for mobile-originating calls, which would not be too onerous, as the number of MSCs in each network is low. Such a solution would demand development on these switches, however.

3.5.4.7. **Summary of advantages**

- Compatible with fixed solution number portability solution.

- Mobile-to-mobile calls can be routed to the most appropriate POI without having to leave the network for number translation by the fixed network.

- Close to optimum routing is achieved.
The use of IN technology in the mobile networks is encouraged.

Provides good basis for fixed-mobile convergence.

The solution should be fully compatible with most supplementary services, as the calls are routed in the most efficient way.

3.5.4.8. Summary of risks

HKTC would need to significantly increase the capacity of its current database look-up apparatus.

All operators would need to invest in look-up equipment, though few calls would benefit from look up in the mobile operators’ network at present.

Extra costs for implementing look up in mobile network for minimal benefit currently.

Central database needs to accept changes from 11 fixed and mobile operators.

Implementation is largely dependent on fixed operators, making cost allocation rules complex.

Fixed network implementation should be straightforward, however, implementation in the mobile network would be less easy, and it is undesirable for all operators to implement NP by this means at one go.

The D-AMPS and CDMA systems would face similar development task to that of GSM operators, though in worst-case the solution could be implemented using an IN solution

Introduces additional dialling delay.

3.5.5. Signal relay-based solutions

Number portability solutions have been developed independently of one another in the UK and Holland. Examination of the two methods has revealed however, that many fundamental similarities exist between the two proposed solutions, and the two technical groups working on these solutions are collaborating to harmonise the solution.

These solutions were not considered in OFTA’s consultation document.
The set of protocols defined as part of the SS7 signalling stack including protocols for handling calls mobile telephony applications is shown in figure 3.5.

**Figure 3.5**

SS7 Signalling Stack.

Completion of circuit-switched calls between fixed telephone nodes is achieved through the use of the Telephony User Part (TUP) of the SS7 signalling stack, which in Hong Kong, and increasingly throughout the world is an implementation of the ISDN subscriber User Part (ISUP).

The Transaction Capability Application Part (TCAP) based on top of the Signalling Connection Control Part (SCCP) is increasingly being used as the basis for more advanced services in the PSTN including packet relay and advanced supplementary services, such as CCBS.

Specialised functions associated with the control and operation of mobile networks are achieved using services offered by the Mobile Application Part (MAP) layer which is located above the TCAP. The protocols that are used to control functions such as mobile location management, security management, networking functions as well as SMS are controlled using the various Mobile Application Parts which sit above the TCAP/SCCP.

The requirements for MNP described in section 1.1 can be translated into technical terms as the ability for the MNP function in Hong Kong’s network to terminate calls and services completed using both:

- ISUP signalling;
- TCAP/SCCP signalling.

TCAP/SCCP functionality is used in Hong Kong only to allow the completion of calls to the international community, and TCAP/SCCP transit functionality is not offered by HKTC’s network.
As the SS7 standard develops, however, applications based on TCAP/SCCP to offer services such as CCBS within fixed networks and between fixed and mobile networks will be increasingly used by mobile networks to offer services such as optimal routing: the ability of internationally roaming subscribers to call a third country without the need for the call to be anchored at the subscriber's home MSC.

The Anglo-Dutch signal relay allows calls for services in the TCAP/SCCP stack to be passed onto the recipient operator's network, thereby more fully allowing the functionality of these TCAP/SCCP-based services, now and in the future.

The way in which MNP is to be implemented in the Dutch and UK networks varies in its detail, but the fundamental mechanism is that MAP signalling that was formerly used only within operators' network is relayed between networks of different operators. Until now the only other example of such interchange of MAP signalling between operators was that required to locate subscribers roaming in international networks. In particular, Signal Routing Information requests (SRIs) are relayed onto the HLR of the recipient network from the donor network, from where the Routing Information (RI) can be returned. This situation is illustrated in Figure 3.6.

![Figure 3.6](image_url)

**Figure 3.6**
The signal relay function (lower diagram) of MAP functions (upper diagram)
Requests to the MSC or by the MSC for information concerning a subscriber are normally serviced and contained within the mobile operator's network. The signal relay mechanism however, allows such requests and responses to be relayed onto a third-party network allowing routing information to be retrieved, or a remote switch to be controlled by TCAP messages.

3.5.5.1. **UK implementation**

The proposed UK solution is illustrated in Figure 3.7.

A call connect request (IAM) is received by the donor operator's MSC. An enquiry is made via the SRF function of the switch for information on the new location of this subscriber to be relayed back to the switch, where the call is routed onto the recipient operator's MSC using a newly defined Intermediate Routing Number (IRN) format - essentially a prefix before the MSISDN number.

Once the call is completed to the recipient operator's switch, a further routing information request is made, and the MSRN or similar routing number returned.

The multi-step nature of this solution is a result of regulatory requirements on the amount of processing that is required of the donor operator's network, and problems that were encountered in resolving accounting problems experienced with earlier solutions.
This particular implementation would be impractical in Hong Kong, however because it requires calls to be completed to the donor GMSC, which would cause tromboning of calls as for the call forwarding solution.

The UK signal relay solution is effectively an interim solution on the way to a final central look up solution.

3.5.5.2. Dutch implementation

The proposed Dutch solution is illustrated in Figure 3.8.

Figure 3.8
Dutch Signal Relay Solution

This solution will be implemented as part of a joint fixed and mobile number portability solution. Calls to both fixed and mobile numbers will make reference to a database to complete calls via a Signal Transfer Point (STP), a device for mediating signalling information to remote switches similar to IN technology.

The SRF is contained within the STP device, and data associated ported numbers are contained on the database. Signalling messages associated with the ported mobiles – both TCAP and ISUP – will be forwarded to the address associated with the ported subscriber.

3.5.5.2.1. Technical feasibility

The SRF functionality is essentially a number translation service for both ISP and TCAP messages. The solutions considered prior to these solutions handle only ISUP messages, and would not be able to handle TCAP based services. The use of this layer is not
widespread in Hong Kong at present, however – HKTC does not offer SCCP transit functionality – and so in the medium term this is not a significant drawback.

The UK/Dutch solution appears to be the only one which does address these aspects, but the solutions can only be considered as proprietary until they are adopted more widely, or until they become an ETSI or ITU-T standard. The solution is being implemented by Ericsson on its hardware.

Discussions with operators and manufacturers suggests that such functionality could be retrofitted to a database look up solution. It appears that the SRF functionality would have to be supported by the FNOs’ networks for the systems to work efficiently.

3.5.5.2.2. Timescales and Migration

The Dutch and UK solutions are due to be in place by January 1999, but after a significant amount of in-house development work. It is difficult to say when manufacturers would offer such functionality in future, but it would seem unlikely to be widely accepted before 2000.

3.5.5.2.3. OSS Impact

It is difficult to assess the impact of SRF on OSSs, as the implementation details in Hong Kong are not clear. Difficulties have been experienced in the development of the UK solution because an original proposal suggested the relaying of calls to a roaming subscriber could proceed without passing through the recipient operators network causing problems with the accounting function. This is only a temporary difficulty, however, because similar problems need to be addressed to be able to implement some phase 2+ modifications to the GSM standard such as optimal routing.

3.5.5.2.4. Fixed mobile convergence

The Dutch solution has shown that such functionality can be implemented in a pure fixed and mobile number portability solution.

3.5.5.2.5. Cost allocation compatibility

The cost allocation principles have needed to be adapted with care in the UK, largely because of the way in which the functionality is implemented. It is difficult to say, therefore, how the cost allocation principles could be applied in Hong Kong.

3.5.5.2.6. Summary of advantages

- A SRF solution will be compatible with SMS services, and other phase 2+ features.
3.5.5 2.7. Summary of risks

- The solution is not likely to be available in the UK and Holland until late 1998.

- The solution is not applicable to non-GSM networks without extra development work.

- In the UK-developed solution routing of calls to mobile numbers is controlled from the donor operator’s MSC. This reduces the tromboning of calls from donor to recipient MSC. In the Hong Kong scenario, however, calls to subscribers operating within the special administrative region would need to be routed via HKTC’s network to the recipient network anyway, and so only calls to international roaming subscribers would benefit.

- Introduces additional dialling delay.

3.5.6. North American solution

3.5.6.1. PCS 1900 solution

In the US, the Government has encouraged operators to implement a combined mobile/fixed solution. Non-geographic and fixed number portability has been implemented, and mobile MNP is to be introduced on a staged-basis from January 1999.

The PCS 1900 operators have decide to route calls using an extension of the fixed number portability solution using Location Routing Numbers (LRN)’s, essentially a number which identifies the serving switch for calls using an database look up. The database lookup may be made by the terminating or preceding networks.

This solution has been developed to be compatible with the existing fixed number portability solution that is in place in the US. The use of such LRN is inappropriate for Hong Kong in which a format for Network Numbers has been defined. Furthermore, the solution’s limitations in handling TCAP-based services suggests that deviation from the other database solutions outlined above would not be justifiable.

Advantages are:

- The solution is a type of database look up solution developed for the US, and has similar advantages to those outlined above, though the solution is developed for use specifically in the US environment.

The risks are:

- The solution may become effectively proprietary if not adopted by other standardisation bodies.
3.6. Standardisation

This section summarises the work being carried out in various world standardisation bodies aimed at the definition of standards for the implementation of mobile number portability.

3.6.1. ETSI

ETSI has an on-going programme of work looking at solution for fixed and MNP, but is confined to technical issues only. At the end of 1996, a special task force was created called the Number Portability Task Force (NPTF) to co-ordinate the work being carried out in the various technical committees. Groups that feed into this committee are the Network Aspects (NA), Signalling Protocol & Switching (SPS) and Special Mobile Group (SMG) committees.

Work on a MNP solution has been developing since early 1997, and the first stage of the three stage process, definition of a high-level service description is now complete. Work on the second and third level standards is due to be complete by mid-1999. For the technical implementation of MNP two solutions appear to be being considered, the joint Anglo-Dutch signal relay solution, and the US-sponsored LRN-based solution. A separate work package has been defined to ease the convergence of fixed and MNP solutions under the supervision of the NPTF.

ETSI hopes to be in a position to strongly influence the standards adopted by the ITU-T.

3.6.2. ANSI

In the US, fixed and mobile operators are being encouraged to move rapidly towards fixed-mobile convergence. The LRN IN solution has been adopted as the most appropriate form to achieve this convergence.

For the PCS-1900 system, the T1P1 committee of the Alliance for Telecommunications Industry Solutions (ATIS) is developing the LRN-based solution which will imminently be submitted to ANSI for acceptance of the US solution.

3.6.3. ITU-T

Work on number portability in general is being developed within SG2 and SG11 looking at aspects such as numbering, routing, network architecture and protocols. Little work has been carried out at ITU level for the definition of MNP portability standards. A task force has been established to begin initial definition work for MNP, and first met in February 1998.
3.7. Option selection and migration recommendations

The previous sections have analysed in detail the benefits and risks associated with each of the technical options for implementing MNP that have been investigated as part of this study.

This section extends that analysis to analyse the most appropriate implementation solutions, any interim solutions that may be appropriate, and the migration path that may be followed towards the support of MNP in the future.

The preferred technical options that are identified here are investigated in more detail in section 4: cost modelling to predict the overall benefits of different migration strategies, and the cost profile of such a roll-out. The remainder of this section investigates:

- the factors that influence the migration strategy;
- the preferred medium-term solution;
- an alternative roll-out solution using a call forwarding solution as an interim solution;
- other solutions that may form a part of an alternative migration strategy;
- the strategy for the long-term technical development of MNP; and
- conclusions of this section.

3.7.1. Factors influencing migration strategy

The factors that influence the most appropriate migration direction for MNP are complex, and difficult to predict in a changing environment such as the Hong Kong mobile telephony market. Predictions of the revenue of individual companies, and other parameters such as the amount of interconnection between future fixed and mobile networks are complicated by developments such as operator mergers, and market, service and technological developments.

The selection criteria appropriate for individual solutions used above are supplemented by other factors such as the effect of these external influences on the solution, and the ease with which migration between solutions can be achieved.

The migration plan that is adopted, both for long term strategy planning purposes and to avoid short-term operational difficulties should take into account the following additional factors.

3.7.1.1. Non-disruptive

The solutions implemented and intermediate migration steps should provide a stable service to the users of Hong Kong's telephony services at all times. Particularly vulnerable
times are during the initial roll-out of the solution and during phases of migration, and therefore radically new solutions in a complex network such as that in Hong Kong should be approached with caution.

The system should also be able handle the capacity of porting requirements, both the number of porting subscribers and the volume of porting traffic, without reaching any inherent limits within the system.

3.7.1.2. Roll-back

The migration strategy should allow the system to be rolled back to its previous configuration at all times in case operational problems are encountered during roll-out or migration.

3.7.1.3. Future proofing

The migration strategy should allow the solution to be developed to satisfy the future needs of Hong Kong's telephony users, and have no negative impact on existing and planned services and facilities, were MNP not to have been implemented. Future migration should also be able to proceed in a cost-effective manner. An example of this is the ability for future solutions to be able to handle SCCP message translation within the network.

It is good practice, however, to delay the implementation of functionality that is not required immediately until a later date, reaping the benefit of reduced costs due to the availability of more planning time and the reduction in the cost of the solution, as well as allowing standards bodies and manufacturers to have settled on a preferred implementation.

3.7.2. Medium-term solution

Analysis of the solutions available to Hong Kong reveals that, in the short-term, there is no obvious solution that will satisfy the requirements of MNP into the future, and that can be rolled out immediately. The expected development of the mobile telephony market, and its effect on the interconnection situation between operators, together with the expected full liberalisation of telephony services will radically influence the most appropriate solution.

The benefits analysis of this study has shown, however, that there major benefits likely to be accrued from the introduction of MNP, and so there is strong motivation for at least a short- or medium-term solution. Therefore, it is advisable for Hong Kong to develop a long-term strategy for the roll-out of MNP functionality, rolling out a medium term solution, and then wait developments in the Hong Kong mobile telephony market.

Analysis of the traffic that passes through Hong Kong's network shows that the vast majority of calls to and from mobile telephones pass through HKTC and HKTI's networks. In the medium-term therefore, the most appropriate technical solution is for calls to be routed to ported subscribers by these networks.
Extension of the functionality of the existing fixed number portability solution would be relatively straightforward, at least until the useful capacity of the current solution is reached. In the long-term it may be necessary for HKTC to consider redesigning its current solution to accommodate the expected increase in demand on the existing system, but the nature of IN technology is that the SCPs at the ICGs should be scalable to a large degree, to allow HKTC to consider options for expansion.

Given the small number of interconnection links between mobile operators, and between mobile operators and alternative FNOs, mandating look-up functionality in these networks would be inappropriate now, and the cost allocation principles should encourage migration to this configuration should commercial and technical conditions make this the most appropriate option.

The existing distributed database functionality would need to be expanded to include the mobile telephone numbering range. HKT would be the main operator performing the database lookups, and therefore initially would control a de facto central database. The mobile number elements of the database would need only to be synchronised with the data held in the individual mobile operators' systems.

The threat of problems caused by porting changes being reported by the seven mobile operators would need to be investigated and assessed, and if necessary steps taken to establish suitable operational procedures to mitigate this danger. If necessary, the introduction of a central database should be considered in the long-term.

The handling of mobile traffic to ported numbers that currently flows between mobile operators and FNOs other than HKTC could be trapped locally and sent via HKTC's network for database look-up and further routing, or the fixed number portability solutions extended to handle this small volume of traffic. The most appropriate strategy must be decided by the individual operators concerned, but routing by HKTC would always be a fallback option.

The planned liberalisation of international services, currently provided exclusively by HKTI will mean that call into Hong Kong may be routed via alternative routes. If the call forward solution is still in place, this will have no impact on the MNP solution. If the FNOs are required to offer a database lookup service, however, then the new operators should be mandated to either perform a database look up as part of its licence conditions, or pass the call through HKTI or HKTC's network for an agreed fee.

3.7.3. Accelerated solution

The fixed operator look-up solution is the most appropriate solution in the medium-term, but the lead time to the implementation of the solution is 12-18 months. An alternative strategy would be to implement an intermediate call forwarding solution which could be rolled out in 6-12 months; this will be more expensive to roll out, but begins to accrue benefits at an earlier time frame, before migrating to a FNO-look up solution.
Resources necessary for the roll-out of the MNP solution would necessarily be engaged in the development of this interim solution and so, coupled with the effort necessary to implement and test the solution, the ultimate roll-out of the FNO look-up solution would be delayed by 6 to 12 months, i.e., the total time to the second stage migration would be 12 to 24 months. The impact of these scenarios on the overall costs of the migration scenarios is investigated in the cost section of this report.

Such a delay in the roll-out of the FNO look-up solution would have the advantage, however, of allowing standards and technology to have matured further and would allow further time for the issues surrounding the possible introduction of a central reference database etc to be resolved.

For mobile networks that are already interconnected, during the period of operation with a call forwarding interim solution, calls to numbers ported between such networks can be forwarded along the interconnecting leased line route.

Migrating between the interim and FNO look-up solution has benefits and risks, both technical and operational.

The two-stage approach will inevitably be more costly than direct implementation of the FNO look-up solution, but this may well be offset by the additional benefits associated with the earlier introduction of MNP in Hong Kong. These additional costs are discussed in more depth in the cost section of this report.

