# Customers' Perception Towards Services of Telecommunications Operators

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## ABSTRACT

Currently the operators in the telecommunications market present offers of subscription to the consumers, and given that competition is strong in this area, most of these advertising offers are prepared to attract and / or keep customers.

For this reason, customers face problems in choosing operators that meet their needs in terms of price, quality of service (QoS), etc..., while taking into account the margin between what is advertising and what is real. Therefore, we are led to solve a problem of decision support. Mathematical modeling of this problem led to the solution of an inverse problem. Specifi-cally, the inverse problem is to find the real Quality of Service (QoS) function knowing the theoretical QoS. To solve this problem we have reformulated in an optimization problem of minimizing the difference between the real quality of service (QoS) and theoretical (QoS). This model will help customers who seek to know the degree of sincerity of Their operators, as well as it is an opportunity for operators who want to maintain their resources so that they gain the trust of customers. The resulting optimization problem is solved using evolutionary algorithms. The numerical results showed the reliability and credibility of our inverse model and the performance and effectiveness of our approach

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## 1. INTRODUCTION

Privatization and liberation services in telecommunications in many countries lead to a diversification of operators; for example in Morocco, after the validation of the law 24-96 in 1997, a number of operators were able to take their place in the Moroccan market as Orange TELECOM, MOROCCO TELECOM and INWI. This diversity leads to strong competition between them, each of which tries to attract and / or retain customers. Since SP s do not give true information about their systems (client confusion), customers do not have complete information to make a good decision. This confusion present an obstacle to customers to have all the information on the operator's offer. So customer choice is often uncertain (bounded rationality).

The problems related to the choice of an operator is on several parameters including: real quality of service, theoretica service quality, bandwidth, price, ... Operators decide a price and QoS for services offered to its customers.

QoS proposed remains a parameter that depends on other variables namely bandwidth, the share of this market operator. In these circumstances an operator can never guarantee the quality of service it promises to customers. We call it then theoretical QoS, while the QoS perceived by customers is the actual QoS.

In the telecommunications market, the credibility of each operator is measured by the difference between its theoretical QoS and the real QoS. A customer is interested in the recognition of SP with good credibility (which has a real QoS close to the theoretical QoS). And as there is no real QoS to operators can not solve this problem in a direct way. Hence this kind of problem can be modelled within the meaning of the inverse problem.

The inverse problem is generally ill-posed problem, on the contrary live with the direct problem that the solution exists, is unique and depends on data. For example, if it is to reconstruct the past state of a system knowing its current state, we are dealing with an inverse problem; but the fact of predicting the future state given the current state is a direct problem. Similarly, in the case of a determination of parameters of a system knowing a part of the stage (a part of the set of parameters); we speak of parameter identification problems.

To my knowledge, there are no previous studies on this problem of rational choice of service providers (SP s) in the telecommunications market. Studies that have been conducted on the relationship between customers and SP S. Our work is part of the relationship between customers and SP s, it is based on the paper [3] whose authors used the theory of games to analyze the competition between the SP s. Several studies have been carried out, by way of example ([9], [4]), which modeled the behavior of customers in the current competition between the SP s in the telecommunications market. The migration of customers in this market is modeled as a Markov chain. The studies were based on the (theoretical) advertising strategies of SP s, which leaves consumers confused since they have no idea about the real strategies of SP s.

The rest of the paper is organized as follows. In Section 2., we present modeling problematic in the sense of inverse problems. In Section 3., We present the algorithm that we used to solve the optimization models proposed in this study. In Section 4., we present the different numerical results obtained. In Section 5., we conclude the paper.

# 2. FORMULATION AND MODELING OF THE PROBLEM

In this section, we model the profit of a customer if he chooses to subscribe in the SPi and we use the Luce model to mathematise the discrete choice of clients by exploiting the softmax function or the normalized exponential function [12], as in the article [11].

#### 2.1. Model of Utility Customers

The benefit of a consumer is often calculated based on the strategies of its operator, which are the QoS and the price it offers. The profit ui of a consumer registers with the operator's services SPi is as follows:

$$u_i(q_i, p_i) = \alpha q_i - p_i \tag{1}$$

With  $q_i$  is a client's revenue if he chooses the SP<sub>i</sub> and > 0.

