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Journal Information Technology

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Knowledge Area

The works must be unpublished and refer to topics of Computer architecture, data banks, code and coding systems, design of communication systems, design of sensor systems, logical design, storage devices, control devices, data transmission devices, teaching with computer support, reliability of computers, heuristics, computers, machine arithmetic instructions, artificial intelligence, algorithmic languages, programming languages, computer logic, maintenance of computers, causal models, analog computers, digital computers and other topics related to Engineering and Technology.

Presentation of the content

In the first article we present, *Development an Artificial Intelligence to Automate the Buying and Selling of bitcoins*, by LEDESMA-URIBE, Norma Alejandra, OLVERA-MONROY, Jared Fabian, ATANACIO-MELCHOR, Jesus David and RODRIGUEZ-MIRANDA, Gregorio, with adscription in the Universidad Tecnológica de San Juan del Río, in the next article we present *Design of a WEB application to create a repository of medicinal plants used by the Nahuas of the Huauchinango region*, by TORRES-VERGARA, Francisco Alberto, CASTILLO-QUIROZ, Gregorio, SAMPAYO-RODRÍGUEZ, Carmen Jeannette and HERNANDEZ-LUNA, Aldo, with adscription in the Instituto Tecnológico Superior de Huauchinango, in the next article we present *Perception of the use of Blockchain and its impact on transparency in public institutions*, by ZAMUDIO-GARCÍA, Víctor Manuel, SERRANO-FRANCO, Glendamira and SOLARES-SUSTAETA, Andrés, with adscription in the Universidad Politécnica Metropolitana de Hidalgo, in the last article we present *Implementation of a workbench platform for the management of smart contracts in BlockChain nodes on Azure Cloud*, by DANIEL-MARTÍNEZ, Wendy, SANTANA-VALADEZ, Luis Alejandro, ZAMUDIO-GARCÍA, Víctor Manuel and HERNÁNDEZ-PÉREZ, Faride, with adscription in the Universidad Politécnica Metropolitana de Hidalgo.

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Development an Artificial Intelligence to Automate the Buying and Selling of bitcoins

Desarrollo de una Inteligencia Artificial para Automatizar la Compra y Venta de bitcoins

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Abstract

Trading consists of purchasing and selling listed assets with high market liquidity such as: stocks, currencies and futures. then this financial market is used electronically and it is regulated (the trading and generation price is freely agreed through a negotiation process between the consumer and the trader.). One of its objective is to obtain an economic benefit when the operation generates a capital income , repeating the process for a considerable number of operations, therefore it makes it possible to increase the initial capital. This article will approach the implementation of an algorithmic trading model which can help to maximize the profitability of a portfolio for cryptocurrency assets based on the application, combination and weighting of some of the most advanced mathematical techniques using the Python programming language, its libraries and some other tools in a controlled development environment and also guided by a previous research and training based on the topics planned for the completion and satisfaction of the project.

Trading, Exchange, Cryptocurrency, Bot, Genetic Algorithms

Resumen

El 'trading' consiste en la compraventa de activos cotizados con mucha liquidez de mercado (acciones, divisas y futuros). Y ese mercado financiero es empleado de manera electrónica y está regulado (el precio de comercialización y generación se pacta libremente mediante un proceso de negociación entre el consumidor y el comercializador.). Su objetivo es obtener un beneficio económico cuando la operación genera una plusvalía, repitiendo el proceso por un número considerable de operaciones, permitiendo así aumentar el capital inicial. En este artículo se bordará la implementación de un modelo de trading algorítmico que ayude a maximizar la rentabilidad de un portafolio de activos de criptomonedas basándose en la aplicación, combinación y ponderación de alguna de las técnicas matemáticas más avanzadas utilizando el lenguaje de programación Python, sus librerías y algunas otras herramientas en un entorno de desarrollo controlado y guiado por una investigación y capacitación previa basada en los temas previstos para la conclusión y satisfacción del proyecto.

Trading, Exchange, Criptomoneda, Bot, Algoritmos genéticos

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Introduction

Cryptocurrencies are virtual currencies. They can be exchanged and traded like any other traditional currency, however these cryptocurrencies are outside governments control as well as financial institutions. This paper discusses the Algorithmic Trading Model applied to cryptocurrencies carried out in a company in the state of Querétaro.