Migration between two solutions must be managed carefully to ensure that service to the subscribers is not interrupted, however, the staged introduction will have the effect of spreading much of the risk over two stages, the first switching solution being relatively straightforward to implement, as well as allowing an intermediate roll-back position should difficulties be encountered with the migration.

A precedent has been set in Hong Kong for the migration of the fixed number portability solution from an interim solution, and it is likely that much of the experience that was gained in that process by the FNOs could be passed onto the mobile community.

3.7.4. Other solutions

The discussion above reveals that the implementation of a call drop back solution as an extension of the interim call forwarding solution is unlikely to be realisable, however, as part of the cost modelling exercise, the savings that may be achieved, were the technical and commercial problems to be solved, have been estimated.

The medium-term strategy outlined above assumes that the distributed database used currently to provide fixed number portability would be extended. Should it be necessary to introduce a central database to mitigate potential operational problems, then the cost of the introduction of such a database has been estimated. For the time being as mobile operators do not need to perform database look-ups it would be relatively easy to maintain
synchronisation of four database, should the other fixed operators chose to route calls to
ported mobile subscribers. Nevertheless updates will be posted from 11 operators in total,
and this risk needs to be carefully monitored.

We have assumed that the introduction of a central database would have essentially no
impact on timescales because its introduction would be a joint to the technical systems
already in place.

It is not possible to judge whether the introduction of such a database would be beneficial
for Hong Kong, and much effort is being expanded in the industry to determine the most
appropriate solutions. The solution will depend on local factors, for example in the US the
central database has been effectively split into 7, whereas in Finland a central database has
been established.

3.7.5. Long-term strategy

Once the FNO look up solution has been established, the strategy should be to develop the
cost allocation principles to encourage the most appropriate technical and commercial
solution to be implemented. For example should two operators decide that it is in their
commercial interests to install a point of interconnection between their networks, the cost of
doing so in a MNP environment should be neutral compared to the cost were MNP not to
be implemented.

Under these circumstances, the number of operators - both fixed and mobile - that perform
database look ups will grow, and so the need for a centralised reference database would
become more pressing in order to ensure that the databases used by the operators are
consistent.

The development of signal relay functionality that can handle translation of SCCP
addresses to support MNP in association with future services such as optimal routing and
CCBS is underway in Europe for GSM-based solutions. This technology as far from mature,
however, and would need to be adapted for the non-GSM systems available in Hong Kong.
Discussions with operators in Europe suggest, however, that should these solutions become
accepted as ETSI and ITU-T standards, such functionality could be retrofitted to the current
database solution when needed. This functionality could also be extended for handling of
calls and services to fixed ported numbers.

Given the large number of variables that will influence the most appropriate technical
solution, it is not possible to predict the direction in which MNP would take in Hong Kong
in the long-term, but by adhering to the above principles, and monitoring the risks
identified with the solutions, on-going development of the MNP should be able to proceed
safely.
3.8. Conclusions

We believe the medium and long-term migration strategies described above best satisfy the migration criteria outlined in section 3.7. Cost modelling will reveal whether the most beneficial migration strategy is to move directly to a FNO look up solution, or whether this should be achieved via an interim call forwarding solution.

In the long-term the MNP should be allowed to develop to reflect the changing technical and commercial environment.
4. THE COSTS OF INTRODUCING MNP

4.1. Introduction

This chapter discusses the methodology developed to estimate the costs of various implementation and migration options, as well as determining the costs of the most likely scenarios to be used in the Hong Kong environment. In so doing the study team has drawn on information gained from interviews with operators and users in Hong Kong, relevant industry contacts, previous international studies and knowledge of the Telecoms industry to estimate the costs of potential implementation and migration options. This Chapter is structured as follows:

- section 4.2 describes the methodology used to determine the costs of implementing and migrating between different technical options. This includes assumptions made for the model, and a description of the elements of cost considered.
- section 4.3 discusses the cost of implementing the two favoured options and variations on the basic configurations to determine the sensitivity of the overall cost to various factors.

4.2. Methodology

The underlying principle behind the determination of the cost of implementing mobile number portability is that only costs that are incurred as a direct result of the introduction of number portability are considered.

Furthermore, in determining the costs the underlying principle is that expenditure for which the net impact is the loss of revenue to the Hong Kong SAR should be included. For example, software, hardware and services delivered from outside Hong Kong should be included, whereas profits on software developed for operators by a Hong Kong based operation should not be included as the profits remain within the Hong Kong SAR.

4.2.1. Assumptions and costing principles

The cost of number portability can be directly or indirectly associated with different parties according to whether work needs to be implemented by an individual operator, or whether inefficiencies associated with the solution which lead to the cost are borne by the party. The parties to whom these costs have been associated are:

- **HKTC and HKT**: the costs associated with these networks have been grouped together and separated from those costs associated with the alternative FNOs because several of the migration options require HKTC and HKT to carry out changes to their networks independent of the other operators;
- **FNOs**: fixed network operators other than HKTC and HKT.
Mobile operators: the costs associated with mobile operators will vary with factors such as number of customers, length of time in market and technology etc, but for the purpose of this study the operators have been grouped into small and large mobile operators dependent upon whether the operator had more than 100,000 subscribers in October 1997. These are:

Table 4.1
Categorisation of Mobile Operators in Hong Kong

<table>
<thead>
<tr>
<th>Large operator</th>
<th>Small operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSL*</td>
<td>Hutchison PCS</td>
</tr>
<tr>
<td>Hutchison GSM</td>
<td>Pacific Link PCS</td>
</tr>
<tr>
<td>Hutchison CDMA</td>
<td>SUNDAY</td>
</tr>
<tr>
<td>SmarTone</td>
<td>New World PCS</td>
</tr>
<tr>
<td>Pacific Link D-AMPS</td>
<td>Peoples Telephone</td>
</tr>
<tr>
<td></td>
<td>P Plus Communications</td>
</tr>
</tbody>
</table>

*Note: CSL UNITACS is outside the scope of this study.

As discussed in the benefits section of this study, the costs incurred by customers can be divided into three types:

- **Type A customer costs:** are those incurred by mobile telephone users who would change network operator, even if MNP were not available. These costs are not therefore caused by MNP. In fact they are reduced by it (e.g. the need to inform friends is avoided) and these reductions in costs are treated as benefits (see Chapter 5);

- **Type B customer costs:** are those incurred by mobile telephone users who would not change network operator if MNP were not available. These include the costs of SIM cards, handset changes and other migration costs. These costs have been implicitly been netted out (i.e. treated as negative Type IB benefits) in Chapter 5.

- **Other customer costs:** are those borne by customers making calls to mobile telephones such as the extra dialling delay introduced by the MNP solutions.

In estimating these costs no attempt has been made to determine how these costs should be recovered. This issue is addressed in detail in section Chapter 6.

The following assumptions have been made in order for the analysis to be in line with the broad principles of the study:

- only costs for resources used within the Hong Kong SAR, or for services and materials outside the Hong Kong SAR have been considered. Profits over and above those deemed reasonable in the calculation of return on capital paid towards
companies' operating within Hong Kong are discounted, whereas similar profits made by companies based outside Hong Kong are included. However, in the absence of detailed knowledge of the likely implementation route of each operator, estimates of these splits are necessarily inaccurate;

- only costs associated with the implementation of MNP have been considered. Where a service or material would already have been incurred, only the marginal cost of providing the service or material for the MNP solution has been include;

- the cost of bespoke development work, for example, to modify the OSS is difficult to assess without detailed knowledge of individual operators' systems, and knowing the efficiency with which individual programmers work, but we have estimated the cost of the time to be equivalent to $1.5 million/year. Similarly, in calculating customer costs, we have assumed that the average salary in Hong Kong is $120 000.

- where appropriate, reductions that can be made in the cost of implementing MNP due to resources being shared between networks operated by the same company are noted in the relevant section;

- estimations of opportunity costs are notoriously unreliable, and have therefore been disregarded by the analysis;

- the later costs are incurred, the lower they will ultimately be driven by increased efficiency in the way activities may be combined with other programs given longer lead times, and the reduction in costs of technical equipment with time. This reduction in costs is assumed to be 10% per year for equipment including large capital items and SIM cards.

4.2.2. Cost elements

It is difficult in the present climate to calculate the costs of buying in equipment from overseas due to currency fluctuations. Therefore the cost of such items are necessarily best estimates assuming that the currency will remain reasonably stable, that manufacturers would adjust prices for them to remain competitive in Hong Kong, or equipment can be sourced from within Hong Kong.

4.2.2.1. Set-up costs and one-off costs

4.2.2.1.1. Solution development costs

For the call forwarding solution, a technique has already been implemented in the fixed network as an interim solution, and so no significant development would need to be carried out besides minor verification and validation work. Such a solution has been implemented in Singapore using two mobile networks. Gateway Numbers (GN), in the form of Network Identifiers (NI) in front of the Directory Numbers (DN), or Network Numbers (NN) can be used to forward calls, and these numbers have been allocated by OFTA, and can be recognised by HKTC's switches. The extent of this validation work has been estimated as
0.25 man-year of effort across all of the operators’ networks, or $375,000 ($1.5 million x 0.25).

Similarly, to develop an extension to the existing distributed database solution would require minor alterations to be made the existing HKTC/HKTI network solution to accommodate the mobile number ranges, but use the same algorithm. The mobile operators would need to develop their switches to accept numbers in the NN format. We have estimated that of the order 0.25 man-years of development time per operator would be appropriate, equating to $2.6 million.

4.2.2.1.2. Switch software upgrades

In order to implement the call-forwarding solution, no upgrade of the current software version would be required. Likewise, the distributed database solution is an extension of the capacity of HKTC’s solution only, and therefore no software upgrade for additional functionality would be required.

4.2.2.1.3. OSS development and implementation

Discussions with operators in the UK, Singapore and Hong Kong have identified that development work will need to be carried out on the following generic OSS functions in order for the technical and operational demands of number portability to be implemented.

- customer billing systems;
- customer information system;
- ordering system;
- internal service provisioning system;
- maintenance system;
- network management system.

To a good approximation the work that needs to be carried out on the OSS is driven by changes in operational procedures, and therefore the cost of this development work will be similar for either solution. After discussions with all operators, and from the experience of operators that have implemented fixed number portability with similar support systems, we estimate that changes that would need to be made in each mobile network would be of order 2 man-years of effort per operator, or $21 million.

HKTC would, by contrast, need to make fewer changes to its OSS, mainly associated with interfaces to the database in the case of an off-switch solution, and for an on-switch solution would need to make no modifications as calls are handled in the usual manner. This assumes that the mechanisms for passing on the additional interconnection charges is handled between the mobile operators alone. As an extension of the OSS development work
discussed above, we estimate that less than 0.5 man-year of effort, or $750,000 would be required for an on-switch solution.

4.2.2.1.4. AD system

The current AD system would need to be extended to allow each mobile operator to inform the fixed operators of ported numbers. The current system typically comprises a small database and application based on a workstation, linked to the other operators via an X25 link. The cost of this equipment is likely to be of order $75,000 per operator, or $525,000.

4.2.2.1.5. Procedural changes

In order to implement MNP, changes will need to be made to existing procedures, for example handling of customers wishing to port their numbers at the point of sale, and new procedures will need to be implemented unique to MNP, such as receiving information from donor networks and extra contractual overheads associated with closing of existing subscriptions.

The changes to procedures associated with an off-switch solution are likely to be marginally more onerous than for off-switch because of the extra interface to the AD system, and large operators are likely to have more difficulty in adapting procedures Therefore we have assigned the cost associated with these changes in the table below, based on discussions with operators in Europe with similar experience. The development of training courses in preparation for the introduction of MNP is also included in this element.

<table>
<thead>
<tr>
<th></th>
<th>Large operator</th>
<th>Small operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-switch</td>
<td>3 man-years ($ 4.5 million)</td>
<td>2 man-years ($ 3 million)</td>
</tr>
<tr>
<td>Off-switch</td>
<td>4 man-years ($ 6 million)</td>
<td>3 man-years ($ 4.5 million)</td>
</tr>
</tbody>
</table>

4.2.2.1.6. Off-switch solution

In order to extend HKTC's off-switch look-up solution to have sufficient capacity to enable it to make a data dip for all calls sent to any connecting mobile network would involve an expansion of the record holding capacity of the database from the current 100,000 records to the expectedly required capacity of in excess of 2,000,000 records, and a commensurate increase in processor capacity to handle the extra volumes of calls.

Without a detailed analysis of the configuration of HKTC's network, and assessment of options for migration to this increased capacity, accurate estimates of the cost to upgrade the facility is extremely difficult. HKTC have stated that it may be necessary to adopt a radically different technical configuration, as the current structure may not necessarily be scalable.
Furthermore, the migration strategy that HKTC would need to adopt in order for the increase in demand due to a larger number of subscribers porting away from operators to whom the number has been allocated is difficult to predict, and the strategy that HKTC may adopt to adapt to this ramped increase is difficult to predict being based on a host of factors.

We believe that the current HKTC solution could be expanded to the limit of its useful capacity of in excess of 200 000 record entries, before a major system upgrade beyond the year 2000 when:

- the demand for MNP can be better estimated;
- the cost of IN, or similar equipment will have reduced;
- the migration can be better planned.

However, a high take-up rate of number portability could mean that earlier investment in the expansion of capacity would be needed, and so we have assumed that to upgrade HKTC’s current system would require major investment of up to $100 million from the beginning of the off-switch solution period. The actual level of this investment, however, would depend on factors such as the technical architecture chosen, developments in IN technology, the actual porting rate of customers and timescales.

Expanding the HKTC solution in this way would alleviate the current problems that HKTC is experiencing in recouping the cost of a currently under utilised resource.

4.2.2.1.7. SMS changes

The method by which the SMS system will be developed in the future is difficult to estimate given the lack of standards for its operation. Were a form of signal relay functionality to be fitted at a later stage, some of this cost could be allocated to MNP. We have assumed therefore, that after year three an investment of $0.5 million would need to be made to each operators’ network to ensure that such a solution is compatible with MNP.

4.2.2.1.8. Migration costs

The cost for migrating from a call forwarding solution to a database look up solution has been assumed to be the same as the costs for implementing the solution immediately, with an appropriate reduction in costs associated with the later implementation discussed above, plus 5 man-years of effort per operator to manage the transition including a period of dual-operation, which is an additional cost of $10.5 million.

For the transition to a call forwarding solution, it is unlikely that the technical problems will be able to be overcome and a solution developed in time for its implementation after 12 months. It is interesting however, to estimate the benefits that would accrue were it to be
developed, and to this end we have assumed that a nominal 10 man-years of effort would need to be invested as a best-case, say $15 million.

4.2.2.2. Per-subscriber costs

4.2.2.2.1. Switch and OSS administration

Cost associated with per line porting of customers would comprise the effort of switching on the unconditional call forward at the donor switch, extra work in mobile telephone outlets and associated paper work. In line with estimates of the work required in other countries, and using the cost estimated for the porting of fixed numbers during the fixed number portability interim solution, we believe that the likely costs will be $150 per port.

Once the off-switch solution has been implemented, the addition of a new subscriber to an operator will have little effect on changes to be made to the network because the information can be entered into the relevant system easily and with little more effort than that required to register a new customer, and therefore we have assumed that the marginal cost of porting the customer will be $10.

4.2.2.2.2. HLR licenses

The call forwarding solution uses up capacity of the mobile operators’ GMSCs which is included in the on-going costs (see below), but each donated subscriber also causes an extra entry in donor operator’s HLR, for which a license fee must be paid. Operators in the UK have confirmed that a reasonable price would be $90 per entry. Once the MNP solution has migrated to an off-switch solution, these costs will no longer be borne.

4.2.2.3. On-going costs

4.2.2.3.1. Additional conveyance: additional interconnection charges

Extra costs associated with the tromboning of calls through donor network via HKTC will be charged at 6.7 cents per minute. However, these calls are not terminated within HKTC’s network, and many will be able to be efficiently routed through ICGs. Therefore the cost to HKTC will be less than the full interconnection, and we have estimated that the efficiency gains would reduce costs to 70%.

New World TC and New World PCS are directly interconnected, as are Hutchison and SmarTone’s networks, where calls will be able to be routed still more efficiently, making this a worst-case estimate.

For the call dropback and database look up solutions, these costs will not be incurred.

4.2.2.3.2. Additional conveyance: additional GMSC resource costs

Whilst the call forwarding solution is in place, capacity of the donor network operator’s GMSC will be used up in forwarding calls on to the recipient operator. It is not clear what
fraction of the capital and operating costs of this equipment should be attributed to the loss of subscriber ports during the duration of calls, the loss of call forwarding functionality and the extra processing that is required but as a worst-case the following algorithm has been used.

We have estimated the extra capacity that the mobile operators would require at their GMSC to be the number of busy hour ported calls, assumed to be twice the average number of ported calls. The traffic forecast data is based on logged data over the past 12 months.

The cost of each line has been estimated to be the cost of buying, operating and maintaining a GMSC, assumed to be a capital cost of $60 million plus 10% for maintenance and 10% for operation, which provides capacity for 150,000 subscribers. Writing this cost off over 10 years, is equivalent to an annual cost of $48/year/line.

Once a call dropback or database solution is implemented, these costs are no longer accrued.