#### **2.2.** The Luce Model

The Luce model is a first probabilistic choice model that incorporates boundedly rational choice of customers[1]-[2]. With this model, customers can choose the operator that will maximize profits by choosing one that has the max-imum probability; but forcing this choice is inadequate in this area given the existence of hidden information that has not been represented in this model. The following equation represents the probability that the customer chooses SP<sub>i</sub>:

$$\rho_i(\mathbf{p}, \mathbf{q}) = \frac{\mathrm{e}^{\frac{\mathbf{u}_i}{\lambda}}}{\sum\limits_{j=1}^{N} \mathrm{e}^{\frac{\mathbf{u}_j}{\lambda}}}$$
(2)

with 2 [0; 1] is the degree of customer irrationality, N is the number of SP s and p and q are respectively the vector of price and QoS.

When tends to 0, means that customer behavior is rational, i.e., they have all the information and rules that allow them to maximize their profit, while customers are irrational when approaches 1.

# 2.3. Demand model Di

We consider a market size n (the total number of customers), the function of the application to the operator's services i, Di is the probability that a customer selects the operator multiplied by the size, n, of the market. It is expressed by:

$$D_i(\mathbf{p}, \mathbf{q}) = n \cdot \rho_i(\mathbf{p}, \mathbf{q}) \tag{3}$$

#### 2.4. Theoretical Quality of Service

We consider Delayu the time required for data transmission to a SPi user u. i This time is expressed in

$$Delay_i^u = \frac{1}{\Phi_i - D_i} \tag{4}$$

That means more demand is greater than the time increases, and vice versa, over the bandwidth increases the time becomes less important. This proportionality is logical since:

- a. More as demand increases, the number of customers connected to the SPi becomes large and thus the time becomes more important.
- b. More than the bandwidth increases, the SP largely has capacity to cover all customers and therefore the time became smaller.

In the model of L. Kleinrock [8] with queues, Quality of service QoS is the inverse of the total response time when the user wants to access the service. Let ci the deadlines for transmission of data between the service provider and the provider services l'SPi, the total time of the answer is accumulates between ci and Delayiu. Thus the quality of service is expressed by the following equation:

$$q_i = \frac{1}{Delay_i^u + c_i} \tag{5}$$

From the two equations (4) et (5), we show the existence of the relationship between the quality of service, demand

Di(p; q) = n i(p; q) and bandwidth i by the following equation [3]:

$$q_{i} = \frac{\Phi_{i} - D_{i}}{1 + c_{i}(\Phi_{i} - D_{i})}$$
(6)

or by the following equation:

$$\Phi_i = D_i + \frac{q_i}{1 - q_i c_i} \tag{7}$$

From the equations (6), we can deduce that when demand of SPi approach covering all the bandwidth; QoS becomes less.

## **2.5. Problem Formulation**

From equation (1), we find that the theoretical benefit of a user is:

$$u_i(q_i, p_i) = \alpha \cdot q_i - p_i, \tag{8}$$

then the real benifit is:

$$u_i^R(q_i^R, p_i^R) = \alpha . q_i^R - p_i^R, \tag{9}$$

with qiR is a real QoS and pRi is a real price.

Assumption 1 In telecommunications, there is no general difference between promotional price (theoretical) and the real price that the user paid when the invoice settlement. However, as in all areas, there are hidden penalties related to VAT, the invoice payment time ... But in our study we assume that pi = pRi.

Taking into consideration this assumption 1, the difference between the real and theoretical benefit becomes:

$$u_i - u_i^R = \alpha \cdot q_i - p_i - (\alpha \cdot q_i^R - p_i^R) = \alpha (q_i - q_i^R)$$

## 2.5.1. Resource Management Model

Used to help operators in the telecommunications field to maintain their resources so that the difference between their offers and advertising that benefit the customer actually is optimal. It is a tool to customers who want to register with the operator that meets their needs.

min 
$$F_i(\mathbf{p}, \mathbf{q}) = \frac{1}{2} \cdot \alpha \cdot \rho_i \cdot \left[ \left( q_i - q_i^R \right)^2 \right]$$

under the constraints:

$$\begin{cases} p_i < P_{max} \\ q_{min} \leqslant q_i^R \leqslant q_i \end{cases}$$

The first constraint is related to customer purchasing power. the second constraint is a formulation in terms of customer needs in real QoS. it must meet a minimum threshold and it should not exceed the theoretical QoS.

