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# Modeling the Steering of International Roaming Traffic

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ABSTRACT

Telecommunications operators offering international roaming services need to decide to which foreign networks they should steer their customers towards, in order to benefit from the best wholesale commercial conditions. This operational managerial decision translates into a least-cost traffic routing problem for which five mixed integer linear programming models, corresponding to the most used commercial agreements in the industry, are hereby introduced. The models are based on a minimum cost flow problem over a layered network following an underlying year-planning managerial approach, with multi-period decision dependency and in the presence of uncertainty. A computational experiment is carried out using a comprehensive framework designed to generate structured semi-random instances that simulate realistic market and business scenarios. Results for this experiment are discussed according to business sustainability performance metrics and confirm the soundness of the models. Given the nature of the problem we consider that the computational effort required is low.



## 1. Introduction

Telecoms operators are able to provide service to their customers outside their own network coverage area through the establishment of technical and commercial contracts with other operators. When these operators are located abroad, the contracts are named International Roaming Agreements (IRA). The governing body of the sector, the GSM Association (GSMA), defines roaming as a service that "enables a mobile subscriber to automatically make and receive voice calls, send and receive data, or access other services when travelling outside the geographical coverage area of their home network, by means of using a visited network" (GSM Association (2015)). Given the usual bilateral nature of the IRA, they serve two purposes, from the perspective of the home or planning operator: providing international coverage to its clients, whereby these customers use the operator's international partners networks; and offering coverage to the clients of its international partners when they visit the operator's country by the use of the operator's network. In the first case, named *roaming out*, or *outbound roaming*, the usage of foreign networks by the customers of the home operator originates wholesale costs to the operator, whereas in the second case, known as *roaming in*, or *inbound roaming*, the usage of its network by the customers of its international partners generates wholesale revenues.

Operators are interested in establishing IRA with multiple operators in every foreign country. This way they are able to provide the best international coverage possible for their customers, and, simultaneously, increase their sources of revenue. However, the home operator then faces a managerial problem: given that each IRA has its own commercial conditions, the operator has to decide to which foreign operators it should steer its *roaming out* traffic, in order to maximize its wholesale roaming service margin.

This paper is dedicated to the study of the Steering of International Roaming Traffic (SIRT) problem formulated as an optimization problem, and is organized as follows: a detailed description of the problem and its place in the literature are presented, respectively, in Sections 2 and 3; Section 4 introduces the operational research models and procedures developed; in Section 5 results from the computational experiment performed are reported and, finally, main conclusions and leads for future work are presented in Section 6.

## 2. The decision problem

### 2.1. Traffic steering

Until the early 2000s, the capability of an operator to decide which foreign network(s) would be used by its *roaming out* customers, and in what proportion, was somewhat limited.

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Traditionally, when a roaming customer arrived at a destination country, its mobile handset would pick up and register on the network with the strongest radio signal. Today, benefiting from technical developments, usually involving radio traffic signaling management over the IMSI (International Mobile Subscriber Identity) provisioned in the customer's SIM card, operators have considerable control over which foreign networks are used by their roaming customers, and to what extent.

Through profiling and segmentation of customers, it is possible to establish certain usage patterns per segments of clients that allow operators to associate a given number of customers to a certain amount of traffic generated by them. As a result, the steering of roaming customers has a direct correspondence to the steering of roaming traffic. Notice that this traffic is perceived as being sent, by the home operator, towards the network of a roaming partner, when in fact it is generated in that network by the customers of the home operator. The SIRT problem has an operational nature in the sense that it assumes that strategical and/or tactical decisions, such as the number of agreements in place, their types and commercial terms have been determined beforehand.

### 2.2. Commercial terms

With the greater level of control over network selection, the industry witnessed an increase in the degree of competition in the wholesale roaming service. Operators started looking for better commercial conditions and thus diverse types of commercial agreements were developed. The basic feature of all IRA is the offer of lower prices in exchange for higher volumes of traffic. Apart from that, each type of commercial agreement has its own distinctive characteristics. Volume-price tiers are frequently used to set the commercial conditions. The first tier establishes a certain unit price to be charged for traffic within a certain volume range. The following tiers define decreasingly lower unit prices for increasingly higher volume ranges.