4.2.2.3.3. Extra signalling costs

The extra costs for signalling associated with each of the solutions are not charged by HKTC but still impact on the analysis. It is difficult to quantify these charges exactly, but after talking to manufacturers, we have estimated that these costs are equivalent to the extra signalling capacity per call as shown in the table below.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Signalling time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call forwarding</td>
<td>0.2</td>
</tr>
<tr>
<td>Database look up</td>
<td>0.2</td>
</tr>
<tr>
<td>Call dropback</td>
<td>0.3</td>
</tr>
</tbody>
</table>

4.2.2.3.4. Database administration and maintenance

The marginal costs of maintaining and operating the database solution has been estimated to require three members of staff working on a 24-hour rota, and the cost of a maintenance contract for the solution, giving a total year on year cost of $2.4 million.

4.2.2.3.5. MNP associated procedures

Once MNP has been established there will be new procedures necessary for the porting process, and some old procedures will need to be developed and subsequently will require more effort to complete. From experience of operators implementing number portability in Europe, we have estimated this to be $100,000 per operator plus $50,000 for HKTC.
4.2.2.4. Customer costs

4.2.2.4.1. Dialling delay

Calls to ported subscribers will experience an additional dialling delay associated with the porting technology. We have assumed that this delay would be 0.2 seconds for call forward and database dips. We have assumed that the salary costs of the originators of these calls can be attributed to MNP for this extra delay imposed.

4.2.2.5. Total costs

In the spreadsheet model, the cumulative real cost of implementing each solution has been calculated, but discount for when the investment is made has been calculated and referred back to the second half of 1998. The assumed discount rate is 6%.

4.3. Options

4.3.1. Introduction

This section describes and considers the costs of various options for the implementation of MNP in Hong Kong. In the discussion of the technical feasibility of the solutions and migration options, the number of realistic solutions to be considered in the medium-term has been reduced to a realistic sub-set of the options available. In the cost modelling work that has been carried out, these options have been examined in some detail to assess the cost of the solutions given realistic variations in the factors that affect these costs.

The number of implementation options available has been reduced to:

- call forwarding;
- call drop back;
- distributed database look up in the fixed network only.

The main migration options that have been considered, and for which detailed sensitivity analysis has been carried out, are:

- **option 1**: immediate roll-out of off-switch solution with database look-up in HKTC's network: option one;
- **option 2**: migration through call forwarding functionality to off-switch solution with database look-up in HKTC’s network.

The above options are considered in detail with various assumptions made concerning churn levels, the time to implement MNP and the time to migrate from the interim to off-switch solution.
Variations on these migration options that have been modelled include migration through call drop back functionality to off-switch solution with database look-up in HKTC’s network.

4.3.2. Sensitivity analysis

For the main migration options sensitivity analysis has been carried out on the following factors.

4.3.2.1. Churn predictions

Predictions have been made concerning the likely number of subscribers that will churn between Hong Kong’s networks over the period of the study. Two cases have been considered:

- **low churn**: the most likely number of customers of both type A and type B that are likely to churn if MNP is in place;
- **high**: the worst-case number of customers of both type A and type B that are likely to churn if MNP is in place.

4.3.2.2. Type A customer porting rate

If MNP is available, it is likely that initially some of the type A customers – those that would have churned anyway – would not be aware of the ability to port their numbers. Therefore it has been assumed that the take up of MNP by these customers will ramp up to approaching all subscribers with time. Two distributions for this ramp profile have been assumed:

- **low porting rate**: the most likely ramp rate of type A customers that would take up MNP;
- **high porting rate**: the fastest likely ramp rate of type A customers that would take up MNP.

4.3.2.3. Implementation and migration timescales

In calculating the benefits of MNP, three cases have been assessed as possible for implementation. These dates are:

- **optimistic start date**: 1 January 1999;
- **realistic start date**: 1 June 1999;
- **pessimistic start date**: 1 January 2000.

The timescales for the implementation and migration of the various options that have been considered are discussed in the technical assessment section. Some of these options are not
possible by the optimistic start date, and various migration period have been considered. Figure 4.1 below shows the implementation and migration options that have been considered.

For the migration from the call forwarding solution to a database solution a delay of 12 months has been considered as realistic, though a pessimistic 18 months timescale has also been considered.

**Figure 4.1**
Implementation and migration timescales considered

<table>
<thead>
<tr>
<th>Task Name</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start dates (opt, real, pess)</td>
<td>Qtr 1</td>
<td>Qtr 2</td>
<td>Qtr 3</td>
<td>Qtr 4</td>
<td>Qtr 1</td>
<td>Qtr 2</td>
</tr>
<tr>
<td>Option one - realistic start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option one - pessimistic start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option two - optimistic start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option two - realistic start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option two - pessimistic start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option three - call back start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option three - with call dropback</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dropback period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3.2.4. **Call dropback**

The implementation of a call dropback solution is probably technically not achievable in Hong Kong in the required timescales, but it is interesting to note the impact that the development of such a solution would have. We have considered therefore, its implementation after six months of call forward operation for the worst-case scenario.

4.3.3. **Migration option one: call forwarding migrating to distributed database look up**

Two migration options have been considered for the direct roll-out of an extension of the FNO solution. Implementation by the realistic date (1 June 1999) and by the pessimistic date (1 January 2000).

Table 4.4 below shows the estimated costs of implementing these options for different combinations of churn and Type A customer porting take up over ten years. These costs are Net Present Value Costs appropriate to the second half of 1998.

57
Table 4.4  
Option NPV costs for migration option one over ten years

<table>
<thead>
<tr>
<th>Implementation date</th>
<th>Low churn</th>
<th></th>
<th>High churn</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low type A port</td>
<td>High type A port</td>
<td>Low type A port</td>
<td>High type A port</td>
</tr>
<tr>
<td>1 June 1999</td>
<td>260 million</td>
<td>272 million</td>
<td>281 million</td>
<td>294 million</td>
</tr>
<tr>
<td>1 January 2000</td>
<td>249 million</td>
<td>262 million</td>
<td>272 million</td>
<td>284 million</td>
</tr>
</tbody>
</table>

Figure 4.2 shows the real costs of MNP using migration option one with time over the ten-year time period for a 1 June start date.

Figure 4.3 shows the proportion of costs that can be attributed to the cost elements as a total of the $260 million NPV with low churn and low type A port ramp rate.
4.3.4. Migration option two: straight to distributed database look up

Five migration options have been considered for the roll-out of MNP using a call forwarding technique, with subsequent migration to an extension of the FNO solution. Combinations of implementation by the optimistic date (1 January 1999), realistic date (1 June 1999) and by the pessimistic date (1 January 2000), and realistic and long migration times to the look up solution of 12 and 18 months respectively.

Table 4.5 below shows the estimated costs of implementing these options for different combinations of churn and Type A customer porting take up over ten years. These costs are Net Present Value Costs appropriate to the second half of 1998.

<table>
<thead>
<tr>
<th>Implementation date</th>
<th>Low churn</th>
<th>High churn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low type A port</td>
<td>High type A port</td>
</tr>
<tr>
<td>1 June 1999 12 months</td>
<td>$245 million</td>
<td>$272 million</td>
</tr>
<tr>
<td>1 June 1999 18 months</td>
<td>$305 million</td>
<td>$337 million</td>
</tr>
<tr>
<td>1 Jan 1999 12 months</td>
<td>$252 million</td>
<td>$280 million</td>
</tr>
<tr>
<td>1 Jan 2000 12 months</td>
<td>$255 million</td>
<td>$280 million</td>
</tr>
<tr>
<td>1 Jan 1999 18 months</td>
<td>$302 million</td>
<td>$337 million</td>
</tr>
</tbody>
</table>
Figure 4.4 shows the real costs of MNP using migration option two with time over the ten-year time period for a 1 June start date.

4.3.5. Call dropback

Table 4.6 below shows the estimated costs of implementing these options for different combinations of churn and Type A customer porting take up over ten years. These costs are Net Present Value Costs appropriate to the second half of 1998, and show in excess of $10 million saving for each case.

| Implementation date | Low churn | | High churn | |
|---------------------|-----------|---------------------|-----------|
|                     | Low type A| High type A         | Low type A| High type A |
|                     | port      | port                | port      | port        |
| 1 Jan 1999 18 months| $305 million | $334 million        | $389 million | $418 million |
5. BENEFITS OF MNP

5.1. Background

The introduction of MNP can be expected to provide benefits to a wide range of consumers in Hong Kong. In particular, mobile users will be able to enjoy the benefits of competition with reduced switching costs. Callers to mobile numbers will also benefit as they will encounter fewer misdialled calls. We have attempted to measure these benefits by categorising them into the following groups:

• **Type 1 benefits**: are defined as the benefits which accrue to subscribers who retain their number when changing operators.

• **Type 2 benefits**: are the efficiency improvements and any associated price reductions which result from increased competitive pressure.

• **Type 3 benefits**: are the other resource savings that arise from fewer number changes and include fewer misdialled calls and changes to information stored in customer equipment.

When measuring the benefits of MNP, we developed a number of scenarios to provide a range for the size of the benefits:

• the **best case**: an optimistic scenario where MNP is introduced in January 1999 and churn increases by 20 per cent;

• the **central case**: a realistic scenario where MNP is introduced in June 1999 and churn increases by 15 per cent; and

• the **worst case**: a pessimistic scenario where MNP is introduced in January 2000 and churn only increases by 10 per cent.

We also conducted sensitivity analysis on the number of customers that change operators and retain or ‘port’ their number. This is discussed in more detail in Section 5.2.1.

The estimates used in this chapter were drawn from the survey of mobile users in Hong Kong, interviews with mobile operators and other parties, international experience, and other available data. The user survey was conducted by SOFRES FSA between December 1997 and February 1998. They interviewed 450 personal subscribers, 450 small to medium business users, and 100 large corporate firms across Hong Kong in order to determine their views on mobile services, their switching behaviour and their attitude to MNP.

5.2. Type 1 Benefits

Type 1 benefits can be estimated as follows. Mobile subscribers will switch to alternative operators if the call bill saving and any other additional benefits (“the discount”) exceeds the costs of switching between operators. These include the cost of a new SIM card and a
new handset (if that is necessary), the time taken to research the market and register with a new operator, as well as the costs of changing number in the absence of MNP. These costs of switching can be represented by a minimum required ("threshold") discount in order for the subscriber to be prepared to move to a new operator.

For the situation pre MNP, the threshold discount is represented by \( d_0 \) in Figure 5.1 and the number of subscribers switching between the operators concerned is given by \( S_0 \). With the introduction of MNP, the costs associated with changing to a new operator decline and hence so too does the threshold discount (to \( d_i \)). As a result, \( S_i \) subscribers now migrate to the new operator.\(^4\) The "Type 1" benefits associated with this change are depicted by areas A and B. Area A represents the benefits to those who would have switched anyway (i.e. the reduction in the costs associated with changing number). Area B shows the benefits to those who switch operators because of MNP. Here the benefits are given by the difference between the discounts received and the new, lower threshold discount.\(^5\)

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\(^4\) We assume that the 'discounts' offered by one operator against another remain the same following the introduction of MNP.

\(^5\) As mentioned above, we have assumed that the discount threshold post MNP reflects residual switching costs. An alternative assumption is that some part of the threshold discount results from bounded rationality (where consumers just do not respond to savings below a certain level, for cognitive reasons). When modelling the benefits of MNP we relied on the former, conservative assumption.
Given estimates of the pre and post MNP threshold discounts, the level of "discount" offered by the new operators and the size distribution of mobile call bills, it is possible to estimate Type 1 benefits. The framework or approach we will use to estimate the two categories of Type 1 benefits is discussed in the following sections:

5.2.1. Methodology for measuring type 1a benefits

The nature of Type 1 benefits depends on how each subscriber would behave in the absence of number portability. Type 1a benefits refer to those subscribers who would switch operator regardless of the availability of MNP. In the absence of MNP, business subscribers in particular would need to inform existing and potential customers of their new number, probably through a mixture of mailshots and advertising. In Hong Kong, however, this may be a less important consideration as customers may typically be able to contact a business through a fixed network number or a pager. Some businesses may also remain with their existing operator and make use of call forwarding services. Other costs associated with a change of number include the cost of printing new stationery, repainting vehicles and changing other references to the old telephone number.
In such cases, the benefits of number portability are the costs avoided as a result of not having to change number, so would include the costs of changing stationery, notifying customers and so on, and also the cost of call forwarding or other number notification services. Although individual business users would include the potential loss of business in the costs of a number change, this should be excluded from the cost benefit calculation if the business is simply transferred to competing suppliers. To the extent that business is transferred to a less efficient supplier, however, there will be a reduction in the well being of the economy as a whole. In practice, however, this latter effect will be very difficult to measure and, although a benefit, we have ignored it in our modelling.

Some subscribers who switch operator might have done so anyway, but in the absence of number portability they may have retained their existing mobile service so as to continue receiving calls on their existing service. This is referred to as dual sourcing and the costs saved by the fact that this is no longer necessary should also be included as a Type 1a benefit.

Our approach to determining the Type 1a benefits for those who would have switched regardless of the availability of MNP can, therefore, be described as a four stage process:

- first, we determine the total number of SME and personal subscribers switching over the next 10 years (without MNP);
- second, we estimate the cost savings enjoyed by those subscribers who would have switched anyway but who will avoid a change of number given MNP;
- third, we make assumptions about the number of subscribers that dual source;
- fourth, we adjust the results to eliminate transfers within the economy. For example, the costs to business users of changing number might include their loss of business to competitors.

Stage 1: Forecasting churn rates

The methodology used to forecast the number of mobile subscribers in Hong Kong over the next 10 years and the associated rate of churn was discussed in greater detail in Chapter 3. These churn rates affect the size of Type 1a benefits as they determine how many subscribers could potentially save switching costs. However, only those that port (retain) their existing number will save on those costs. In our view, it is very unlikely that all of the subscribers that churn will retain or 'port' their existing number when they change operators, particularly in the initial years. This is due to a number of reasons including:

- a lack of consumer awareness that it is possible to change operators and retain their existing numbers. The Consumer Council in Hong Kong suggested that lack of consumer awareness was one reason why the fixed network has experienced relatively low levels of porting:
• a charge for number portability (if one exists). If porting customers face a charge for
number portability they may be deterred from porting. The experience with MNP
in Singapore suggests that a high charge may be responsible for the low level of
porting mobile customers in that market; and
• the fact that some subscribers want to change their number.

Table 5.1 shows our assumptions on the penetration rate of mobile telephony, churn rates,
and the rate of take-up of portability.

Table 5.1
Our Assumptions on Switching Behaviour (per cent)

<p>| Per cent of Type 1a switching subscribers that | Penetrati  | Base case churn rate | High take-up of MNP | Low take-up of MNP |</p>
<table>
<thead>
<tr>
<th>port</th>
<th></th>
<th>(without MNP)¹</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>29</td>
<td>36</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>1998</td>
<td>36</td>
<td>36</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>1999</td>
<td>42</td>
<td>38</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>2000</td>
<td>48</td>
<td>34</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>2001</td>
<td>52</td>
<td>32</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>2002</td>
<td>54</td>
<td>30</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>2003</td>
<td>56</td>
<td>28</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>2004</td>
<td>58</td>
<td>26</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>2005</td>
<td>59</td>
<td>24</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>2006</td>
<td>59</td>
<td>22</td>
<td>80</td>
<td>55</td>
</tr>
<tr>
<td>2007</td>
<td>59</td>
<td>20</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>2008</td>
<td>60</td>
<td>20</td>
<td>90</td>
<td>65</td>
</tr>
<tr>
<td>2009</td>
<td>60</td>
<td>20</td>
<td>90</td>
<td>70</td>
</tr>
</tbody>
</table>

¹ The base case churn rate is the churn from PMRS mobile networks to PCS networks. We
have also estimated the rate of churn between PMRS and PCS (in both directions) for both
the base and switching models. The introduction of MNP is estimated to increase these
churn rates by 10 per cent under the low churn scenario and by 20 per cent under the high
churn scenario.

Source: NERA estimates

Stage 2: Estimating the cost savings

The costs of switching between operators are high. The survey carried out as part of this
study showed that in the absence of MNP, residential and business subscribers taken
together incurred an average one-off cost of $348 when switching between operators. The
costs were higher for business subscribers than for personal subscribers.

Most (90 per cent) of business users were required to change their number when they
switched operators. Only those that who moved between the analogue and digital
networks of the same operator avoided such a change. On average, business subscribers
incurred one-off costs of $143 informing friends or colleagues of the number change. In
addition, 46 per cent of those business that had to change their number spent an average of $523 to change stationery while 7 per cent also spent an average of $628 on repainting signs, changing brochures etc.

As with business subscribers, a large majority (90 per cent) of personal subscribers who had switched mobile operators in Hong Kong in the past reported that they had to change their number. Those subscribers that were required to change number stated that they each informed an average of 33 people at an average total cost of $114. Of the personal subscribers that were required to change their number, eight per cent also incurred 'other costs'. These additional costs included changes to cards and stationery.

**Stage 3:**  **Estimating the number of dual sourcers**

In the absence of MNP, we would expect some subscribers to subscribe to two operators simultaneously in order to avoid the switching costs associated with a number change. These subscribers, however, would face increased administration costs from dealing with two operators and higher monthly charges (due to their inability to switch to a low cost operator for a complete service). The availability of MNP would, therefore, be expected to eliminate the costs associated with dual sourcing by those who do so to avoid the switching costs.

