# IMPROVEMENT IN THE CUSTOMER SERVICE IN A BANKING COMPANY USING L.P. AND MIMO 4G CHANNEL FOR TRANSACTIONS.

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**Abstract**

This paper presents an improvement in response time to client enquiries in a banking system through the use of System Dynamics to model the information and material flows inside and outside the enterprise, and to identify the principal causes for service delays. First, we propose and then evaluate the implementation of a mobile wireless data transmission system with a Multiple-Input-Multiple-Output (MIMO) channel infrastructure to improve the data transmission time from the customer to the banking company. Second, a linear programming model is proposed to minimize the transport cost within the main office. With this methodology, the computer simulation shows an improvement of 27% in the number of customer enquiries addressed.

**Keywords**:
System Dynamics, MIMO channel, Linear Programming LP, Customer service, codification.

## 1 INTRODUCTION

The motivation of this paper is to show the profit in the service time and transactions time that are obtained in a banking company, knowing that it performs great importance for high customer satisfaction levels, due to the easy thing that is to change Banking institution. The proposed modifications contribute to the constant improvement of customer attention using to this three utile tool.

The process begins when a customer comes to a bank office to present any problem. The office sends this information to the main office and this problem is sent to a specialist area to solve it. However if this information transaction take a lot of time, all process is inefficient. Zuckerman[1] presents a way to understands this kind of problems. This tool is oft great value in business due to the fact that a great number of problems can be characterized, as problems of come and bulging congestion [2].

Secondly the use of Multiple-Input Multiple-Output (MIMO) channels has recently attracted considerable interest as an approach that can yield significant capacity gains over conventional smart antenna arrays and using it in combination with LDPC codes to encoder gives a high performance to transmit a lot of information with a low bit error rate (BER) in wireless communications[3]-[4]. Zheng[5]. shows the design of a practical low-density parity check (LDPC)-coded and MIMO system composed of transmit $M$ and $N$ receive antennas operating in a flat-fading environment where channel state information (CSI) is assumed to be unavailable both to the transmitter and the receiver. He shows a structure has lower decoding complexity and further leads to tractable exit functions of the component soft decoders.

The innovation of this paper is some design issues to improve the attention customer requests system in banking company, improving the current situation with the approach of System Dynamics, giving the changes in the data channel input-output like basis for the progress of the information transmission system. Moreover is evaluating the transactions in turn a proposed code for this particular application and is selected the code that provokes less Bit Error Rate (BER) for a data 4G transmission channel to response the customer requirement in any place of the country in which the customer be. These three concepts give together big benefits to the organization and provokes an improvement of the customer service.

This paper is organized as follows: Section 2 corresponds to the formulation of the problem. Section 3 is the description of the problem. Section 4 presents the results and finally, the conclusions are given in the last section.

## 2 PROBLEM FORMULATION

The attention system of customer requests is formed by a multiple net of 14 areas in which depending on the origin of the request, it is assigned to different areas that give response. The characteristics of this system, they do that a request comes to an area, it is attended, and then happens to a new area where a different task is waited and that it must be realized to be able to emit a response to the customer.

To understand the system complexity in Figure 1. had drawn the general situation using the influence diagrams, which shows the influences of the different types of customer requirements entries of customer as Government, Press, Call-Center, SBIF, SERNAC and Personal. In this case the denunciations for problems by the different entries, the transmission time of data inside the banking Company and between customer-Banking Company, and a high requirement response time, affect positively in number of claims, increasing the number of cases that must be resolved and the transport cost for requirement. On the other hand, the improvements of customer service decreased the number of claims. The priority caused by the type of entry, such as the government, increased the times of response to the personal requests. In red colour is marked the areas that must be changed whit the new infrastructure and this areas are going to explain in the next section.