In the type of agreements known as Quantity agreements (QNT) the home operator is charged a single price according to the volume-price tier reached by its total *roaming out* traffic volume.

Alternatively, in the type of agreements named Incremental (INC), total traffic is segmentally charged at more than one unit price. In this case, the volume ranges of all tiers start at zero and are considered cumulatively (or incrementally). Volume tiers are successively filled, starting from the one with the highest price, until all traffic sent by the home operator is distributed by the tiers. Each slice of the total traffic is charged according to the unit price of its tier.

Another type of commercial practice is known as the Send-or-Pay (SOP) commitment clause. This can exist either on top of a QNT (Q_SOP) or an INC (I_SOP) agreement, and it establishes a minimum amount of traffic that has to be sent by the home to the visited operator or, otherwise, paid just the same, at a given unit price. This clause guarantees a minimum level of business between operators, acting as a penalty in case the volume objective is not met. If the total traffic exceeds the SOP commitment, it is charged according to the respective volume-price tier of the Quantity or Incremental agreement.

A different concept is used in the Balanced-Unbalanced (BUB) type of agreements. Unlike the previous types of agreements, which can be established just for one of the traffic streams - *roaming in* or *roaming out* -, in this case the agreements have a mandatory bilateral nature. This is due to the fact that the relevant volume reference for the price is defined by the lowest volume of traffic one of the operators, home or visited, sends to the other. The operator that sends more traffic than it receives benefits from a lower price applicable to the share of excess (unbalanced) traffic, while both operators pay the volume of equal (balanced) traffic at a higher price.

These five types of agreements - QNT, INC, Q_SOP, I_SOP, and BUB - correspond to the most-used commercial contracts in the industry, and they are modeled in the next section.

### 2.3. Scope of decision

Most operators are part of some international group or alliance of operators that share the same commercial agreements. Moreover, commercial conditions are not defined individually for the volume of traffic sent to each operator of the group. Instead, it is the sum of the volume of traffic sent to all operators, in different countries, that are members of the same group, that will determine the price applicable to each one of them. Accordingly, traffic steering decisions cannot be taken country by country. The home operator needs to consider to which group each destination operator belongs to.

That interdependency of traffic between countries means that, ultimately, the scope of the decision is not per country but, save for countries with no operators belonging to international groups, for the whole *roaming out* traffic of the home operator.

### 2.4. Period of decision

The typical reference period for a mobile telecoms company, concerning the wholesale roaming service, is one full year. IRA commercial conditions associate the applicable price(s) with the annual volume of traffic. However, the home operator does not know beforehand how much traffic there will be for each country since the annual volume of *roaming out* traffic actually sent to each country is generated all throughout the year by its customers. In absence of precise information, the operator makes and implements its traffic routing decisions based on forecast information and in view of the yearly targets.

As can be expected, actual traffic registered along the year often differs from the forecast. In order to achieve their year-end targets, operators usually revise their traffic steering decisions throughout the year using the most up-to-date information. If necessary, adjustments to those decisions are regularly made. Depending on the importance of each destination in terms of business volume, this recurrence may be quarterly, monthly, or even weekly. Naturally, revised steering decisions only apply to traffic of the coming periods. Subsequently, if, on the one hand, the home operator is able to adjust its steering decisions throughout the year, on the other hand, it will only know with complete certainty the total volume of its *roaming out* traffic to each country, and therefore the applicable price, at the end of the year. This associates a considerable level of uncertainty to the steering decision.

To conclude, it is possible to sum up the SIRT problem as follows: given a certain amount of *roaming out* forecast traffic to each destination country, and the commercial agreements in place with its operators, decide, at any chosen moment of the year, what is the traffic distribution per operator that maximizes the wholesale roaming service margin of the home operator at the end of a one year period. The home operator is considered as a single operator, i.e. not part of a group of operators. The decision is taken for the year's forthcoming traffic, knowing there is an interdependency of traffic sent to operators of different countries and that actual traffic may differ from forecast traffic based on which the steering decisions are taken.

## 3. Literature review

Literature on the telecommunications sector is abundant, namely in the engineering field, from broader scope studies, such

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