The results of the user survey, however, suggested that few subscribers joined more than one network because of the absence of MNP. The survey showed that 12 per cent of respondents currently (or at some stage) subscribed to multiple operators. The most popular reason for dual sourcing was to achieve better coverage. In Hong Kong, there is some evidence that some subscribers are subscribing to one or more new PCS operators but are also retaining their GSM subscription because of the relatively poor coverage of the new entrants. This, however, is expected to change as PCS operators expand their coverage over the next 18 months.

Some of these subscribers, particularly large business users, might dual source for security reasons (that is, so they can still make and receive calls if there is a fault on one operator's network), and so would continue with such an arrangement even if number portability was available.

We conclude that few people in Hong Kong currently dual source because of the lack of MNP. In other words, a majority of the subscribers that currently dual source in Hong Kong would continue to do so if MNP were available because of geographic coverage and other reasons. Therefore, we have not made any allowance for the avoided costs of those who would no longer dual source with MNP in our modelling of benefits. This omission means that our estimate of the benefits errs on the conservative side.

**Stage 4:**  **Adjusting the results to capture transfers in the economy**

One of the costs faced by businesses when changing a number might be the loss of business they incur when customers are unable to contact them. However, these costs should be
included in our cost benefit analysis only if they represents a genuine loss of business and not simply a transfer of business between competing suppliers.

As discussed in Stage 2, the estimates we used to measure the switching costs were derived from the user survey. The survey asked business to nominate the costs they incurred in informing customers of the number change, the costs involved in changing stationery and business cards, and any other costs they incurred (such as changing brochures or repainting vehicles etc). The survey did not ask businesses to estimate their losses to competitors arising from a number change.

In our view, the loss of business from a change in the mobile phone number is likely to be negligible. Almost all business will face a trade-off between the costs of informing customers of their new number and the likely loss of business following a number change. Given the once-off nature of the costs of informing customers (compared with the possibly permanent nature of lost business), we would expect a firm facing a potentially large loss of business to invest quite heavily in all possible ways of informing customers. Any firm which faces a really serious loss of business, moreover, is unlikely to be among the group of subscribers who switch operators in the base case.

The loss of customers to business through a number change is also likely to be small because of the options available to customers. The survey also showed that a significant majority of SME subscribers used a pager as well as a mobile phone (43 per cent). For that group of SMEs, over 41 per cent of customers used the pager to call the business. In short, if customers could not contact a SME by mobile phone they have many other options including the fixed network number or a pager. Also, what losses there are will largely be picked up by competitors.

5.2.2. Estimates of Type 1a benefits

Type 1a benefits are the largest source of benefits following the introduction of MNP in Hong Kong. Table 5.2 illustrates those benefits under the three scenarios discussed in Section 3.1. In addition, we have conducted a sensitivity analysis on the number of porting customers given the alternative estimates in Table 5.1.
Table 5.2
Type 1A Benefits Under All Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NPV (1999-2009) HK$Millions (high porting)</th>
<th>NPV (1999-2009) HK$Millions (low porting)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best case (MNP in January 1999, high churn)</td>
<td>1,116</td>
<td>1,086</td>
</tr>
<tr>
<td>Central case (MNP in June 1999, medium churn)</td>
<td>1,116</td>
<td>1,086</td>
</tr>
<tr>
<td>Worst Case (MNP in January 2000, low churn)</td>
<td>1,074</td>
<td>1,058</td>
</tr>
</tbody>
</table>

The benefits in the table above range from a net present value of HK$1,058 million to HK$1,116 million over the eleven years reviewed. Under each scenario, these benefits become more important over time as more subscribers churn and retain their number. Figure 5.2 shows the growth in Type 1a benefits under the central case (low porting assumption). It is worth noting that the pattern displayed is consistent across all scenarios.

Figure 5.2: Growth in Type 1a Benefits over Time (Central Case)

5.2.3. Methodology for measuring type 1b benefits

Type 1b benefits accrue to those subscribers who switch operators only as a result of number portability. In other words, they would remain with their current operator if number portability was not available. Such subscribers benefit from the improved characteristics of the services offered by their new supplier (usually some combination of lower call and/or monthly access charges and higher service quality).

It is, however, important to note that these represent genuine economic benefits only to the extent that new operators offer lower charges or higher quality because they are more efficient than existing operators. If instead, lower charges or higher quality result in reduced profit margins then there is a transfer of producer surplus (profit) from the original operator which is shared between the subscriber and the new operator. This transfer should not be included as a benefit in the cost benefit analysis.
In other words, the cost-benefit analysis should only take account of the net impact on profits. That is, if a PMRS operator loses a subscriber to a competitor, it is necessary to look at the PMRS operator's loss in profits minus the competitor's gain. We have assumed the profit margins on incremental volumes of traffic are the same for both PMRS and PCS operators.\footnote{PCS operators may have a lower average level of profits at present but this is assumed to result from a high level of fixed costs relative to the volume of traffic that they have.}

Our estimates of the size of Type Ib benefits rely on the number of subscribers that switch operators because of the availability of number portability and the cost savings they enjoy once they have made the move. Both of these estimates are drawn from the survey of users conducted in Hong Kong.

5.2.3.1.1. Number of subscribers switching because of MNP

The availability of MNP in Hong Kong removes a significant barrier to switching. The perceived problems and costs associated with a number change in the absence of MNP are shown in Table 5.3 which shows the results of the question regarding problems that subscribers might encounter if they switched operators. Around 60 per cent of respondents claimed that the number change was the largest problem they would face (see Table 5.3).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Personal subscribers</th>
<th>SMEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number change</td>
<td>59</td>
<td>64</td>
</tr>
<tr>
<td>Don't know</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Poor coverage</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Cost of handset change</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Cost of terminating contracts</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Higher prices</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Loss of services</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

1. Subscribers were asked to nominate more than one problem so total will not sum to 100.

A number of the constraints nominated by consumers are, to some extent, unique to the Hong Kong market. For example, the cost of terminating a contract in Hong Kong is less than in other countries such as the UK, largely because contracts are rarely enforced in Hong Kong. The importance placed on coverage as a constraint to switching may also be expected to decline over time as the coverage of the new PCS operators extends to the MTR, the tunnels and the shopping malls. Most of the new PCS operators expect that their coverage will reach a level that is comparable to the PMRS operators by the end of 1998. Increased penetration of dual band handsets can also be expected to reduce the need to change handsets. These factors all suggest that, in the long run, the inconvenience...
associated with a number change will grow in importance relative to other constraints on switching.

These results were supported by other results from the survey. Clearly, the inability to retain their existing number is a significant influence in the decision of subscribers to switch. Just under 85 per cent of personal and SME subscribers suggested that the (in)ability to retain their existing number influenced their decision to switch. Table 5.4 shows the difference that the availability of MNP would have on the switching decisions of subscribers.

Table 5.4
Relative Importance of Some Decision Variables Associated with Switching

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Strong influence</th>
<th>Slight influence</th>
<th>No influence</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handset subsidy</td>
<td>13</td>
<td>42</td>
<td>44</td>
<td>1</td>
</tr>
<tr>
<td>Ability to choose own number</td>
<td>13</td>
<td>41</td>
<td>45</td>
<td>1</td>
</tr>
<tr>
<td>A 3 second calling delay</td>
<td>8</td>
<td>29</td>
<td>62</td>
<td>1</td>
</tr>
<tr>
<td>Availability of short messaging service</td>
<td>8</td>
<td>26</td>
<td>65</td>
<td>1</td>
</tr>
<tr>
<td>Ability to retain existing number</td>
<td>49</td>
<td>34</td>
<td>17</td>
<td>0</td>
</tr>
</tbody>
</table>

A large number of respondents also reported that they would be increasingly likely to switch operators if MNP were available. Table 5.5 shows that almost three quarters of personal subscribers would be considerably more likely or slightly more likely to switch operators if MNP were available.

Table 5.5
Likelihood of Switching if MNP was Available (per cent)

<table>
<thead>
<tr>
<th>Response</th>
<th>Personal subscribers</th>
<th>SME's</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Considerably more likely</td>
<td>24</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Slightly more likely</td>
<td>49</td>
<td>44</td>
<td>46</td>
</tr>
<tr>
<td>No difference</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Don't know</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

We have assumed that churn would increase by 10-20 percentage points once MNP were implemented. This figure was derived from adding those that stated that they were considerably more likely to move in the survey into the churn rate derived in the base case (see Appendix 2). The resulting estimate of the additional churn following the introduction of MNP was consistent with the view expressed by many of the mobile operators in Hong Kong during our visits with them in December.
5.2.3.1.2. The cost savings enjoyed by those who switch because of MNP

In order to determine the cost savings enjoyed by those who switch because of number portability we were required to work out the difference between the threshold discount before MNP and the new, lower threshold discount required after MNP (see Figure 5.1, Section 5.2). This difference was determined by identifying, through the user survey, what discount was required before and after MNP. Where the phone is provided by a company, the views of users are less relevant because they do not make the decision to switch operators. Also, there is evidence from the survey that business users did not require a change in the threshold discount with MNP. Indeed, once an allowance is made for outliers in the user survey, the discount requested before and after MNP was virtually unchanged both SMEs and corporate users.

Type 1b benefits are very sensitive to the difference in the threshold discount required by mobile phone users with and without MNP. We only considered the discount requested by personal subscribers because they were involved in choosing their mobile phone, and more importantly, paid their own bills (see Table 5.6). Almost 70 per cent of SME subscribers replied that they had their mobile phone bills paid by the company. Such a result implies that these users will be less sensitive to price discounts than personal subscribers who are largely (93 per cent) responsible for their own phone bills.

<table>
<thead>
<tr>
<th>Table 5.6</th>
<th>Responsibility for Paying Mobile Phone Bills (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Who pays?</strong></td>
<td><strong>Personal subscribers</strong></td>
</tr>
<tr>
<td>User</td>
<td>93</td>
</tr>
<tr>
<td>Company</td>
<td>3</td>
</tr>
<tr>
<td>Family</td>
<td>4</td>
</tr>
</tbody>
</table>

CSL did not believe that it was appropriate to quantify the threshold discount cut required to give subscribers enough incentive (with or without MNP) to switch. They argued that:

"Since we are not comparing the electricity bills of two electric companies, each telecom product is quite unique in the sense that each band has its own characteristics such as footprint (coverage), quality (GOS), VAS, human factors (Customer Service, Sales), price (tariff plan), band image. In order to improve his mobility and enjoy the benefits under a quality network, the user may switch to a higher price product offered by another mobile operator. Therefore, the value they 'gain' in switching is not purely measured by the phone bill."

New World also argued that it was difficult to quantify the percentage discount required to entice subscribers to switch operators. They suggested that price was not the only reason why people would switch. They would look at the handsets being offered and other programs offered by the operators. Corporate customers, for instance, may require additional inducements such as new business cards etc before they switched operators. They did, however, state that if MNP were available, they would need to do even more
aggressive marketing because a barrier to switching would be lowered and competition would be even fiercer.

P Plus have estimated that a 50 per cent reduction in telephone bills is required in order for subscribers to be prepared to switch. Such a reduction is particularly important for a small business or corporate subscribers because the cost reduction must be large enough to compensate for the additional hassle caused by switching networks. If number portability were available, a price reduction of 20 per cent would be enough to encourage people to switch.

Sunday suggested that in the absence of MNP, a 20 per cent reduction in mobile telephone bills, other things being equal, would be required for subscribers to switch. They did not think that the situation would differ if MNP was available. SmarTone did not give a view on the change in the required discount given MNP. However, they stated that they did not believe that marginal differences in price mattered to consumers. The entry of the new PCS operators and the innovative pricing packages that accompanied them, have significantly affected SmarTone. For example, between 1993 and 1996, SmarTone experienced low levels of churn. Following the introduction of the PCS operators in 1997, the churn rate has increased to about 3 per cent a month. SmarTone attribute this increase to the heightened competition in the mobile telephony market and the aggressive marketing plans of the new entrants.

Table 5.7 shows the price discount required under different scenarios to encourage personal subscribers to switch operators. The discount required (both with and without MNP) is high but it lies within the range quoted by mobile operators in Hong Kong nor is it out of line with the discounts currently on offer in Hong Kong.

<table>
<thead>
<tr>
<th>Table 5.7</th>
<th>Mean Monthly Price Reduction Necessary to Encourage Personal Subscribers to Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without MNP</td>
</tr>
<tr>
<td>Dollars</td>
<td>221.25</td>
</tr>
<tr>
<td>Percentage of average bill size</td>
<td>47</td>
</tr>
</tbody>
</table>

1. The average bill size for personal subscribers in the survey was $469.78 per month.

These results can be used to calculate the size of Type 1b benefits. Figure 5.3 shows the three percentage point reduction in the threshold discount and the additional 10-20 per cent annual churn due to MNP. These two figures can be used together with the average monthly bill to calculate the Type 1b benefits.:

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6. The Type 1b benefits in a particular year are equal to the number of subscribers who churn because of MNP (Type 1b subscribers) by the average residential bill size by half the fall in the threshold discount. We only consider half the fall in the discount required (1.5 per cent in this case) as that is the average discount required to attract the additional customers.
5.2.4. Results of Type 1b benefits

The type 1b benefits were the second largest source of benefits following the introduction of MNP in Hong Kong. Table 5.8 shows how these benefits varied with each of the scenarios.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NPV (1999-2009) HK$ Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best case (MNP in January 1999, high churn)</td>
<td>216</td>
</tr>
<tr>
<td>Central case (MNP in June 1999, medium churn)</td>
<td>168</td>
</tr>
<tr>
<td>Worst Case (MNP in January 2000, low churn)</td>
<td>109</td>
</tr>
</tbody>
</table>

The NPV of the Type 1b benefits from 1999-2009 range between HK $109 million and HK $216 million with the central or realistic case yielding benefits of HK$ 168 million.

5.3. Type 2 Benefits

Type 2 benefits are the efficiency improvements, and any associated price reductions, which result from increased competitive pressure. While it is generally accepted that increased competition leads to lower prices and costs, very few studies have tried to estimate the effects, not least because it is necessary to screen out the impact of all the other influences on costs and prices.

The increase in competition may bring a range of benefits to Hong Kong Telecommunications’ users and operators. It may lead to improved cost efficiency and encourage a faster rate of innovation, both of which should be included in the cost benefit analysis. In addition, if efficiency improvements or lower profit margins lead to lower prices for subscribers, this will generate additional demand for telecommunications and lead to further welfare gains.
It is important to note that when estimating the Type 2 benefits we are interested only in the increase in competition and hence efficiency and innovation benefits associated with MNP rather than the impact of competition as a whole. The Type 2 benefits that are incremental to the introduction of MNP are identified by comparing the outputs of the base case and the MNP switching models.

5.3.1. Methodology for measuring Type 2 benefits

Most of the operators and many observers argue that the mobile market in Hong Kong is already competitive. They point to the large number of operators, wide choice of networks, and relatively high churn rates as evidence of a competitive market. Moreover, the entry of the new PCS operators has already reduced prices and increased the number of mobile phone users in Hong Kong.

Our preliminary examination of the Hong Kong mobile market suggests that the market appears to act competitively. However, we also note that it is also quite concentrated. CSL, Hutchison, and SmarTone, for example, account for 80 per cent of the total number of subscribers. This, of course, is due to the limited number of mobile licences in Hong Kong prior to the introduction of PCS and can be expected to change over time.

The economic literature reviewed suggests that in competitive markets that exhibit high levels of concentration new entry and enhanced competition can lead to increases in efficiency and innovation. A study by Nickell in 1996, for example, found that increased competition in industries where concentration was high was associated with higher total factor productivity growth. Using data from around 700 UK manufacturing companies over the period 1972-86, Nickell was able to determine the impact of variables (such as concentration and rent) on output. From that, he was then able to measure the impact on the total factor productivity in particular industries. He concluded that there was sufficient evidence to suggest that competition - measured either by an increased number of competitors or by lower levels of rents (profits) - is associated with a higher level of and higher growth rates in total factor productivity.

A later study by Nickell, Nicolitsas, and Dryden (1996) also tried to explore the role of product market competition and other variables in improving the productivity performance in companies. This research builds on earlier work by a number of authors (such as Caves & Barton, 1990, Caves et al, 1992, and Green & Mayes, 1991) that find that, above a certain threshold, increases in market concentration are associated with reductions in technical efficiency. These latter studies use frontier production techniques to compute efficiency indices which are related to competition variables. Nickell et al used data from 580 manufacturing companies in the UK over the period 1982-94. Competition is measured inversely as ex-post rents (profit less capital costs), normalised on value-added. They found that product competition (as well as the other variables they were measuring) was associated with some degree of productivity growth.
5.3.2. Estimates of Type 2 benefits

We have drawn on the findings of Nickell (1996) to estimate the relationship between the market share of individual operators in Hong Kong and the level of productivity. Nickell was interested in the impact of new entry, greater competition and falls in market share on the growth and level of total factor productivity. He concluded that a 25 per cent increase in market share leads to a 1 per cent fall in total factor productivity in the long run. In the case of new entry, Nickell’s finding could be turned around to state that a 25 per cent decrease in market share leads to a 1 per cent increase in total factor productivity in the long run.

Applying this result to the mobile market in Hong Kong, we obtain a net present value for these benefits that ranges from HK$14 to 19 million. This is very low relative to the Type 1 and Type 3 benefits and in line with our initial observation that the mobile market in Hong Kong is already competitive.

5.4. Type 3 Benefits

These are the other resource savings that arise from fewer number changes and include fewer misdialled calls and changes to information stored in customer equipment.