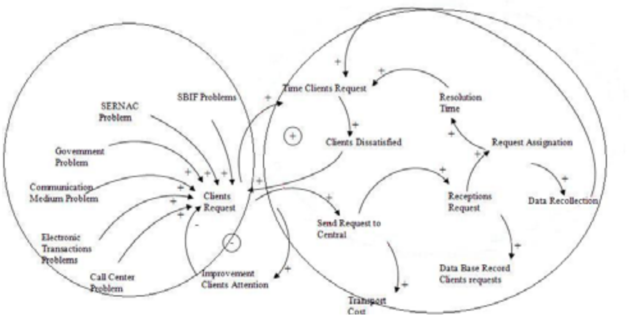


Figure 1: Influences Diagram.

The main problem in the banking company is the arrival time of customer request and the time of response of these requirements. Due to it's reason that the intervention that has been developed for this organization considers helping to diminish the time of arrival requests. The behaviour of the customer arrival request can be represented using system dynamics for:

$$\frac{d\,Y(x)}{d\,x} = C_i(x)*(1-Ph(x))*Per_{ij} - C_i(x+Del_\alpha) \qquad (1)$$

$$\frac{d\,Pun(x)}{d\,x} = Tex_i(x)*Um_i - Tex_i(x+Del_\beta) \qquad (2)$$

Where:

$Y(x)$: Number of customer requirements inside of the banking company in week $x$ during 2006.

$C_i(x)$: Number of customer requirements in the tail of wait origin of customer $i \in [1,6]$, $i = \{$ Customer $C_1$, Customer $C_2$, Customer , Customer $C_3$, Customer $C_4$, Customer $C_5$, Customer $C_6$ $\}$, during 2006.

$Ph(x)$: Probability of the server $i$ isn't idle during 2006.

$Per_{ij}$: Percentage of entrance to area $j$ of customer $i$ with $j = \{$ CCI, SBIF, Current Client $\}$

$Del_\alpha$: Delay produced by the permanence of customer requirements in the system.

$Pun(x)$: Number of customer requirements with time of response greater than the permitted (punished requirements). During 2006.

$Tex_i(x)$: Number of customer requirements origin of customer $i$ with time of response greater than the permitted, $i \in [1,6]$ during 2006.

$Um$: Unitary monetary cost for every customer requirements origin of customer $i$ with time of response greater than the permitted, $i \in [1,6]$ during 2006.

$Del_\beta$: Information Delay of the punished requirements in the time $x$.

## 3 SYSTEM DESCRIPTION

In the formulation stage, the situation has modeled itself as a net of systems, where every node is represented as a server who it has limited capacity of wait. Every area has a probabilities distribution of input/output of flows. These probabilities are included inside the model. Figure 2 shows the application of the proposed methodology that help to find the troubles and apply system improvements like the mobile transactions and the linear programming and finally to compare each other.

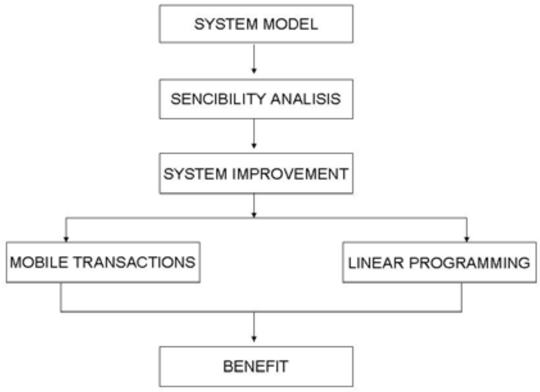


Figure 2: Applied methodology.

In figure 3, the trapeze $E1$ are symbolizing the entry of customer requirement and the entry channel is the same for every customer. The rectangles are symbolizing the processes, $Pi, i \in [1,12]$ that must be realized in order that the response from the primary server to the following one, every process is programmed in agreement to the maximum capacity of attention and the probability distribution calculated, in this model exist 12 process. The rhombuses are symbolizing decisions, $Di, i \in [1,3]$ that are taken in agreement to the characteristics of every request and in this model exist 3 decisions. The round vertices square $Ai, i \in [1,2]$ are symbolizing assignment of requirements to corresponding areas in this model exist 2 assign. The trapezes $Ci, i \in [1,7]$ are symbolizing the devices that count the requests in this model exist 7 counts. Finally the trapezes $Si, i \in [1,3]$ are symbolizing store that are submitting to the customer in this model exist 3 storages. The probabilities distributions of response time is calculated to view the response capacity of the system and it shows that the input stage provokes a great loss of time for the whole system, due to the fact that all the information is sent in documents to the capital to be resolved. In red colour is marked the area that can be modified to input of requirements for mobiles devices.