#### 2.5.2. Discrete Choice Model Customers

Lets customers know the weight (sincerity) of all operators in the telecommunications market. This problem is formulated as a this multi-objective model:

min 
$$G(\mathbf{p}, \mathbf{q}) = \begin{pmatrix} F_1(\mathbf{p}, \mathbf{q}) \\ F_2(\mathbf{p}, \mathbf{q}) \\ \vdots \\ F_N(\mathbf{p}, \mathbf{q}) \end{pmatrix}$$

under the constraints:

$$\begin{cases} \forall i \in \{1, ..., N\} p_i < P_{max} \\ \forall i \in \{1, ..., N\} q_{min} \leqslant q_i^R \leqslant q_i \end{cases}$$

To solve the multi-objective problem (MOP), we must transform it into a single-objective problem weighted. For this, we applied the aggregation method and the result of the transformation is:

$$\min G(\mathbf{p}, \mathbf{q}) = \sum_{i=1}^{N} \gamma_i . F_i(\mathbf{p}, \mathbf{q})$$

under the constraints:

$$\begin{cases} \forall i \in \{1, ..., N\} \ 0 \leqslant \gamma_i \leqslant 1 \ et \ \sum_{i=1}^N \gamma_i = 1 \\ \forall i \in \{1, ..., N\} \ p_i < P_{max} \\ \forall i \in \{1, ..., N\} \ q_{min} \leqslant q_i^R \leqslant q_i \end{cases}$$

To solve the multi-objective problem (MOP), we must transform it into a single-objective problem weighted. For this, we applied the aggregation method and the result of the transformation is:

$$F_i(\mathbf{p}, \mathbf{q}) = \frac{1}{2} \cdot \alpha \cdot \rho_i \cdot [(q_i - q_i^R)^2], i = 1, 2, ..., N$$

with is considered vector weight of the operators in the telecommunications market.

#### 3. GENETIC ALGORITHM

Genetic Algorithms (GAs), developed by Holland [9] and his student Goldberg [6], are based on the mechan-ics of natural evolution and natural genetics. GAs differ from usual inversion algorithms because they do not require a starting value. The GAs use a survival-of-the-fittest scheme with a random organized search to find the best solution to a problem. Solve an optimization problem is find the optimum of a function from a finite number of choices, often very large. The practical applications are numerous, whether in the field of industrial production, transport or economics - wherever there is need to minimize or maximize digital functions in systems simultaneously operate a large number of parameters. Algorithm (1) represents the genetic algorithm used to optimize the models proposed in this work.

```
Algorithm 1 Genetic Algorithm
1: Initialize the initial population P.

Evaluate P(t).

3: while No convergence do
4:
           P(t+1)= Selection of Parents in P(t).
     a:
     b:
           P(t+1) = Apply Crossing Operator on P(t+1)
           P(t+1) = Apply on Mutation Operator P(t+1)
     C:
           P(t) = Replace elders of P(t) Descendants of their P(t+1)
     d:
           Evaluate P(t)
     e:
5 end while
```

#### 4. NUMERICAL RESULTS

In this section, we present the numerical results obtained by assuming that we have SP s in this telecommunications market. We use the genetic algorithm with the parameters that will allow us to obtain the optimal solution for our proposed models.

# 4.1. The Real Quality of the Function Study

# 4.1.1. Study of a Limited Case

In the telecommunications market, the real quality of service is a function that depends on the bandwidth i and the demand Di of SPi. In reality, we know that when the bandwidth increases, the real quality of service (QoS) increases and vice versa; also when demand increases, real service quality decreases and increases when demand decreases. In this context, we observed that the real quality can be expressed as a polynomial of degree 2, the variable xi is the ratio between i and Di, as following:



We used the genetic algorithm (with the table settings 1) to find these coefficients for different values of bandwidth i and of demand Di. The Figures 1 et 2 show the influence of respectively i and Di on QoS (theorical and real).