5.4.1. Methodology for measuring Type 3 benefits

There are several potential benefits that may occur if number portability reduces the frequency of number changes. We have identified two kinds of Type 3 benefits. The first arises because in the absence of MNP, a mobile customer who switches operator will inform friends or customers that they have changed their numbers. In this case, users will need to amend the numbers programmed into any customer premises equipment (such as telephone handsets or fax machines with stored numbers). By reducing the frequency of number changes, therefore, number portability will lead to savings in the time required to reprogramme stored numbers.

The second type of benefit arises when the mobile customer neglects (or is unable) to inform their friend or customer that they have changed their number. The friends or customers will then try to call the mobile customer resulting in a misdialled call. Following a misdialled call, moreover, some subscribers may call a fixed number or a pager number to locate the new number for the moved subscriber. The introduction of number portability would eliminate many such calls, so the benefits of number portability should include the costs saved by operators who would carry misdialled calls, the time saved by subscribers who would otherwise make misdialled calls and the cost of calls to fixed numbers or pagers to locate the subscriber.

The data used to measure the Type 3 benefits come from the user survey. Table 5.9 shows the percentage of people that changed their mobile number without informing the average respondent.

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10 In practice, this cost is likely to be small. We will, however, attempt to quantify it for the final report.
Table 5.9
Mobile Phone Number Changes Made by Friend or Colleagues

<table>
<thead>
<tr>
<th></th>
<th>Personal Subscribers</th>
<th>SMEs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have been informed of number change</td>
<td>57</td>
<td>41</td>
<td>49</td>
</tr>
<tr>
<td>Have not been informed of number change</td>
<td>43</td>
<td>59</td>
<td>51</td>
</tr>
</tbody>
</table>

Table 5.9 shows that about half of the respondents had experience of a friend or business contact changing their number without informing them. The survey also suggested that, on average, eight people called each respondent regularly. We have used these two results to assume that only 20 per cent of eight regular callers will not be informed of a number change. That assumption then allows us to measure the two categories of type 3 benefits discussed above.

Our approach to measuring Type 3 benefits is presented diagrammatically below. The benefits to those who are informed of a number change are relatively straightforward to calculate. The user survey indicated that over 76 per cent of respondents took less than 2 minutes to revise their personal or professional records. We used 1.5 minutes as a reasonable, conservative approximation in our modelling.

The benefits to those who were not informed of a number change are more difficult to determine. The user survey suggested that most (93 per cent) of respondents will make up to five enquiries to find the new number. Our approach when measuring these types of benefits was to measure both the time taken to locate the new number and the cost they incur to do so. We assumed that 5 enquiries will be made by the 20 per cent of the callers, 10 per cent of which will be done through a mobile phone. Each of these inquiries is assumed, conservatively, to have a duration of only one minute. If the user uses their fixed network telephone no cost will be incurred. Similarly, no cost will be incurred if the caller tries to call the mobile users' pager number. A cost will be incurred for the 10 per cent of searches that will be undertaken via a mobile phone (at an average cost of $1 per minute).
Type 3 benefits require an estimate to be made of the value of time taken to locate or change a mobile telephone number. Such an estimate is required in order to recognise that the time lost by individuals is not without cost. We have used an estimate for leisure time in Hong Kong of $40 per hour.

5.4.2. Estimates of Type 3 benefits

The Type 3 benefits are smaller than Type 1 benefits and contribute, on average, just over 5 per cent of the total benefits of MNP. The NPV of these benefits between 1999 and 2009 ranges between HK$89 million and HK$106 million with the central case yielding a NPV of HK$87 million. As with the Type 1 benefits, these benefits increase over time as the subscriber base increases.

5.5. Summary

The benefits of MNP in Hong Kong are significant. In total, the NPV of benefits ranges from HK$1,249 million, under the worst case scenario of a pessimistic implementation date, low churn, and low porting, to over HK$1,467 million in the best case scenario of an optimistic implementation date, high churn, and high porting (see Table 5.10).
Table 5.10
Benefits of MNP Under All Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NPV (1999-2009) HK$ Millions (high porting)</th>
<th>NPV (1999-2009) HK$ Millions (low porting)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best case (MNP in January 1999, high churn)</td>
<td>1,467</td>
<td>1,427</td>
</tr>
<tr>
<td>Central case (MNP in June 1999, medium churn)</td>
<td>1,402</td>
<td>1,362</td>
</tr>
<tr>
<td>Worst Case (MNP in January 2000, low churn)</td>
<td>1,275</td>
<td>1,249</td>
</tr>
</tbody>
</table>
6. RECOVERING THE COSTS OF MNP

6.1. Introduction

One of the important aspects of the introduction of mobile number portability (MNP) in Hong Kong will be the determination on cost allocation between operators. In the case of fixed network number portability in Hong Kong, the TA has expressed concern over the slow progress in the negotiations between operators on the necessary compensation arrangements. We have drawn on that experience, and also experience in other countries, to arrive at what we believe to be an efficient, equitable and practical set of principles regarding the recovery of the costs of MNP in Hong Kong.

6.2. The Options for MNP in Hong Kong

At this stage, it is difficult to identify the best solution for mobile number portability in Hong Kong. From an economic and technological point of view, the best solution is likely to vary with time and complexity depending on a wide range of factors including market conditions, the number and condition of fixed and mobile operators, the cost and nature of interconnection between operators, the number of consumers porting, and technological developments. For these reasons, it may be inappropriate for OFTA to mandate a specific solution. Instead, we recommend that OFTA mandate a functional specification and a set of cost recovery principles that will:

- allow the introduction of number portability at the earliest cost-effective and reasonable opportunity; and
- encourage operators to develop the way number portability in their networks in a way that is economically and technologically appropriate, and adaptable to the market situation.

In our view there are two realistic options or migration paths which could be followed in Hong Kong. They are:

- the introduction of simple call forwarding as an interim solution in six to twelve months time followed by a distributed database solution with the look-up performed by HKTC, or
- the distributed database solution with the look-up performed by HKTC introduced in 12-18 months time without an interim solution.

The attraction of simple call forwarding is that it can be implemented in a short time scale with minimal technical complexity and low set-up costs. Although the additional conveyance costs are relatively high our modelling has suggested that there are significant net benefits associated with this option.

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A call forwarding solution using call drop back has not been recommended given the significant investment required both for fixed and mobile switches.
It can be seen that in both instances we recommend the introduction of a distributed database solution with the look-up performed by HKTC. This is appropriate for the mobile market in Hong Kong for a number of reasons. Firstly, most calls (about 95 per cent) currently pass through HKTC's network so this solution would not require a major realignment of traffic patterns. Secondly, given that HKTC already perform the necessary number translation functions for the fixed networks this solution would only require an expansion of their existing duty to include calls to ported mobile numbers. As discussed in Chapter 3, the optimal solution in the long run would be to have all operators performing the look up. Such an investment can, however, by made by each operator when it becomes commercially feasible to do so.

6.3. General Principles for Cost Recovery

In the case of operator number portability in the fixed network, the TA outlined five compensation principles which included:

- **relevant costs**: defined as those costs which are directly incurred as a result of the provision of Operator Number Portability (ONP);
- **cost causality**: this principle required that a customer whose decision to port causes costs to be incurred should pay for the costs;
- **cost minimisation**: this required that all those who have the ability to affect the size of the costs should face the incentive to minimise them;
- **effective competition**: which requires that one operator should not have the ability to raise its competitors' costs or to weaken their ability to compete; and
- **distribution of benefits**: this principle recognises that customers who port their numbers are not the only beneficiaries of number portability and hence that other beneficiaries might pay for some of the costs.

These principles were derived, in part from the six principles identified in the UK by the Director General of OFTEL. These were:

- cost causation
- cost minimisation;
- distribution of benefits;
- effective competition;
- reciprocity and symmetry;
- practicability.

In the fixed telephone network in the UK, these principles lead to the following cost recovery principles being introduced:
• Each operator would be responsible for its own system set-up costs.

• BT could pass on its per line set-up costs to the operators to which its customers port their numbers.

• BT should bear the additional costs of conveyance under the call drop-back solution. During the period of tromboning, however, the estimated additional costs compared with call drop-back should be shared equally between BT and other operators.

6.4. Cost Recovery in the Fixed Network in Hong Kong

Number portability for the Fixed Telecommunication Network Services (FTNS) has been available since July 1995 when simple call forwarding was used as the interim solution. At that time, there was a clear consensus that use of the Intelligent Network (IN) would be the preferred, sustainable long term solution for both operator and geographical portability. Although satisfied with the progress on the technical implementation of number portability, the TA believes that the progress of the negotiation between operators on the compensation arrangements has been too slow.

As a result, the TA issued a Statement in September 1997 in which it outlined an economically efficient regulatory framework for the recovery of the cost of operator number portability. It argued that the cost recovery mechanisms it developed were consistent with the principles of relevant costs, cost causality, cost minimisation, effective competition, and distribution of benefits.

The TA identified the following cost components that are incurred in the provision of inter-operator number portability under the long term IN solution in Hong Kong:

• System set-up costs:
  - database costs;
  - costs of upgrading software.

• Additional conveyance costs:
  - signalling capacity costs; and

• Per line set-up costs

6.4.1. System set-up costs

The system set-up costs included the database costs and the costs of upgrading software. Under the IN approach for FTNS operator portability, the four fixed operators and HKTI must have access to a database to find ported numbers. The industry has chosen to adopt a non-central reference database (non-CRD) solution which involves four, off-line replicated databases linked up by inter-operator data links. The costs incurred in modifying switches 12

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12 Geographic portability is the ability for users to retain their telephone number when moving location. Operator portability allows them to retain their number when moving operator.
so that originating local calls and incoming international calls can obtain information from the on-line databases are referred to as the costs of upgrading software.

The TA assessed the system set-up costs against each of the principles deemed relevant to the Hong Kong market (see Section 4) and concluded that:

"... the TA's view that each FTNS operator should bear its own relevant set-up costs is consistent with principles of cost causality, cost minimisation, effective competition and distribution of benefits. In a multi-operator environment where the provision of operator number portability constitutes one of the general licence conditions, the system of each operator must be capable of routing calls to the ported numbers efficiently and correctly."

6.4.2. Additional conveyance costs

The additional conveyance costs under the IN solution are the signalling capacity costs. These are incurred because of the different nature of conventional calls and ported calls. Under the IN approach to FTNS portability, a call dialled to a ported number is directly routed from the originating exchange to the new terminating exchange. The difference between such a ported call and a conventional call is that the operator of the originating exchange has to obtain routing information from the database before knowing where to terminate the call. Only a call to a ported number would, therefore, entail signalling capacity for consulting the database.

The TA's view on the recovery of these costs was that:

"Among the four FTNS operators, only HKTC would incur additional conveyance costs in routing calls to some of the ported numbers. The principles of cost causality, cost minimisation, effective competition and distribution of benefits imply that HKTC should bear the additional conveyance costs. These are basic conditioning costs in a multi-operator environment. The costs are incurred for serving the access customers of HKTC."

6.4.3. Per line set-up costs

Once a customer has ported their fixed network number, both the donor (DNO) and recipient network operators (RNO) incur a series of one-off costs. These costs include the following:

- the RNO will send a number portability request with a proposed cut-over date and the signed customer request form to the DNO;
- the DNO will check the system to ensure that the proposed cut-over date can be achieved;
- the RNO will have to complete all installations and testing procedures up to the physical cut-over point;
*both operators will need to confirm changes to their databases; and
*the DNO will need to confirm to the RNO that the re-route has been successfully activated.

The TA’s view on the per line set-up costs under the IN solution for fixed network portability can be summarised as follows:

“The RNO should compensate the DNO for the per line set-up costs which are directly attributable to implementing the porting customers’ decision. These inter-operator charges should be based on the LRAIC plus a reasonable share of the common costs arising from porting, service connection and disconnection, and the provision of Type II interconnection. The per line set-up costs should be recovered as one-off charges from the RNO, unless the DNO could demonstrate that there would also be recurrent costs to be induced by the porting customers. The RNO could determine for itself how it would like to recover these costs from the customers”.

6.5. The Views of Operators in Hong Kong

HKT CSL has said that the responsibility for routing the call should rest with the originating network as that would ensure that it works out the most efficient way to route the call. It also added that:

“... cost recovery is a matter between three parties, namely the originating network, the terminating network and the ported subscriber. According to the principle of cost causation, the ported number incurs additional costs and therefore causes the network resources to be used. To make an economically rational decision, that ported user needs to be given the correct price signals about what the service will actually cost, so that the user can make an informed cost/benefit decision before subscribing to the number portability service. Otherwise, it would encourage over-use of the limited resources.”

The joint submission for number portability by Mandarin Communications, New World PCS, Peoples Telephone Company, and P Plus made the following comments regarding cost recovery:

“The PCS operators submit that any cost recovery principles determined by the TA should be pro-consumer and pro-competition and as such the compensation payable by the RNO to the FTNS operator should be as low as possible as it represents a major barrier for any mobile customers to change operators. In any event, the PCS operators take the view that in the event that Option 3 is chosen, the compensation for the provision of NP services by FTNS operators should be no more than a one-off per line set-up charge on the RNO which would cover the relevant administrative cost only in order to prevent the DNO from “selling” customers to the RNO.”
In a further submission to the TA regarding cost recovery principles, New World PCS warned against leaving the decision on cost allocation to the operators to determine by negotiation.

"We do not think that the TA should take a "laissez faire policy" regarding cost recovery principles amongst the operators by leaving them to determine the reasonable relevant cost through commercial agreements. This policy has proved to be a failure amongst the fixed network operators in the implementation of NP for fixed lines. In this regard, we believe that the TA should impose a ceiling price pursuant to Section 36A of the Telecommunications Ordinance which the FTNS operators may charge on the mobile operators. It is up to the mobile operators to negotiate with any of the FTNS operators for a lower competitive price for the provision of NP or translation services."

6.6. Cost Recovery for MNP in Hong Kong

When determining the cost recovery principles for MNP in Hong Kong, it is useful to bear in mind the Hong Kong SAR Government's main policy objectives for Hong Kong's telecommunications industry. These are:

- that the widest range of quality telecommunications services should be available to the community at reasonable cost;
- that telecommunications services should be provided in the most economically efficient manner possible; and
- that Hong Kong should serve as the pre-eminent communications hub for the region now and into the next century.

Based on previous studies of number portability we will divide the costs of MNP into three categories - the system set-up costs, the additional conveyance costs, and the per subscriber set-up costs. The precise definition of these cost categories will vary by country and by system. TA's definitions were discussed in Section 6.4. Table 6.1 below defines the cost categories we have used when recommending our solution for MNP cost recovery. These closely follow those used by OFTA.
Table 6.1
Cost Terminology for MNP in Hong Kong

<table>
<thead>
<tr>
<th>Cost category</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>System set-up cost</td>
<td>Those costs incurred by an operator to establish the capacity to provide portability in its network and its associated administrative systems.</td>
</tr>
<tr>
<td></td>
<td>Under the call forwarding solution, mobile operators will face few switch set-up costs but will be required to change their operational support systems.</td>
</tr>
<tr>
<td></td>
<td>Under the distributed database solution, no immediate development work will be required in mobile switched networks. HKTC will, however, be required to expand its database look-up capacity.</td>
</tr>
<tr>
<td>Additional conveyance</td>
<td>These are the costs associated with any inefficiency in way of routing calls for MNP compared with the way calls would be routed were MNP not implemented.</td>
</tr>
<tr>
<td>Additional conveyance</td>
<td>Under the call forwarding solution, the costs arise mainly through the tromboning of calls between HKTC's network and that of the donor operator. These costs comprise both the inherent cost of handling the extra traffic at the donor GMSC, the cost of utilising interconnection capacity between operators other than HKTC, as well as the additional interconnection charges that are paid to HKTC.</td>
</tr>
<tr>
<td>costs</td>
<td>Additional conveyance costs under the distributed database solution consist of the additional signalling capacity costs required for calls to mobile numbers.</td>
</tr>
<tr>
<td></td>
<td>Per subscriber set-up costs These are the administration costs involved in transferring a subscriber from the donor network operator to the recipient donor network (see Section 6.4.3 for the types of costs). They are incurred under both the call forwarding and distributed database solution.</td>
</tr>
</tbody>
</table>

Our recommendations on cost recovery differ depending on the form of the solution implemented. For example, the solution we suggest for the recovery of system set-up costs under the interim call forwarding solution will differ from that we suggest for the distributed database solution. Our reasoning is discussed in detail in the following sections.

It is also important to note that the principles discussed in section 6.3 do not always offer clear assistance to policy makers. The TA, for instance, when deciding how the costs of ONP should be recovered noted that not all of these principles would be applicable to the recovery of each cost component. They went on to argue that:

"They may conflict with one another in some cases. For example, the imposition of no inter-operator charges, as proposed by the new entrants, is usually consistent with cost minimisation and effective competition. However, the principles of relevant cost and cost causality imply that inter-operator charges are
inevitable in a multiple network environment. And yet the principle of cost causality itself may not be in harmony with the distribution of benefit principle when there are external benefits.

In the following sections, we draw on the principles developed by the TA for ONP and experience in other countries to set out our preliminary views on the way that the costs of MNP should be recovered in Hong Kong.

6.7. Cost Recovery Under the Interim Call Forwarding Solution

6.7.1. System set-up costs under the interim call forwarding solution

We have assumed that call forwarding for mobile number portability would be achieved using a standard unconditional call forward divert which would tie up an extra port on the switch for the duration of the call and utilise corresponding processor requirements. Such an approach requires minimal modifications to the switching equipment of mobile operators and does not require the fixed operators to make modifications to their look-up databases.