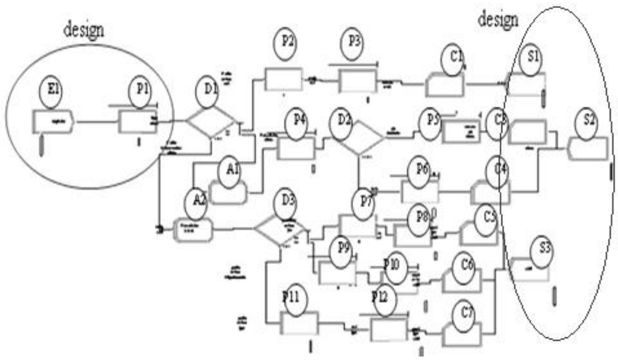


Figure 3: System of response of customers requirements.

### 3.1 Linear Programming

In the present item its analyzed the assignment cost of response in the main office. In order to route the demands between two terminal nodes, the original node has to deliver all its demands to the hub it is assigned to. Then this hub sends them to the hub the destination node is assigned to (this step is skipped if both nodes are assigned to the same hub). Finally the destination node gets the demands from its hub. No direct routing between two terminal nodes is permitted. Two types of costs are counted: the cost of routing between terminal nodes and transit nodes and the cost of routing between transit nodes. There are often economies of scale for inter-hub traffic. This work assume that are given a set of fixed hubs[8] $H = [1,2,....,k]$ and a set of areas $C = [1,2,....n]$. Directed demand $d_{ij}$ to be routed from area $i$ to area $j$ is given. The distance from area $i$ to hub $s$ is $c_{is}$, which is also called the per unit transportation cost. Similarly is defined $c_{st}$ to be the distance from hub $s$ to hub $t$. Define $\vec{x} = \{x_{is} : i \in C, s \in H\}$~x to be the assignment variables. The quadratic formulation is:

$$\min Z = \sum_{i,j \in C} d_{ij} (\sum_{s \in H} c_{ij} x_{ij} + \sum_{i \in H} c_{jt} x_{jt} + \sum_{s,t \in H} \alpha c_{st} x_{i,s} xj,t)$$

subject to $\sum_{s \in H} x_{i,s} = 1; \quad \forall i \in C,$

$$x_{i,s} \in \{0,1\} \qquad \forall i \in C, s \in H$$

All coefficients $\mathrm{d_{ij}}, \mathrm{c_{is}}, \mathrm{c_{jt}}, \mathrm{c_{st}} \geq 0$, and $\mathrm{c_{st}} = \mathrm{c_{ts}}, \mathrm{c_{ss}} = 0, \forall i, j \in C, \forall s,t \in H$ $\alpha$ is the discount factor and $0 \leq \alpha \leq 1$. Without loss of generality, $\alpha$ can be assumed to be one. Note that the transportation cost from areas to hubs, $\sum_{i,j \in C} d_{ij} (\sum_{s \in H} c_{ij} x_{ij} + \sum_{i \in H} c_{jt} x_{jt})$ is linear on $\vec{x}$, and it call the linear cost of the objective function and denote it by $L(\vec{x})$ Similarly, call the other part of the objective function the inter-hub cost or quadratic cost, and denote it by $Q(\vec{x})$. This model can be linearized[9].

$$\min U = \sum_{i,j \in C} \sum_{s,t \in C} d_{ij} (c_{ij} + c_{jt} + c_{st})$$

Subject to:

$$\sum_{s,t \in H} x_{ijst} = 1, \quad \forall i, j \in C,$$

$$\sum_{i \in H} x_{ijst} = x_{i,s} \quad \forall i, j \in C, s \in H,$$

$$\sum_{s \in H} x_{ijst} = x_{j,t} \quad \forall i, j \in C, t \in H, .$$

$$x_{ijst} \geq 0, \quad \forall i, j \in C, s,t \in H,$$

$$x_{i,s} \in \{0,1\}, \quad \forall i \in C, s \in H.$$

Here $x_{ijst}$ is the portion of the flow from area $i$ to area $j$ via hub $s$ and $t$ sequentially. The formulation involves nonnegative variables and constraints. This formulation enables us to obtain an LP relaxation for the problem by replacing the zero-one constraints with non-negative constraints. This LP relaxation is very tight and often produces integer solutions. However, the size of the LP relaxation is relative large, which restricts its applications to large-sized problems.