Table 1. Genetic Algorithm Parameter	s to the Figures of the Results	l et 2
Population size	N 16	
Type selection	roulette	

Type selection	roulette
Type of crossover	Single-points
Probability of crossover Pc	0.7
Type of mutation	uniforme
Probability of mutation	0.05
Maximum number of generations	100

From figs (1 et 2) we note that with the change of bandwidth i and the demand Di, the genetic algorithm was able to find the good coefficients of the polynomial to minimize the gap between what is theoretical and what is real. In the next part, we will not restrict ourselves to the case presented above, but we are expanding the study of the variation of the actual quality using the technique of discretization dominates definition of theoretical quality seeking at each point the value of the actual quality by solving the model for managing resources.



Figure 1. Variation of  $q_i^t$  and  $q_i^R$  in terms of  $\Phi_i$ 

Figure 2. Variation of  $q_i^t$  and  $q_i^R$  in terms of  $D_i$ 

# 4.1.2. Study of a General Case by Discretization

The quality theoretical of a SPi may vary within a range delimited by a minimum and maximum value qit 2 [qmin; qmax]. To make a digital resolution, we will discretize the interval 3, that is to say, turn it into an approximate problem (discrete) to find the values of the actual quality qiR at each point of the discrete domain.



Figure 3. Discretization of an interval

or h is a positive regular pitch.

Study The Impact of Bandwidth on qt and qr We launched the genetic algorithm; Matlab programmed with the parameters listed in Table 2; on the model of resource management with variation of bandwidth i, and we obtain the results shown in Figures 4, 5 and Table 3.

Table 2. Genetic Algorithm Parameters to the Figures of the results 4 and 5

Population size N	20
Type selection	at roulette
Type of crossover	Multi-point
Probability of crossover Pc	0.65
Type of mutation	non uniforme
Probability of mutation	0.05
Maximal Number of generation	300

The Figure 4 shows the decrease of the function F itness relative to iterations (generations) the genetic al-gorithm. The objective function value begins 103, in the first generation, to reach the value 10 4, in the 253me generation. This result shows that the decrease is Igue (remarkable). From Figure 5, we note that to achieve the same minimum value, the algorithm needs to go to the 253 generation.

Table 3. Convergence Results of the Genetic Algorithm (variation of i)



Figure 4. Decrease in the Objective function according Figure 5. Changes in the rela quality of service over the generations

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Figure 6. Decrease in the Objective function according Figure 7. Changes in the real quality of service over the generations

Impact on Demand Study qt and qr We launched the genetic algorithm; with the parameters listed in Table 4;on the model of resource management with variation of the demand Di, and we obtain the results shown in the following Figures 6, 7 and table 5.

Population size N	10
Type of selection	at roulette
Type of crossover	Multi-point
Probability of crossover Pc	0.60
Type of mutation	not uniforme
Probability of mutation	0.05
Maximum number of generation	200

Table 4. genetic algorithm parameters to the Figures of the results 6 and 7

The Figure 6 shows the decrease of the function F itness relative to iterations (generations) the genetic algo-rithm. the objective function value begins with 102 in the first generation, reaching the values 5; 694 10 4, in the 167th generation. This result shows that the decrease is Igue (remarkable). From the Figure 7, We note that to achieve the same minimum value, the algorithm needs to go to the 167 generation.



Table 5. Convergence Results of the Genetic Algorithm (variation of Di)

Number of generation	167
minimum cost	5:694*10-4
step of discritization h	1
	20

#### 4.2. Model Resolution of the Weight Calculation

In this part, we consider that we have a telecommunications market two operators. We will use the model of discrete choice of customers to find their weight in this market ranging phii and Di an operator. The calculation of these weights is a kind of decision support for customers seeking to register with the services of the most sincere operator (who has more confidence in the sense of the difference between qt and qR).