The system set-up costs associated with call forwarding are part of the investment that an operator needs to make to enable it to provide telecommunications services in today’s environment. Hence the principle of cost causation points to each operator being responsible for its own system set-up costs.

The same conclusion is reached by applying the distribution of benefits principle. The system set-up costs mainly fall on mobile operators. The benefits of MNP would also accrue mostly to mobile phone subscribers who would have a constraint to switching between operators removed and would thus be able to benefit from lower prices on low switching costs. Some benefits (Type 3 benefits) would accrue to fixed network subscribers, but these represent a minority of total benefits. Similarly a small amount of system set-up costs would fall on fixed operators.

The conclusion that each operator should bear its own set-up costs is also consistent with cost minimisation and the development of effective competition. An operator that bears its own system set-up costs has both the incentive and the power to minimise them. At the same time, by not favouring one operator or another a level playing field is ensured.

6.7.2. Additional conveyance costs under the interim call forwarding solution

Additional conveyance costs can be defined as those which are additional to the costs of a non-ported call from the originating network to the recipient network.

In the UK, OVUM recommended that each operator should bear its own additional traffic costs caused by the introduction of MNP. As discussed above, this could be seen as an economically efficient solution as it places the incentive to minimise the additional conveyance cost on those that can affect the cost. In the long run, it is also arguably both
equitable and consistent with the distribution of benefits principle because the flows of subscribers between the donor and recipient operators could be expected to even out and so to would the additional conveyance costs. However, in the short run, the existing (PMRS) mobile operators would bear most of the costs.

The situation in Hong Kong differs from that in the UK in a number of ways. The two most significant differences are:

- mobile subscribers in Hong Kong pay for both incoming and outgoing calls; and
- the size difference between the two countries means that the additional conveyance costs in Hong Kong will be smaller than those in the UK.

The first of these differences is the most significant. With the interim call forwarding solution, ported calls that originate from the fixed network and are destined for the recipient network will incur two additional conveyance stages (illustrated as the links between the donor mobile network and HKTC’s network in Figure 6.1). The recipient network will incur the cost for the final link in Figure 1, but as the ported mobile subscriber will pay for that incoming call, the recipient network will receive the call revenue from the subscriber. The donor network, however, will be charged by HKTC for the use of the two additional interconnection links per call without receiving any revenue for the call.

As discussed in Table 6.1, there are two categories of additional conveyance costs, namely:

- the inherent cost of handling the extra traffic at the donor GMSC; and
The first type of additional conveyance cost (i.e. the inherent cost of handling the extra traffic at the donor GMSC can be argued to be similar to system set-up costs). We therefore, conclude that each operator should bear its own share of this category of additional conveyance costs.

The second category of additional conveyance costs is the charge imposed by HKTC on the donor network for the use of the two additional interconnection links per call. The donor network, who loses a customer, is in effect further penalised by the charge for the two links. We believe, therefore, that it is appropriate that the recipient network should reimburse the donor network for this part of the additional conveyance costs under the interim call forwarding solution.

Such a recommendation is consistent with the principles of cost causation and distribution of benefits. It is the act of porting that causes the additional cost to be incurred and the recipient network will benefit from the introduction of mobile number portability and will gain a customer and a future revenue stream. Moreover, this revenue will far exceed the additional conveyance cost incurred by the donor when the call is forwarded to the recipient network.

At the same time we are mindful of the need to create incentives to encourage cost minimisation during the interim solution. During the interim call forwarding solution the recipient network will bear costs that it has no ability to control. However, the current cap on the per minute interconnection charge set by OFTA, should help to ensure that the cost is minimised.

Recipient network operators may argue that the additional conveyance cost will raise their costs for ported customers by requiring a higher charge to be paid to the originating operator compared to the charge for an incoming call to a non-ported customer. This in turn will limit their capacity to compete. Although we have some sympathy with this view, it is difficult to see any alternative that meets the cost recovery principles. The additional conveyance cost must be borne by either the originating network, the donor network, or the recipient network. As already stated, it seems unfair for the donor network - who has lost its customer - to be further penalised by having to pay for the additional conveyance costs involved in completing the call. Also the donor network has not caused the porting to take place. Meanwhile, the only argument for suggesting that charge should be borne by the originating operator is that it can control them and is therefore in the best position to minimise them. However, given that OFTA currently regulates the per-minute charge, it is unlikely that high charges are being levied on recipient operators.

6.7.3. Per subscriber set-up costs under the interim call forwarding solution

We suggest that per subscriber set-up costs be treated in a similar way to that adopted for fixed network portability. That is, the recipient network compensates the donor network for the reasonable relevant costs based on the LRAIC plus a reasonable share of the
common costs arising from porting, service connection and disconnection, and the provision of Type II interconnection.

We believe that the recipient network should, if it chooses, be allowed to pass on the per subscriber set-up costs to the porting customer. Whether it will or not will be a commercial decision to be made by each operator. Such an approach is clearly consistent with the cost causation principle as the subscriber, by porting, causes the cost to be incurred. If the cost is passed on to the porting customer, then it is taken into account in the porting decision, a situation which is consistent with economic efficiency and cost minimisation.

It is also important to note that charging a customer for MNP is not inconsistent with the principle of effective competition. In general, a cost based price - far from being anti-competitive - could often lead to an optimal solution. In other words, a price on porting may prove a useful mechanism for discouraging an inefficient level of porting.

6.8. Cost Recovery Under the Distributed Database Solution

6.8.1. System set-up costs under the distributed database solution

Under this solution, there would be a distributed database solution with the look-up performed by HKTC. Although in time other operators would also provide a database look-up service, initially HKTC would be the only operator performing this function. This is reasonable particularly given the current interconnection arrangements and the look-up functions currently performed by HKTC for ONP. In this way, the situation could be seen as analogous to a centralised database solution.

The costs of implementing this solution fall almost exclusively on the fixed network. The types of system set-up costs involved would include an expansion of its database look-up capacity. Mobile operators, on the other hand, would not be required to undertake any immediate developmental work in their networks.

One option for recovering the costs of the distributed database solution would be to set a charge for each database look-up. In this way, the costs of the database could be recovered over time in line with the volume of traffic through the database. Whether or not a charge will be incurred will depend on the type of operator. For example, if a call to a mobile originated in HKTC’s network, HKTC should bear the cost of a database look-up. Such an outcome is consistent with the distribution of benefits principles insofar as callers in the fixed network are able to have their calls completed. On the other hand, a call from a mobile subscriber to a mobile subscriber would need to pay HKTC (or, in the longer term, whoever they choose) for the database.

The above reasoning is broadly similar to the view that each operator should bear its own set-up costs. The operators should, in other words, have the ability to route calls to the correct destination using a database. This ability is part of the investment required in a multi-operator environment in order to allow operators to route calls to the ported numbers.
efficiently and correctly. Operators, therefore, should acquire this capacity either by investing in the database or by 'purchasing' the look-up by other operators.

Under such a solution, the system set-up costs would be shared by fixed and mobile operators depending on the mix of traffic. Initially at least, as most calls originate in HKTC's network, it would be expected to bear a majority of the costs.

However, the charging principles currently in Hong Kong create the need for a different set of cost recovery principles for system set-up for distributed database solution. In Hong Kong, local calls are free. If a customers from the fixed network calls a mobile customer, the mobile customer bears the cost. The critical implication is that the fixed network does not recover any revenue from its customers when calls to mobile networks - or indeed any network - are made. The costs are recovered from the terminating mobile operator.

Under our proposed distributed database solution, the charge incurred in the fixed network when a fixed network customer calls a mobile subscriber would, therefore, be treated in the same way as the other costs involved in completing the call. The rationale for this is that the fixed network operator receives the revenue from the terminating operator rather than their own customer.

We would, therefore, recommend that the system set-up costs under the distributed database solution be recovered from the mobile operators in either of the following forms:

1) An agreed fee between mobile operators and HKTC for the provision of a bundle of number translation services. That is, mobile operators and HKTC could agree on a fee that will enable a certain number of database look-ups to be conducted by HKTC. This fee could also be checked by OFTA.

2) A charge per database look-up to be paid to HKTC by the mobile operators. Mobile operators that do not wish to purchase a bundle of number translation services or cannot agree on a price, could pay a charge to HKTC for each call. This charge would need to be determined and reviewed by OFTA and would be based on the long run average incremental cost of the system set-up costs incurred by HKTC to upgrade its distributed database. The charge would be paid by the terminating mobile operator if the call originates from the fixed network. If the call originates in the mobile network, the charge would be shared by the originating and terminating operators (as is currently the case with mobile call charges).

We believe that under either option, a charge on the terminating mobile operator (in the case of a mobile to mobile call, a charge shared by the originating and terminating operators) is also consistent with the principle of effective competition and cost minimisation. With regards to effective competition, a charge only on recipient network operators would increase the cost of a ported customers. This would in effect treat the ported customers differently. It implies that the numbers do belong to the existing operators and any variation from that policy should incur a cost. A charge on all
terminating mobile calls, on the other hand, treats all mobile operators (donor network operators and recipient network operators) equally.

The proposed charge could also help to encourage a more efficient outcome. Mobile operators may, over time, develop a cheaper way of implementing portability (such as their own look-up) and may avoid the charge imposed by HKTC. In the long run, a competitive market for number translation services may develop further reducing the cost and charge of number translation services. In short, a charge on mobile operators will provide an incentive to operators to move towards an IN solution and perhaps direct interconnection with other operators when commercially viable. In the short term, the level of the charge could be regulated by OFTA.

The relevant cost principle is also relevant here. Any charge should only recover those costs employed for the provision (and maintenance) of a database look-up caused by the introduction of MNP (that is, the incremental costs), not those costs that have been incurred to enable the current database look-up for ONP.

6.8.2. Additional conveyance costs under the distributed database solution

The additional conveyance costs under the distributed database solution consist of the additional signalling capacity costs required for calls to mobile numbers. We see these costs as similar in nature to the costs associated with a database dip and with the correct routing of numbers and would therefore treat them in a similar way.

6.8.3. Per subscriber set-up costs under the distributed database solution

These costs would be treated in the same way as in the interim call forward solution. That is, the recipient network should compensate the donor network for the reasonable relevant costs based on the LRAIC plus a reasonable share of the common costs arising from porting, service connection and disconnection, and the provision of Type II interconnection. Again, the recipient network should, if it chooses, be allowed to pass on the per subscriber set-up costs to the porting customer.
6.9. Summary

Table 6.2 shows how the costs of mobile number portability in Hong Kong are to be allocated. Under the distributed database solution, we discuss HKTC as it will bear the costs in the short run.

<table>
<thead>
<tr>
<th>Cost</th>
<th>Call forwarding</th>
<th>Distributed database</th>
</tr>
</thead>
<tbody>
<tr>
<td>System set-up cost</td>
<td>Each operator bears its own costs</td>
<td>HKTC to recover its costs from all mobile operators</td>
</tr>
<tr>
<td>Additional conveyance costs</td>
<td>Donor network operator to recover interconnect charge from recipient network operator. Each operator to bear its own remaining costs</td>
<td>HKTC to recover its costs from all mobile operators</td>
</tr>
<tr>
<td>Per subscriber set-up costs</td>
<td>Donor network operator to recover from recipient network operator</td>
<td>Donor network operator to recover from recipient network operator</td>
</tr>
</tbody>
</table>
APPENDIX 1. THE BASE CASE

1.1. Introduction

This appendix discusses the future of the Hong Kong's mobile telecommunications market in the absence of Mobile Number Portability (MNP) over the next 10 years. There are currently four Public Mobile Radiotelephone Service (PMRS) licensees offering one analogue and five digital systems (including GSM, CDMA and TDMA). In 1996, six operators were licensed to provide Personal Communications Services (PCS). By the end of 1997, there were just over two million subscribers, representing a penetration of around 32 per cent of the Hong Kong population.13

GSM systems have been operating since 1993 and PCS since 1997. Analogue systems are being phased out and subscribers of these systems encouraged to migrate to either GSM or PCS. As a result, this study does not consider the impact of MNP on analogue subscribers. As GSM and PCS are relatively new services, there is limited historic data available14 on subscriber numbers, prices and the volume and value of services. Consequently, we have had to make arrangements based on the survey of mobile users, interviews with mobile operators and other industry participants, and expected developments in mobile markets in other countries.

The derivation of the base case forecasts for mobile subscriber growth and the results are presented in the next section. The proportion of mobile subscribers switching to other networks is estimated in Section 1.3. Finally, Section 1.4 provides our forecasts for revenue per subscriber.

1.2. Forecasting Mobile Subscribers

1.2.1. The logistic curve

The logistic curve is often used to forecast the penetration of products which, after a start-up phase, show rapid growth before tapering off. A generalised form of the logistic function is used in the following analysis (see Figure A1.1):

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13 All penetration rates are for the end of the calendar year. Forecasts of future penetration rates take into account population growth, based on information on the projected population to 2016 provided by OFTA

14 For forecasting purposes
where $a$ and $d$ are parameters to be estimated, $b$ shows the speed of take-up of services, and $c$ is the saturation penetration level.

A best fit is obtained by minimising the sum of the squared differences between the actual level of penetration and the logistic function value for each year's data. This has been carried out using Excel and the associated facility, Solver.

### 1.2.2. Assumed penetration rates

Assumptions have been made with respect to total mobile phone penetration in Hong Kong as well as market shares of each system (GSM, PCS, CDMA, TDMA). These are discussed separately below.

#### 1.2.2.1. Overall Market

Table A1.1 shows our assumptions on mobile penetration in the Hong Kong market. These assumptions are based on discussions with operators in Hong Kong. We expect a mobile penetration rate of about 50 per cent by 2002 and 60 per cent by 2007 anything, these forecasts. Thereafter we expect the penetration rate to remain broadly constant. If anything these forecasts are conservative.

This assumption is consistent with the rapid growth in mobile phone penetration experienced in Scandinavian markets, such as Sweden and Denmark, where current penetration levels are above 30 per cent and expected to reach 50 per cent by the year 2000.
Appendix 1: The Base Case

Table A1.1
Mobile Penetration (%) - Overall Market

<table>
<thead>
<tr>
<th>Year</th>
<th>Penetration*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>0%</td>
</tr>
<tr>
<td>1997</td>
<td>32%</td>
</tr>
<tr>
<td>2002</td>
<td>50%</td>
</tr>
<tr>
<td>2007</td>
<td>60%</td>
</tr>
<tr>
<td>2009</td>
<td>60%</td>
</tr>
</tbody>
</table>

Source: NERA estimates
* This excludes analogue subscribers.

Higher levels of mobile penetration are driven by:

- increased market segmentation as operators develop service packages that address the needs of a growing number of consumer market segments based on the combination of communications and security needs of individuals;
- a need for differentiation of services - value added services will be critical for maximising profits and network utilisation in a highly competitive market such as Hong Kong;
- a requirement by mobile subscribers for constant contactability and control over their communications services. The customer’s choice will be based on network quality and coverage, handset prices and tariffs, and the level and quality of customer service.

The base case takes into account the fact that technological inhibitors, such as network coverage restrictions in buildings and rural areas and the perception that call quality is low, are expected to reduce rapidly over the next few years. We expect these inhibitors to become less important in the light of the fact that PCS operators are looking to increase their network coverage over the next 18 months.

The price of calls is also a barrier to the adoption of mobile services. Currently, most of the mobile operators subsidise the provision of handsets and, in order to recover the cost of the subsidy, require higher call charges than would otherwise be the case. With the introduction of the PCS networks in Hong Kong, the mobile market is expected to be characterised by declines in average revenue per subscriber resulting from lower service prices and less utilisation by incremental users.

The increased use of value added services, such as data, are expected to mitigate some of the effects of this trend. However, with competition increasingly cutting the safety net provided by annual subscriber contracts, operators will be forced to reduce subscriber acquisition costs as well as network operating and infrastructure costs, enabling operators...
to offer lower tariffs. Against this background we have assumed on the basis of what the operators have told us, that the handset subsidy will be phased out soon.

It should be noted that these assumptions also hold for the market with the introduction of MNP. The Hong Kong mobile market is already competitive and even in the absence of MNP, competition is expected to lead to lower prices and enhance service quality. MNP will make it easier to switch to other networks, therefore increasing the number of subscribers switching between networks. As a result, we do not assume a different set of penetration rates for the overall market in the MNP scenario, but assume a different set of penetration rates by type of mobile system in the MNP scenario.

1.2.2.2. Mobile systems

Ideally a customer migration model should be based on forecasts of price differentials, switching costs and inertia, enabling the forecast of base case market shares by type of system. In the absence of sufficient historic information on developments in market share (in terms of number of subscribers), it has not been possible to calibrate such a model using data. Our approach is, therefore, led by conservative assumptions described in this section.

The rationale for making separate forecasts for the different mobile systems is that they have different cost structures, revenue per subscriber, churn rates, and spectrum allocations.