In order to reduce the time complexity, flow formulation for the proposed problem, which is adapted from a formulation for the model proposed by Ernst and Krishnamoorthy [10]. In this formulation, is not specified the route for a pair of areas $i$ and $j$ [11]. Moreover this formulation does not need decision variable $X_{ijst}$. Instead, is necessary to define $\vec{Y} = \{Y^i_{st} : i \in C, s,t \in H, s \neq t\}$ where $Y^i_{st}$ is the total amount of the flow originated from city $i$ and routed from hub s to a different hub $t$. Define $P_i = \sum_{j \in C} d_{ij}; D_i = \sum_{j \in C} d_{ji}$ and the problem can be represented by:

$$\min W = \sum_{i \in C} \sum_{s \in H} c_{is} (P_i + D_i) x_{i,s} + \sum_{i \in C} \sum_{s,t \in H: s \neq t} c_{st} Y^i_{st}$$

Subject to $\sum_{s,t \in H} x_{ijst} = 1, \quad \forall i, j \in C,$

$$\sum_{t \in H: t \neq s} Y^i_{st} - \sum_{t \in H: t \neq s} Y^i_{ts} = P_i x_{i,s} - \sum_{j \in H} d_{ij} x_{j,s}, \ \forall i, j \in C, t \in H$$

$$x_{i,s} \in \{0,1\}, \quad \forall i \in C, s \in H.$$

$$Y^i_{st}, \qquad \forall i, j \in C, t \in H, s \neq t$$

This linearized model can by applied to this problem, and reports an optimum assignment for every area. Moreover this is the assignment that minimized the total cost.

### 3.2 Proposed Channel

The channel proposed is MIMO/LDPC to decreased the requirement response time for every customer in the entry of the system. Figure 4. shows the data sent from the customer are encoded and modulated so they can be sent through the MIMO channel. Since, the channel includes a LDPC codes for encoder/decoder process, a BPSK modulation and a wireless link that passes through an AWGN and fading of the signal. In that condition the signal must be demodulated and decoded so it can be received in the Banking Company.

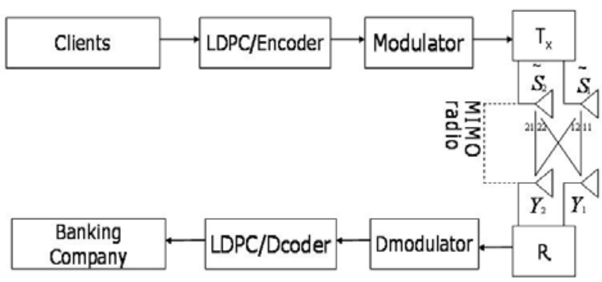


Figure 4: Proposed data MIMO channel.

### 3.2.1 MIMO system model

It is considered a MIMO system with a transmit array of two antennas and a receive array of two antennas [6]. It was assumed flat fading between each transmit and receive antenna and also assumed that the channel is memory less. The channel matrix at any given time t is given by [7]:

$$\mathrm{H}_t = \begin{bmatrix} \mathrm{h}^{t}_{1,1} & \mathrm{h}^{t}_{1,2} \\ \mathrm{h}^{t}_{2,1} & \mathrm{h}^{t}_{2,2} \end{bmatrix} \qquad (3)$$

Where the $\mathrm{jith}$ element, denoted by $h^{t}_{j,i}$, is the fading attenuation coefficient for the path from transmit antenna $i$ to receive antenna $j$.