# 4.2.1. Impact of Bandwidth on The Weight of Operators

We vary the bandwidth of the operator 1 and observe the influence on weight and that of the adversary. The Figure 8 show that the weight of the operator is an increasing function compared to bandwidth 1, then the weight of its adversary is a decreasing function with respect to 1. This result is real, since the increase in bandwidth 1 causes the improvement of the real QoS q1R and therefore the operator 1 must have a good reputation and a good weight for his adversary.

# 4.2.2. Impact of Demand D on The Weight of Operators

We will vary the request of the operator 1 and observe the influence on weight and that of the adversary. The Figure 9 shows that the wight of operator 1 is decreasing function compared to demand D1, then the wight of its adversary is a increasing function compared to D1. This result is real, because the increase in demand D1 causes degradation of the real QoS q1R and therefore the operator 1 must not have a good reputation and a good weight for his adversary.

#### 5. CONCLUSION

we used the Inverse Problem Theory in the telecommunications field to solve the problem of minimizing the difference between the theoretical quality and the actual quality which the operator offers to users, which is a problem of decision support. We have offered customers a tool for decision by calculating the weight of the operators in the telecommunications market.

For the numerical solution of inverse problems formulated as optimization problems, we used genetic algo-rithms that have shown their powers in the field of optimization. The first model, has allowed us to study the shape of the real quality. The second model, allowed us to calculate the weight of the operators in the telecommunications market as a decision support tool that allows users to streamline their operator choice.

In this work, the numerical results show the effectiveness of the approach followed.

# REFERENCES

- [1] H.S. Kim; C.H. Yoon, "Determinants of subscriber churn and customer loyalty in the Korean mobile telephony market", *Telecommunications Policy*, vol. 28, pp. 751765, 2004.
- [2] J. Qi, Y. Zhang, Y. Zhang, and S. Shi, "Treelogit model for customer churn prediction", in APSCC 06: Proceedings of the 2006 IEEE AsiaPacific Conference on Services Computing. Washington, DC, USA: IEEE Computer Society, pp. 7075, 2006.
- [3] Mohamed Baslam, Rachid El-Azouzi, Essaid Sabir, Loubna Echabbi. "Market Share Game with adversarial Access providers : A Neutral and a Non-neutral Network Analysis". Roberto Cominetti and Sylvain Sorin and Bruno Tuffin. NetGCOOP 2011 : International conference on NETwork Games, COntrol and OPtimization, Paris, France. IEEE, pp.5, Oct 2011.
- [4] Baslam M; Echabbi L; Azouzi, R. E., and Sabir, E. "Joint price and qos market share game with adversarial service providers and migrating customers." Proc. of GameNets, Shanghai, China, April 2011.
- [5] Z. Michalewicz. "Genetic algorithms + data structures = evolution programs." SpringerVerlag, Berlin, second edition, 1994.
- [6] Goldberg, D. E., and Holland, J. H. Genetic algorithms and machine learning. Machine learning 3, 2 (1988), 9599.
- [7] K. Deep and M. Thakur, "A new mutation operator for real coded genetic algorithms," *Appl. Math. Comput.*, vol.193, no.1, 2007.
- [8] L. Kleinrock. Queuing systems. Wiley Interscience, 1975.
- [9] Holland, J. H. "Adaptation in natural and artificial systems: an introductory analysis with applications to biology, control, and artificial intelligence", U Michigan Press, 1975.
- [10] P. Maille, M. Naldi and B. Tuffin, "Price War with Migrating Customers," 17th Annual Meeting of the IEEE/ACM International Symposium on Modelling, Analysis and Simulation of Computer and Telecommunication Systems, IEEE Computer Society, London, UK, September, 2009.
- [11] Pleskac, T. J. Decision and choice: Luces choice axiom. In J. D. Wright (Ed.), International encyclopedia of the social and behavioral sciences (Vol. 5, 2nd. ed., pp. 895-900). Oxford: Elsevier, 2015.
- [12] Bishop, Christopher M,. Pattern Recognition and Machine Learning, Springer, 2006.