Overall mobile phone penetration can be sub-divided according to the four main types of system (see Table A1.2.). These are based on NERA estimates of the saturation level per system and, therefore, market shares arising from current spectrum constraints:

- **GSM.** The GSM band could support about 2.1 million subscribers. Currently, GSM systems have nearly 1.3 million subscribers. Based on historic data, which shows high growth over the last three years, it would be unrealistic to assume in the base case that penetration of GSM systems will fall. Since it currently has about 65 per cent of market share (in terms of number of subscribers) and accounts for 21 per cent of total mobile penetration, we expect GSM penetration to continue to grow in a growing market, although its market share may fall as a result of competition from PCS operators. Although it is extremely difficult to forecast market shares, especially as dual GSM/PCS operators could optimise their networks allowing users to use both bands, given the current spectrum constraint for the GSM band, we expect GSM penetration to reach 25 per cent by 2002, and increase to nearly 29 per cent by 2007 and then remain at that level;

- **CDMA & TDMA.** It is claimed that these systems are more spectrum efficient than GSM/PCS but our experience suggests that in reality there is no significant difference. The CDMA and TDMA systems also have spectrum allocations of 2 x 7.5

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15 Where the capacity of each GSM network is about 700,000 subscribers, based on the full spectrum allocation of 2 x 7.5 MHz for each of the GSM operators. There are three GSM operators in Hong Kong.
MHz and, therefore, should be able to support around 700,000 subscribers each. CDMA has grown by over 350 per cent during the last year, to achieve a level of over 240,000 subscribers by the end of 1997, compared with 17 per cent growth for TDMA over the same period. We expect CDMA to outstrip TDMA in terms of number of subscribers over the next ten years. Penetration rates of CDMA and TDMA are expected to be 8.5 per cent and 5.5 per cent, respectively, by 2002, and 7.2 per cent and 6.6 per cent, respectively, by 2007;

- PCS. With the current 5 MHz allocation, each PCS can support 300,000 subscribers. A total of 70 MHz is, however, available across the band which could support 4.2 million subscribers. With market shares being determined by spectrum constraints for the other systems, PCS market shares account for the remainder of the mobile market. PCS is expected to have a market share (in terms of number of subscribers) of about 30 per cent by 2007, or 17 per cent of total mobile penetration.

### Table A1.2
**Mobile Penetration (%) - By System**

<table>
<thead>
<tr>
<th>Year</th>
<th>GSM</th>
<th>PCS</th>
<th>CDMA</th>
<th>TDMA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0%</td>
</tr>
<tr>
<td>1997</td>
<td>20.6%</td>
<td>3.7%</td>
<td>3.3%</td>
<td>4.1%</td>
<td>32.1%</td>
</tr>
<tr>
<td>2002</td>
<td>25.0%</td>
<td>13.0%</td>
<td>6.5%</td>
<td>5.5%</td>
<td>50.0%</td>
</tr>
<tr>
<td>2007</td>
<td>28.8%</td>
<td>17.4%</td>
<td>7.2%</td>
<td>6.6%</td>
<td>60.0%</td>
</tr>
<tr>
<td>2009</td>
<td>28.8%</td>
<td>17.4%</td>
<td>7.2%</td>
<td>6.6%</td>
<td>60.0%</td>
</tr>
</tbody>
</table>

*Source: NERA estimates*

As discussed earlier, the introduction of MNP will not affect the size of the total mobile market but has an impact on how that market is divided up between the different systems. We take this into account when we make assumptions on mobile penetration by system in the MNP scenario.

It should be noted that OFTA is currently conducting a review of spectrum allocations to mobile operators and considering whether additional spectrum will assigned to GSM, CDMA and TDMA networks. The results are not yet known. It is our understanding that any additional spectrum allocations are likely to be small and, therefore, will not have a significant impact on our assumptions.

### 1.2.3. Results

#### Expected growth of mobile subscribers - overall market

This section shows the results obtained by fitting a logistic curve using the historic data and assumptions on penetration rates (Figure A1.2).
Fig A1.2 - Expected Penetration of Mobile Phones 1997-2007

Table A1.3 shows the likely size of the mobile market in Hong Kong based on the logistic curve. The best fit shows that, by 2002, there will be around 3.8 million subscribers and that this figure will rise to nearly 4.4 million by 2007, and 4.6 by 2009. The results presented here do not exactly correspond to the assumptions presented in Table A1.1, as these results are the obtained from the best fit using the sum of the squared difference between the actual and the function value for each year’s data. However, the differences are very small.

The results presented here take account of churn in the market. This is investigated further in Section 1.3, where we estimate inter-mobile churn.

<table>
<thead>
<tr>
<th>Year</th>
<th>Penetration (%)</th>
<th>Subscribers (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>29%</td>
<td>1.89</td>
</tr>
<tr>
<td>1998</td>
<td>36%</td>
<td>2.41</td>
</tr>
<tr>
<td>1999</td>
<td>42%</td>
<td>2.86</td>
</tr>
<tr>
<td>2000</td>
<td>48%</td>
<td>3.27</td>
</tr>
<tr>
<td>2001</td>
<td>52%</td>
<td>3.59</td>
</tr>
<tr>
<td>2002</td>
<td>55%</td>
<td>3.84</td>
</tr>
<tr>
<td>2003</td>
<td>56%</td>
<td>4.02</td>
</tr>
<tr>
<td>2004</td>
<td>58%</td>
<td>4.18</td>
</tr>
<tr>
<td>2005</td>
<td>59%</td>
<td>4.28</td>
</tr>
<tr>
<td>2006</td>
<td>59%</td>
<td>4.36</td>
</tr>
<tr>
<td>2007</td>
<td>59%</td>
<td>4.44</td>
</tr>
<tr>
<td>2008</td>
<td>60%</td>
<td>4.50</td>
</tr>
<tr>
<td>2009</td>
<td>60%</td>
<td>4.56</td>
</tr>
</tbody>
</table>

Source: NERA estimates
1.2.3.2. Expected growth of mobile subscribers - by system

This section shows the results obtained by fitting the logistic curve to the assumptions on penetration rates by mobile system (Table A1.4).¹⁶

Subscriber numbers in 2009 are estimated as follows:

- 2 million for GSM;
- 1.3 million for PCS;
- about 0.5 million each for CDMA and TDMA.

<table>
<thead>
<tr>
<th>Year</th>
<th>GSM</th>
<th>PCS</th>
<th>CDMA</th>
<th>TDMA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pen (%)</td>
<td>Subs(mn)</td>
<td>Pen (%)</td>
<td>Subs(mn)</td>
</tr>
<tr>
<td>1997</td>
<td>21%</td>
<td>1.33</td>
<td>4%</td>
<td>0.23</td>
</tr>
<tr>
<td>1998</td>
<td>26%</td>
<td>1.70</td>
<td>5%</td>
<td>0.34</td>
</tr>
<tr>
<td>1999</td>
<td>27%</td>
<td>1.80</td>
<td>7%</td>
<td>0.48</td>
</tr>
<tr>
<td>2000</td>
<td>27%</td>
<td>1.84</td>
<td>9%</td>
<td>0.63</td>
</tr>
<tr>
<td>2001</td>
<td>27%</td>
<td>1.87</td>
<td>11%</td>
<td>0.78</td>
</tr>
<tr>
<td>2002</td>
<td>27%</td>
<td>1.90</td>
<td>13%</td>
<td>0.92</td>
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<tr>
<td>2003</td>
<td>27%</td>
<td>1.92</td>
<td>15%</td>
<td>1.03</td>
</tr>
<tr>
<td>2004</td>
<td>27%</td>
<td>1.95</td>
<td>16%</td>
<td>1.13</td>
</tr>
<tr>
<td>2005</td>
<td>27%</td>
<td>1.96</td>
<td>16%</td>
<td>1.20</td>
</tr>
<tr>
<td>2006</td>
<td>27%</td>
<td>1.99</td>
<td>17%</td>
<td>1.24</td>
</tr>
<tr>
<td>2007</td>
<td>27%</td>
<td>2.00</td>
<td>17%</td>
<td>1.28</td>
</tr>
<tr>
<td>2008</td>
<td>27%</td>
<td>2.03</td>
<td>17%</td>
<td>1.31</td>
</tr>
<tr>
<td>2009</td>
<td>27%</td>
<td>2.05</td>
<td>18%</td>
<td>1.34</td>
</tr>
</tbody>
</table>

Table A1.4
Expected Mobile Subscribers - by System

Source: NERA estimates

Figure A1.3 shows the expected growth of mobile users over the next ten years by system.

¹⁶ The numbers in Tables A1.3 and A1.4 differ slightly due to the process of fitting separate logistic curves for each system.
1.3. Switching Forecast

1.3.1. Introduction

This section sets out our assumptions and methodology for estimating the number of subscribers switching networks.

Customer retention becomes increasingly important as the number of operators in a given market increases. A high proportion of a mobile operator’s subscriber base turns over or “churns” to a different carrier (or simply quits using mobile services) every year. With the cost of acquiring a customer being around five times the cost of maintaining a customer, the easiest and least expensive way to achieve and maintain a given customer base is to keep the ones you already have.

Current churn rates are extremely high in Hong Kong, ranging from 24 per cent p.a. to as much as 55 per cent p.a.17 Such rates are the result of fierce price competition since the launch of PCS services offering low tariff packages. Current churn rates are higher, on average, for the GSM and CDMA and TDMA than for PCS.

1.3.2. Assumptions

In the medium and long-term, churn rates will decrease for GSM, CDMA and TDMA due to:

- the bundling of other telecom services;
- convergence of retail tariffs between these systems and PCS; and

17 Source: OFTA
These effects are taken into account by decreasing the churn rate for GSM, CDMA and TDMA systems. We assume that:

- that there is a 36 per cent churn rate in the market (based on the views of operators), which reduces to 30 per cent to 2002 and 24 per cent by 2007. This is line with expected changes in churn rates in Europe;
- 80 per cent of all subscribers who leave one network will join another (inter-operator churn). This assumption is conservative since a mobile subscriber is unlikely to leave the market altogether until there is a superior substitute for mobile telephony.

It should be noted these forecast churn rates take into account the introduction of dual mode handsets in the Hong Kong mobile telecommunications market. In the absence of MNP, should a subscriber with a dual handset decide to switch operators within a system (ie GSM-GSM churn), he will not be able to take his old mobile number to the new operator and, therefore, this may discourage greater switching within a system. The ability to switch between PCS and GSM, however, is captured in the churn rate. It is likely that with the introduction of MNP there will be greater switching by mobile subscribers.

Churn rates for PCS operators are assumed constant at 24 per cent over the same period due to:

- the lower churn rates that PCS operators currently experience; and
- their tariff packages relative to other systems are expected to remain cheaper over the next ten years.

Thus churn rates for PCS will be lower than churn rates for other systems, but these differences will narrow, and finally converge, over time.

It should be noted that the switching model:

- takes into account differences in churn rates between different systems;
- captures those subscribers switching out of one technology into another. The model is, therefore, dynamic and all subscribers switching within the model are accounted for;
1.3.3. Approach and Results

Inter-operator churn is apportioned to each system, where inter-operator churn $r$ is:

$$\text{churn to another operator } r \times \sum_{k=1}^{4} \frac{\text{subst}_{k} - 1}{\text{substr} - 1}$$

where:

- $i$ is the mobile system
- $j$ is the alternate mobile system
- $k$ is:
  - all operators, for churn from PCS and GSM systems;
  - all operators other than $i$, for churn from CDMA and TDMA systems; and
- $t$ is end year of the forecast period.

This approach is also the one used to estimate inter-operator churn in the switching model with MNP.

Table A1.5 shows the switching forecast for each mobile system.
## Appendix 1. The Base Case

### Table A1.5

**Movement of Mobile Subscribers (millions)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PCS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCS-GSM</td>
<td>0.031</td>
<td>0.043</td>
<td>0.057</td>
<td>0.070</td>
<td>0.083</td>
<td>0.093</td>
<td>0.101</td>
<td>0.107</td>
<td>0.112</td>
<td>0.096</td>
<td>0.098</td>
<td>0.100</td>
</tr>
<tr>
<td>PCS-CDMA</td>
<td>0.008</td>
<td>0.011</td>
<td>0.015</td>
<td>0.018</td>
<td>0.021</td>
<td>0.024</td>
<td>0.026</td>
<td>0.028</td>
<td>0.029</td>
<td>0.025</td>
<td>0.025</td>
<td>0.026</td>
</tr>
<tr>
<td>PCS-TDMA</td>
<td>0.008</td>
<td>0.011</td>
<td>0.014</td>
<td>0.017</td>
<td>0.020</td>
<td>0.023</td>
<td>0.025</td>
<td>0.028</td>
<td>0.027</td>
<td>0.023</td>
<td>0.024</td>
<td>0.024</td>
</tr>
<tr>
<td>PCS-PCS</td>
<td>0.020</td>
<td>0.028</td>
<td>0.037</td>
<td>0.046</td>
<td>0.054</td>
<td>0.061</td>
<td>0.066</td>
<td>0.070</td>
<td>0.073</td>
<td>0.063</td>
<td>0.064</td>
<td>0.065</td>
</tr>
<tr>
<td><strong>GSM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSM-PCS</td>
<td>0.149</td>
<td>0.167</td>
<td>0.153</td>
<td>0.146</td>
<td>0.139</td>
<td>0.131</td>
<td>0.123</td>
<td>0.115</td>
<td>0.107</td>
<td>0.098</td>
<td>0.099</td>
<td>0.100</td>
</tr>
<tr>
<td>GSM-CDMA</td>
<td>0.059</td>
<td>0.066</td>
<td>0.061</td>
<td>0.058</td>
<td>0.055</td>
<td>0.052</td>
<td>0.049</td>
<td>0.046</td>
<td>0.042</td>
<td>0.039</td>
<td>0.039</td>
<td>0.040</td>
</tr>
<tr>
<td>GSM-TDMA</td>
<td>0.052</td>
<td>0.058</td>
<td>0.053</td>
<td>0.051</td>
<td>0.048</td>
<td>0.045</td>
<td>0.043</td>
<td>0.040</td>
<td>0.037</td>
<td>0.034</td>
<td>0.034</td>
<td>0.035</td>
</tr>
<tr>
<td>GSM-GSM</td>
<td>0.229</td>
<td>0.257</td>
<td>0.235</td>
<td>0.224</td>
<td>0.213</td>
<td>0.201</td>
<td>0.190</td>
<td>0.177</td>
<td>0.164</td>
<td>0.151</td>
<td>0.152</td>
<td>0.154</td>
</tr>
<tr>
<td><strong>CDMA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDMA-PCS</td>
<td>0.034</td>
<td>0.039</td>
<td>0.041</td>
<td>0.041</td>
<td>0.040</td>
<td>0.038</td>
<td>0.036</td>
<td>0.034</td>
<td>0.031</td>
<td>0.029</td>
<td>0.029</td>
<td>0.029</td>
</tr>
<tr>
<td>CDMA-GSM</td>
<td>0.053</td>
<td>0.060</td>
<td>0.063</td>
<td>0.061</td>
<td>0.058</td>
<td>0.055</td>
<td>0.052</td>
<td>0.048</td>
<td>0.044</td>
<td>0.045</td>
<td>0.045</td>
<td>0.045</td>
</tr>
<tr>
<td>CDMA-TDMA</td>
<td>0.012</td>
<td>0.013</td>
<td>0.014</td>
<td>0.014</td>
<td>0.014</td>
<td>0.014</td>
<td>0.014</td>
<td>0.013</td>
<td>0.012</td>
<td>0.011</td>
<td>0.010</td>
<td>0.010</td>
</tr>
<tr>
<td><strong>TDMA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDMA-PCS</td>
<td>0.035</td>
<td>0.037</td>
<td>0.037</td>
<td>0.036</td>
<td>0.035</td>
<td>0.033</td>
<td>0.031</td>
<td>0.029</td>
<td>0.027</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>TDMA-GSM</td>
<td>0.054</td>
<td>0.057</td>
<td>0.057</td>
<td>0.056</td>
<td>0.053</td>
<td>0.051</td>
<td>0.048</td>
<td>0.045</td>
<td>0.041</td>
<td>0.038</td>
<td>0.038</td>
<td>0.039</td>
</tr>
<tr>
<td>TDMA-CDMA</td>
<td>0.014</td>
<td>0.015</td>
<td>0.015</td>
<td>0.014</td>
<td>0.014</td>
<td>0.014</td>
<td>0.013</td>
<td>0.012</td>
<td>0.011</td>
<td>0.010</td>
<td>0.010</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Source: NERA estimates
1.4. Forecast Revenue Per Subscriber

Based on discussions with the industry, we expect average revenue per subscriber (for the market as a whole) to decrease over the next ten years. Increased competition, especially since the launch of PCS services, will result in reduced tariff rates and an increasing number of low volume users. These forecasts of revenues per subscriber are inputs into the calculation of benefits of MNP. Our survey results indicate that the switching behaviour of business users (SMEs and corporate) will not be affected by MNP.\textsuperscript{18} As a result, we focus on revenue per subscriber for personal users.

GSM operators are expected to respond to the challenge of lower tariff packages offered by PCS by offering lower tariffs to their subscribers. They are, however, expected to cushion the impact of this trend on profits by:

- providing more value added services to increase usage;
- increasing international roaming revenues; and
- introducing new service offerings, such as wireless data communications and bundled paging services.

As a result, GSM operators are likely to experience a decrease in revenue per subscriber over time. However, others systems are expected to remain cheaper than GSM, although the price differential is expected to narrow (Table A1.6)

TDMA is expected to experience a decrease in calling rates and, therefore, revenue per subscriber.

In contrast, revenue per subscriber for PCS is expected to increase, albeit slightly, over the same period. This reflects the fact that:

- current special deals offered by PCS operators will be discontinued this year; and
- calling rates for PCS are expected to increase (based on discussions with the industry).