At the receiver, we note that the signal at each antenna is a noisy superposition of 2 transmitted signals degraded by channel fading. At time t the received signal at antenna $j$, $j = 1, 2$ denoted by $r^{j}_{t}$ is given by:

$$r^{j}_{t} = \sum_{i=1}^{2} h^{t}_{j,t} s^{i}_{t} + n^{j}_{t} \qquad (4)$$

Where $n^{j}_{t}$ is the noise component of receive antenna $j$ at time $t$, which is also i.i.d. Gaussian.

It is represented:

$$r_t = (r^{1}_{t}, r^{2}_{t}) \qquad (5)$$

And

$$n_t = (n^{1}_{t}, n^{2}_{t}) \qquad (6)$$

Thus the receive signal vector can be represented as:

$$r_t = \mathrm{H}_t s_t + n_t \qquad (7)$$

### 3.2.2 LDPC Encoder/Decoder Process

The parity check equations in this example have four variable characterizing by the nine functions $f_i \;\; \forall i \; \in 1 \le i \le 9$ where $f_1(x_3, x_6, x_7, x_8)$, $f_2(x_1, x_2, x_5, x_{12})$, $f_4(x_2, x_6, x_7, x_{10})$ …and $f_9(x_2, x_3, x_9, x_{10})$, functions that can take values “0” or “1” according to if the equations are or not satisfied. Figure 5. shows these equations represented in $H$ matrix $(12,4)$. Therefore $f_i \;\; \forall i \; \in 1 \le i \le 9$ are binary functions to belong at code and we can represent $H$ matrix for: $H = \left[P^{T} / I\right]$.

In order to obtain a codified word we applied the following relation: $C = cod\left|x\right| = x \otimes G$, where $C$ correspond to our codified word.

$$H = \begin{bmatrix}
0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \\
1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 \\
0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0
\end{bmatrix}$$

Figure 5: Example of H matrix.

The generating matrix $G$ can be express like $G = \left[I / P\right]$, where $I$ is the identity matrix. For this application the generator matrix characterizing for $(r = 4/12)$, where $(r = k/n)$, the generator matrix $G$ for this code The decoder process begins when the transmitted word is multiplied with the parity check matrix, and if $C \otimes H^{T} = 0$, the transmitted word is ready to decoder, else $C \otimes H^{T} \neq 0$ begins the iterative decoder process. The sum-product algorithm replaces each variable in the constraint graph with a random variable. The task is then to compute the (conditional) probability mass of one variable, given the available independent (conditional) probability masses of all other variables. Each edge in the graph is then associated with four probability masses, because each edge is connected to four nodes.

Where the initial probability is calculated:

$$P(y) = \frac{1}{1 + e^{\frac{-2y_k}{d^2}}} \qquad (8)$$

Message sent by the parity node:

$$\begin{aligned} r^{0}_{k} &= \left(1 + \prod \left(q^{0}_{k} - q^{1}_{k}\right)\right) \\ r^{1}_{k} &= \left(1 - \prod \left(q^{0}_{k} - q^{1}_{k}\right)\right) \end{aligned} \qquad (9)$$

Using the update factor to calculate the variable message:

$$\begin{aligned} q^{0}_{k} &= \alpha_k \, p^{0}_{j} \prod r^{0}_{k} \\ q^{1}_{k} &= \alpha_k \, p^{1}_{j} \prod r^{1}_{k} \end{aligned} \qquad (10)$$

Where the update factor is:

$$\alpha_k = \frac{1}{\left[P^{0}_{j} \prod r^{0}_{k}\right] + \left[P^{1}_{j} \prod r^{1}_{k}\right]} \qquad (11)$$

Each function node produces, for every edge, a unique estimate of the (conditional) probability mass, based on the information which appears at the other edges. Probability masses are generally represented by vectors, and may sometimes be represented by summary messages, such as log-likelihood ratios or soft bits.

$$L(x_i / y) = \ln \frac{p(x_i = 1/y)}{p(x_i = 0/y)} \qquad (12)$$

## 4 RESULT AND DISCUSSION

In present work was evaluated the option to create a new process to data input service and the amplification of the service capacity of "bottleneck", considering for this the balance between the efficiency measurements: units and time of service inside the company versus server amplification capacity costs.

