Cost Models for Telecommunication Networks and Their Application to GSM Systems

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INTRODUCTION

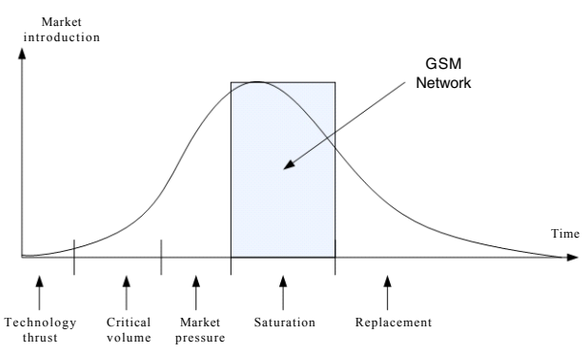
Currently mobile networks are one of the key issues in the information society. The use of cellular phones has been broadly extended since the middle 1990s, in Europe mainly with the GSM (Global System for Mobile Communication) system, and in the United States (U.S.) with the IS-54 system. The technologies on which these systems are based, Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) are completely developed, the networks are completely deployed and the business models are almost exhausted[1] (Garrese, 2003). Therefore, these systems are in the saturation stage if we consider the network life cycle described by Ward, which is shown in Figure 1.

At this stage, it is possible to assume that all work is over in this field. However, in this time stage there are new critical problems, mainly related with network interconnection, regulation pricing and accounting.

These types of questions are quite similar to the regulatory issues in fixed networks in the fields of Public Switched Telephone Network (PSTN), Integrated Service Data Network (ISDN) and Digital Subscriber Line (DSL) access. In the European environment, there is an important tradition in these regulatory issues, mainly produced by the extinction of the old state-dominant network operators and market liberalization. National Regulatory Authorities (NRAs) give priority to guarantee the free competition through different strategic policies that apply mainly to the following topics:

- **Interconnection and call termination prices:** The most common situation is a call originated in the network of operator A, and terminates in a customer of another network operator, B. There are other scenarios, like transit interconnection, where a call is originated and terminated in the network of operator A but has to be routed through the network of operator B. In any case, the first operator has to pay some charge to the second one for using its network. The establishment of a fair charge is one of the key points of regulatory policies.
- **Universal service tariffs:** In most countries, the state incumbent operator had a monopolistic advantage; hence, the prices were established by a mixture of historical costs and political issues. Currently, with market liberalization and the entry of new operators, these tariffs must be strictly observed to avoid unfair practices.

Figure 1. Network life cycle (Source Ward, 1991)



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- **Retail and wholesale services (customer access):** This situation deals mainly with the local loop; that is, the final access to the customer. An example is when a network operator offers physical access to the customer—the copper line in DSL access, and an Internet Service Provider (ISP) offers the Internet access.

The establishment of these prices, tariffs and other issues related with the regulatory activities requires defining cost methodologies to provide an objective framework.

The following sections present different cost methodologies applied in telecommunication networks. Furthermore, a specific model named *Forward-Looking Long-Run Incremental Cost (FL-LRIC)* is deeper studied. Finally, the FL-LRIC model is applied to the specific case of the GSM mobile network.

COST METHODOLOGIES

Cost methodologies must ensure that prices led to profitability, or that they at least cover the proper costs (cost-based prices). A fundamental difficulty in defining cost-based pricing is that different services usually use common network elements. A large part of the total cost is a common cost; hence, it is difficult to divide the different services. The cost-based prices must perform three conditions (Courcoubetis, 2003):

- **Subsidy free prices:** each customer has to pay only for its service.

Figure 2. Bottom-up approach

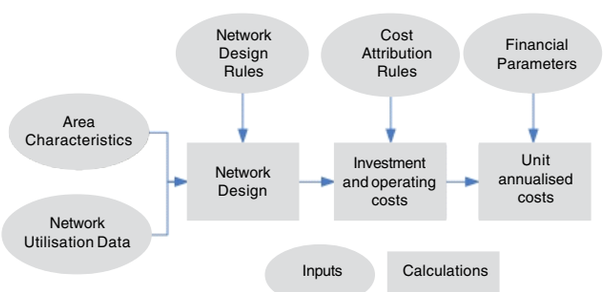
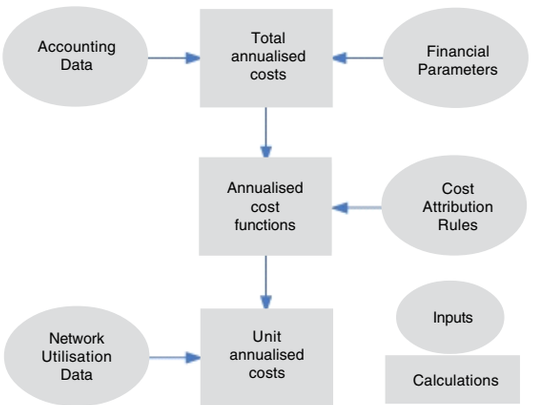


Figure 3. Top-down approach



- **Sustainable prices:** prices should be defensive against competition.
- **Welfare maximization:** prices should ensure the social welfare maximization.

Note that the three conditions could be mutually incompatible. The aim of welfare maximization may be in conflict with the others, restricting the feasible set of operating points. Several methods (Mitchell, 1991; Osborne, 1994) have been developed for the cost-based prices calculation, but they have practical restrictions; that is, the ignorance of complete cost functions. This article presents a set of practical methods for the calculation of the cost of services that fulfill the conditions mentioned.

In practice, the main problem is the distribution of common costs between services. Usually only a small part of the total cost is comprised of factors that can be attributed to a single service. The common costs are calculated, subtracting the cost imputable to each service to the total cost. There are two alternatives for the calculation of the common cost: top-down and bottom-up (see Figures 2 and 3, respectively).

In the bottom-up approach, each cost element is computed using a model of the most efficient facility specialized in the production of the single service, considering the most efficient current technology. Thus, we construct the individual cost building models of fictitious facilities that produce just one of these services. The top-down approach starts from

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