Based on current revenue per subscriber for CDMA, it is likely to be system that competes with PCS on price. Hence, revenue per subscriber for CDMA is also expected to rise, albeit slightly, until 2006 and, subsequently converge to PCS levels by 2007.

\textsuperscript{18} Results from the user survey reveal that business users require the same discount to switch operators with MNP as they do without it.
Table A1.6
Forecast Revenue Per Subscriber - by System (HK$ per month)

<table>
<thead>
<tr>
<th>System</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM</td>
<td>550</td>
<td>525</td>
<td>500</td>
<td>500</td>
<td>480</td>
<td>460</td>
<td>440</td>
<td>420</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>PCS</td>
<td>300</td>
<td>310</td>
<td>320</td>
<td>335</td>
<td>335</td>
<td>335</td>
<td>340</td>
<td>340</td>
<td>350</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>CDMA</td>
<td>330</td>
<td>340</td>
<td>350</td>
<td>370</td>
<td>370</td>
<td>370</td>
<td>375</td>
<td>375</td>
<td>350</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>TDMA</td>
<td>440</td>
<td>420</td>
<td>400</td>
<td>400</td>
<td>385</td>
<td>370</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
</tr>
</tbody>
</table>

Source: NERA estimates
APPENDIX 2. SWITCHING MODEL WITH MNP

2.1. Introduction

This appendix discusses the development of the Hong Kong mobile telecommunications market over the next ten years if mobile number portability is introduced. The number of subscribers who switch will increase due to MNP because it enables subscribers to retain their mobile telephone numbers.

The next section discusses our approach to forecasting subscribers by system. For switching, the approach is similar to that used for the Base Case. There are differences in some of our assumptions with MNP and these are discussed in Section 2.3. Results of the switching model, including different scenarios and sensitivity analyses, are presented in Section 2.4.

2.2. Forecasting Subscribers by System

As discussed in Appendix 1, the introduction of MNP will not affect the size of the total mobile market but will have an impact on how that market is divided up between the different systems. We take this into account when we make assumptions on mobile penetration by system in the MNP scenario (Table A2.1).

<table>
<thead>
<tr>
<th>Year</th>
<th>GSM (%)</th>
<th>PCS (%)</th>
<th>CDMA (%)</th>
<th>TDMA (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>0.0</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1997</td>
<td>20.6</td>
<td>3.7</td>
<td>3.8</td>
<td>4.1</td>
<td>32.1</td>
</tr>
<tr>
<td>2002</td>
<td>23.0</td>
<td>14.0</td>
<td>7.0</td>
<td>6.0</td>
<td>50.0</td>
</tr>
<tr>
<td>2007</td>
<td>24.0</td>
<td>19.2</td>
<td>9.0</td>
<td>7.8</td>
<td>60.0</td>
</tr>
<tr>
<td>2009</td>
<td>24.0</td>
<td>19.2</td>
<td>9.0</td>
<td>7.8</td>
<td>60.0</td>
</tr>
</tbody>
</table>

Source: NERA estimates

With MNP, it is expected that GSM, being the most expensive system and the system experiencing higher levels of churn, will have a lower penetration rate than without MNP.

The methodology used to forecast subscribers by type of system is similar to that used for the Base Case (see Appendix 1). Table A2.2 shows the results obtained by fitting the logistic curve to the assumptions on penetration rates by mobile system. Subscribers numbers by 2009 are estimated as follows:

- 1.8 million for GSM;
- 1.5 million for PCS;
- about 0.7 million for CDMA; and
around 0.6 million for TDMA.

Table A2.2
Expected Mobile Subscribers with MNP - by System (mn)

<table>
<thead>
<tr>
<th>Year</th>
<th>GSM Pen (%)</th>
<th>GSM Subs(mn)</th>
<th>PCS Pen (%)</th>
<th>PCS Subs(mn)</th>
<th>CDMA Pen (%)</th>
<th>CDMA Subs(mn)</th>
<th>TDMA Pen (%)</th>
<th>TDMA Subs(mn)</th>
</tr>
</thead>
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<td>0.35</td>
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<td>7%</td>
<td>0.47</td>
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<td>2002</td>
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<td>14%</td>
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<td>0.52</td>
<td>7%</td>
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<td>24%</td>
<td>1.67</td>
<td>16%</td>
<td>1.12</td>
<td>8%</td>
<td>0.56</td>
<td>7%</td>
<td>0.49</td>
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<tr>
<td>2004</td>
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<td>1.69</td>
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<td>18%</td>
<td>1.31</td>
<td>8%</td>
<td>0.62</td>
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<tr>
<td>2006</td>
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<td>1.73</td>
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<td>0.64</td>
<td>7%</td>
<td>0.53</td>
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<tr>
<td>2007</td>
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<td>1.75</td>
<td>19%</td>
<td>1.41</td>
<td>9%</td>
<td>0.65</td>
<td>7%</td>
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<tr>
<td>2008</td>
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<td>1.77</td>
<td>19%</td>
<td>1.45</td>
<td>9%</td>
<td>0.66</td>
<td>7%</td>
<td>0.55</td>
</tr>
<tr>
<td>2009</td>
<td>24%</td>
<td>1.79</td>
<td>19%</td>
<td>1.48</td>
<td>9%</td>
<td>0.68</td>
<td>7%</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Source: NERA estimates

Figure A2.1 shows the forecast growth of mobile users over the next ten years by system, assuming the introduction of MNP.
2.3. Assumptions

The switching model changes with the introduction of MNP, the main consequence being an increase in the churn rate.

Churn rates after the introduction of MNP are expected to increase by an extra 10-20 per cent. This is based on the views of the operators, who expect an increase in churn of about 10-20 percent.

We carried out sensitivity analyses on the extra churn with MNP: high churn (20 per cent), medium churn (15 per cent) and low churn (10 per cent).

In addition, not all Type A subscribers (those who would switch without MNP) port their numbers. It is expected that about 10-15 per cent of subscribers switching systems will port in 1999; 35-40 per cent by 2002; and between 70-90 per cent by 2007. Sensitivity analysis has been carried out on the porting rate.

The main reason why not all switches will port is that not all subscribers who switch will be aware of the availability of MNP. As with all new services, there is a learning process for users and the number of subscribers switching who port will increase over time. Also some subscribers actually want to change their number.

In contrast, it is axiomatic that all subscribers who switch because of the introduction of MNP (Type B) will port their number.
The number of subscribers switching systems given MNP has been estimated for different starting dates for MNP. Three possible scenarios are modelled:

- Optimistic - MNP introduced in January 1999;
- Realistic - MNP introduced in June 1999;
- Pessimistic - MNP introduced in January 2000.

2.4. Results

Information derived from the Base Case switching model and the switching model with MNP are used to calculate the numbers of Type A & B mobile subscribers, that are used in the cost-benefit analysis. The forecast numbers of Type A & B subscribers are shown in Table A2.3.

Table A2.4 shows the number of Type A subscribers who port their numbers. The ranges shown reflect the results of the sensitivity analyses on the porting rate for Type A subscribers. The porting rate does not influence the number of Type B subscribers since, by definition, all of them port their numbers.
### Table A2.3
Type A and Type B Subscribers

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
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<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A (mn)</td>
<td>0.863</td>
<td>0.850</td>
<td>0.854</td>
<td>0.849</td>
<td>0.840</td>
<td>0.818</td>
<td>0.7803</td>
<td>0.759</td>
<td>0.684</td>
<td>0.694</td>
<td>0.703</td>
</tr>
<tr>
<td>Type B (mn)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pessimistic</td>
<td>0.016</td>
<td>0.313</td>
<td>0.362</td>
<td>0.406</td>
<td>0.440</td>
<td>0.467</td>
<td>0.484</td>
<td>0.496</td>
<td>0.545</td>
<td>0.550</td>
<td>0.566</td>
</tr>
<tr>
<td>Realistic</td>
<td>0.204</td>
<td>0.452</td>
<td>0.514</td>
<td>0.569</td>
<td>0.613</td>
<td>0.649</td>
<td>0.671</td>
<td>0.688</td>
<td>0.741</td>
<td>0.756</td>
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<tr>
<td>Optimistic</td>
<td>0.517</td>
<td>0.591</td>
<td>0.666</td>
<td>0.733</td>
<td>0.787</td>
<td>0.830</td>
<td>0.858</td>
<td>0.880</td>
<td>0.937</td>
<td>0.955</td>
<td>0.971</td>
</tr>
</tbody>
</table>

Source: NERA estimates

### Table A2.4
Type A Porting Subscribers

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
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<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A (mn)</td>
<td>0.086-0.129</td>
<td>0.128-0.170</td>
<td>0.256</td>
<td>0.297-0.339</td>
<td>0.335-0.418</td>
<td>0.368-0.491</td>
<td>0.395-0.553</td>
<td>0.418-0.608</td>
<td>0.410-0.615</td>
<td>0.451-0.624</td>
<td>0.492-0.638</td>
</tr>
</tbody>
</table>

Source: NERA estimates

Note: The lower and upper bounds are determined by low and high porting rates, respectively.
3.1. Introduction

This section describes the telecommunications environment in Hong Kong including arrangements for interconnection between fixed telecommunications networks, mobile telecommunications operators and pager operators. The section also includes a description of the method of implementing Fixed Number Portability (FNP).

3.2. Network Architecture

Following liberalisation of the local-loop market in 1995, three new operators were allowed to offer alternative local-loop access networks to HKT's (Hong Kong Telecom) network. These new operators were not allowed to offer international services, nor were they allowed to provide leased-line services. HKTC was divided into two entities:

- HKTC (Hong Kong Telephone Company Limited) responsible for the provision of local-loop services, leased lines, interconnection services, and having a Universal Service Obligation;

- HKTI (Hong Kong Telecom International Limited), responsible for providing interconnection to international networks via its International Switching Centres (ISC).

Figure 3.1 represents a schematic diagram of the interconnection arrangements in Hong Kong.
The mobile operators currently transfer most of their traffic via E1 links to the HKTC network, though there is a limited amount of inter-mobile network connection, particularly between networks owned by a single operator. Though most operators have considered further interconnection, few concrete plans are in place, with operators quoting lack of inter-mobile network traffic and contractual difficulties as key blocking factors.

HKTC provides links to the mobile operators' switching frames and charges interconnection rates that are determined by OFTA and are currently 6.7 cents per minute. Alternatively, leased lines could be installed between two mobile operators' networks at an operating cost of $11 000 per month. Currently direct interconnection exists between networks owned by the same operator (e.g., between Hutchison Telecom's IS-95, GSM, PCS and fixed networks, and between New World PCS and New World Telephone's networks).

The signalling system used throughout the Hong Kong networks is ISUP, although for the interconnection between the D-AMPS system operated by Pacific Link and HKTI's network, R1 signalling is used, which does not support CLI transfer functionality. Currently HKTC is not able to offer SCCP-transit functionality.

In January 1998, the Government came to an agreement with HKT for the early surrender of HKTI's exclusive license to provide international services. Service-based competition will begin in January 1999, followed by liberalisation of infrastructure in January 2000.

The mobile marketplace is very volatile at the moment with Pacific Link having been recently acquired by CSL, and further market consolidation and shake-out is expected.
will be very difficult to predict the structure of the mobile market over the next ten years, which may have significant impact on the roll-out and cost of implementing and developing MNP functionality.

3.3. Fixed number portability in Hong Kong

Fixed number portability was implemented in Hong Kong in July 1995. For the first 18 months of operation - the time needed to develop the database solution including agreement on the method for notifying all parties of ported numbers and installation and testing of hardware - a call-forwarding solution was used, before migrating to the current distributed database implementation. The interim call-forward solution operation allowed procedural and OSS changes to be made in conjunction with a relatively simple switching solution.

Figure 3.2 and Figure 3.3 illustrate the operation of the database look up in HKTC's network for calls to subscribers porting into and out of the network respectively. Calls to numbers that have been ported from HKTC's local switches are re-routed via the ICG using a gateway number retrieved from a database held locally on the switch. All other calls passing out of HKTC's network, via the ICGs, cause a database look up to be performed using IN technology. The solution is implemented in slightly varying ways in each of the alternative fixed network operators' networks.

DN represent the actual Dialled Number string of the porting subscriber, and NN represents the Network Number, a 9-10-digit network address format designed for use within Hong Kong's telecommunications networks.

Figure 3.2:
Fixed number portability by database solution: calls to subscriber porting away from HKTC

Figure 3.3:
Fixed number portability by database solution: i) calls to subscribers porting between two other fixed operators ii) calls to subscribers porting into HKTC's network
The databases of the four fixed network operators are kept updated by means of electronic messages passed via a dedicated network system linking the operators' operational support systems known as the Administration Database (AD) system, which has been developed as a proprietary system for Hong Kong. Porting customers are cut over at mid-night each day. The four databases are compared once a month to ensure that synchronisation has been maintained.

3.4. Network technologies

3.4.1. Introduction

This section describes the technologies used by the mobile operators of Hong Kong, and their implications for MNP solutions. For each technology, the history of the technology is given and any special features associated with technology are highlighted.

3.4.2. GSM

Global System for Mobile communications (GSM) is a standard for digital cellular telephony developed in Europe by ETSI as a second generation offering to supersede the plethora of incompatible analogue networks in use throughout Europe. The standard was agreed in 1989, and early systems rolled out in 1990.

The system has become extremely popular world-wide, dominating the European market, and having made significant inroads into North and South American, Asian and Australasian markets. As a result of this popularity, the system has been highly developed to offer many supplementary services culminating in the latest tranch of features included in the phase 2+ features.
Appendix 3  Telecommunications Environment in Hong Kong

The air interface operates in the 800-900MHz band, and utilises a TDMA structure with 200kHz channel widths.

Hardware for the system is manufactured by most major telecommunications manufacturers, but the market in Hong Kong is dominated by Ericsson, Nokia and Nortel. Currently the system offers only voice and circuit switched data bearers, though plans are under development for the implementation of a packet relay service.

3.4.3. PCS

Personal Communication System (PCS) is a derivative of the GSM standard operating the 1800 and 1900MHz bands, in response to market demand for greater capacity in countries supporting GSM networks. Such systems are being rapidly rolled out around the world.

Though having a shorter air interface range than the lower frequency GSM system, the switching systems of the PCS networks are identical to those of GSM networks and will therefore be considered synonymous for the remainder of the study.

3.4.4. IS-95 (CDMA)

IS-95 is a standard for a second generation digital cellular system, and is the first mass market cellular system to utilise a Code Division Multiple Access (CDMA) air interface. The system is built by a variety of manufacturers including Motorola and Siemens under license to its developers, Qualcomm, and is used in other applications such as wireless local loop products.

Several companies involved in the development of CDMA products and services have formed the CDMA Development Group (CDG), which was officially announced in 1994 and now has approximately 100 member companies including network equipment manufacturers, subscriber unit manufacturers, cellular and PCS operators and test equipment manufacturers. Motorola is the dominant IS-95 network equipment manufacturer. In 1996 CDG membership included 12 network equipment manufacturers and 27 cellular and PCS operators.

IS-95 is a direct competitor to GSM for the worldwide second generation market, and is enjoying success in the US and the Asia-Pacific regions, though its late arrival on the market means that fewer features have been developed for it than have been for GSM and uptake has been less rapid. Hutchison’s Hong-Kong system was the first to become operational worldwide in 1995.

3.4.5. IS-136 (D-AMPS)

The Advanced Mobile Phone System (AMPS) is an analogue cellular mobile phone system, capable of operating in the 800 MHz band, which has been developed to include a digital air interface, and is operated in the 800 MHz band in Hong Kong.
The system utilises Time Division Multiple Access (TDMA) and uses 20kHz channels and is now a mature system offering an upgrade route for those networks which already contain IS-54 AMPS. D-AMPS is particularly strong in the range of business communication services.

D-AMPS is the only global wireless standard that today can support packet data and circuit-switched voice traffic in the same network infrastructure, and offering voice and data simultaneously.

The system is widely used in the USA. In particular use is made of the A, B and C frequency bands (low 800MHz, upper 800MHz and 1.9GHz respectively), and is a dual-band/dual-mode 800/1900 MHz standard offer full national and international roaming as well as feature transparency.

D-AMPS is widely operated in more than 34 countries throughout the globe with 4 million subscribers at the end of 1996 in a variety of markets. D-AMPS is therefore a 'near de-facto' standard like GSM, its major competitor.

3.4.6. TACS

Total Access Communications System (TACS) is a derivative of the US AMPS standard, the major modifications being the adaptation of the system to the European channel spacing of 25 kHz, and the provision of better support for national deployment, rather than the metropolitan deployment which is typical in the USA. TACS is an analogue cellular mobile phone system, operating in the 900 MHz band.

The TACS system was the first mass market cellular system in the UK, and the first services launched in 1985. As well as the two systems operated by Cellnet and Vodafone in the UK, the system is deployed in a limited number of areas in Europe (namely Ireland, Italy, Malta, Spain) and beyond (eg Gabon, Kuwait, Macau, Mauritius, Nigeria, Sri Lanka, Tanzania). With the exception of the networks in Italy and Spain, the numbers of subscribers in each of the countries is relatively low (ie 150,000 or less).

Only one TACS network remains in operation in Hong Kong, but with its imminent decommissioning, the technology remains outside the scope of MNP, and therefore will not be considered further.
Feasibility study & cost benefit analysis of number portability for mobile services in Hong Kong: a preliminary report for

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