There has modeled itself the flow of the actual requests of the Banking Company and there has been evaluated a plan of short-term improvement. The gains expressed as decrease of penalties by delay imposed by SBIF allow to the Bank Company to improve the corporate image, improvement the projects of loyalty post sale and decrease of the costs. Figure 6 shows the comparison costs between the actual situation and the proposed situation. This simulation includes the channel effect and the optimization of the assignment problem.

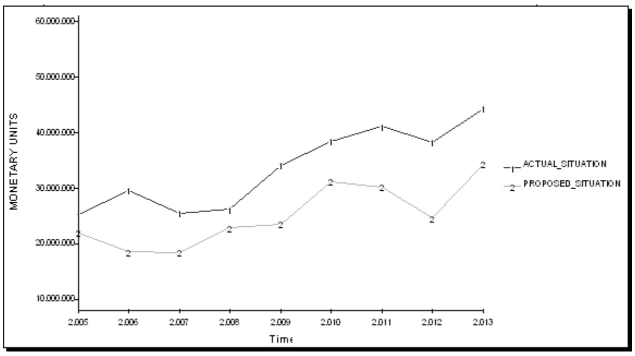


Figure 6:Comparison between actual and proposed situation.

Figure 7 shows the comparison between SISO (Single Input-Single Output) and proposed MIMO (Multiple Input-Multiple Output) channel with two antennas on the transmitter and two on the receptor, for Convolutional and LDCP, Encoder/Decoder and BPSK modulation process respectively. The SISO channel, to generate a stable conversation, that means a BER efficiency level equal to 1,0E-04, need an approximately 14 dB SNR. The MIMO/Convolutional just needs 9 dB. This generates an approximate profit of 5 dB SNR and MIMO/LDPC only needs 6 dB SNR. The profit that a MIMO channel can introduce in Banking Company has been compared at the transaction level [**¡Error! Marcador no definido.**2]. which can reverberate on more electronic services, and a higher speed on the transactions.

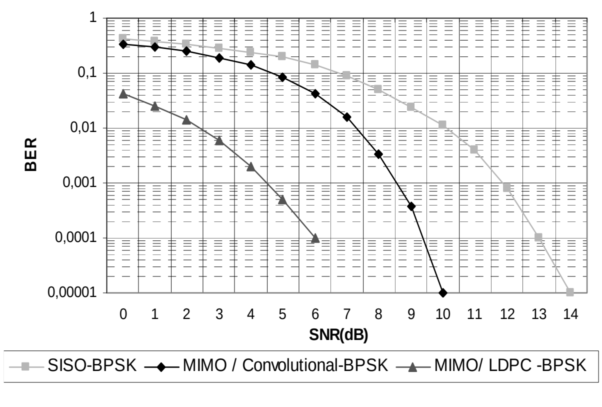


Figure 7: Comparison between SISO and MIMO channel, with Convolutional and LDCP codes, respectively.

## 5 CONCLUSIONS

The proposed methodology to solve troubles, contains conceptualization and modelling of the actual situation and application of optimization techniques in the sensitive areas. This methodology has helped to determine and solve the improve of customer service problem.

In this paper is compared the use of a mobile wireless communication to transmit the data from the customer to the banking company and from the banking company to the customer. The computer simulation is effected supposing that the current situation can be represented by a wireless communication SISO and the proposed for one of type MIMO. The benefit provoked by the utilization of MIMO channel is equivalent to 5 dB for 1,0E-04 BER using Convolutional codes and 8 dB for 1,0E-04 BER using LDPC codes, moreover this paper shows the importance of the code in the data transmission.

The particular assignment Problem was obtained and solved to minimize the cost of response in the main office, giving a feasible solution.

With these changes the computer simulation shows an improvement of 34% in the customer service. The proposed modifications support the extension plan of the company, the constant improvement of customer attention and its market permanency. Finally the proposed system gives high performance for the same transactions requirements and an new infrastructure to more efficient communications.

## 6 ACKNOWLEDGMENTS

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