Cryptocurrency trading is the act of speculating on the price movements of cryptocurrencies through a CFD trading account, or buying and selling the underlying cryptocurrencies in a trading market. (Binance Academy, 2021)

Actually is intended to create an algorithm that allows us trading with cryptocurrencies in which a large number of transactions will be executed in a short time on the Binance Exchange (exchange market), where transactions must be made by acquiring coins at the lowest possible price then after selling it on the exchange platform with a higher price than what we have acquired, then lastly We can acquire a profit. In this process, you want a bot (a program that performs repetitive, predefined and automated tasks) to make multiple purchases in a short period of time (Kaspersky Lab, 2022).

One of the main needs to create a bot to be able to perform this activity comes from the problem that markets change rapidly the value of currencies varying in small prices hence complicating multiple purchases.

Currently performing a large number of operations for a human is difficult, reasoning and making a correct decision in a short period of time having emotions in between, therefore this will be the task of implementing the bot that will allow us to make a decision that at the end would give us a real gain, actually It is our main objective.

Nowadays there are several bots that can be configured to operate in an exchange, having all one thing in common, you must pay to use their tools. This development uses free software and free resources, with the main objetive of using a bot, which actually it is also free.

The bot development will be developed under the visual studio code environment and programmed in the Python programming language which provides us with different libraries with which it will be necessary to work, ranging from pandas, ccxt, to the most important one called pyjuque that will make it easier to reach our final goal.

Objective

Develop an algorithmic trading model that maximizes the profitability of our portfolio of cryptocurrency assets, based on the application, combination and weighting of some of the most advanced mathematical techniques.

Problem

Currently investors, traders, speculators and anyone who wants to get into cryptocurrency trading in the so-called Exchange requires to perform a huge series of activities and calculations that a person could not perform in the time and accuracy demanded, so they are performed by a bot. Making use of computer tools, the aim is to provide a solution to market operations (trading), generating many sentences in a short time with bots, and then obtaining the highest possible profit. (Caminiti, 2021). Among bots, you can find some that may inject malicious codes, stealing their information, movements and cryptocurrencies. To prevent this attack it is recomendable to block JavaScript in browsers as well as the use of software specialized in blocking all types of processes that refer to mining in browsers, such as "MinerBlock" and "No Coin". (Malwarebytes, 2022)

Development

The bot design is based on the course "DE CERO A QUANT", Algorithmic trading for cryptocurrencies with python and machine learning. (Cajina Ramirez, 2021). The actual development was developed on a PC with a Linux operating system with the Ubuntu distribution, by using Python programming language. Before starting the development it is necessary to specify parameters to generate strategies, therefore purpose the ccxt library was used, with the objective of accessing information of different cryptocurrencies in the exchanges with which it is compatible, since the information that can be found is public.

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In the event that it is required to access private information like user balance, view buy or sell orders, or make transactions, it is necessary to use public and private keys provided by the Exchange. Figure 1 shows how the library is used.

```
import ccxt

print(ccxt. exchanges)

kucoin = ccxt. kucoin({
    'apiKey': 'YOUR_APIKEY',
    'secret': 'YOUR_SECRET',
    'timeout': 3000,
    'enableRateLimit':True,
    })
```

Figure 1 Data import ccxt library
Source: Own Elaboration

Figure 2 shows in which Exchange the information is searched, followed by a variable named "symbol" that will store the value of the symbol of the required cryptocurrency. The information frequency is also assigned, minutes, hours, days, etc., since the prices of digital currencies change permanently.

```
exchange = ccxt. binance()
symbol = 'BTC/USDT
timeframe = '1h'
ohlcv = exchange. fetch_ohlcv(symbol,
timeframe)
```

Figure 2 Data import ccxt library
Source: Own Elaboration

Once information is received, it is formatted and saved in a "dataframe", with the help of the Pandas library. To use the library, it is installed in the computer and the steps shown in figure 3 are used.

```
def
ccxt_ohlcv_to_dataframe(ohlcv):
    df = pd. DataFrame(ohlcv)
    df. columns = ['time', 'open',
'high', 'low', 'close', 'volume']
    df['date'] = pd.
to_datetime(df['time']*1000000,
infer_datetime_format = True)
return df
```

Figure 3 Transforming information with pandas
Source: Own Elaboration

In order to develop a strategy that would predict the market price as well as recognizing patterns, quantitative analysis was used with indicators such as: the Simple Moving Average (SMA), the Exponential Moving Average (EMA), the Relative Strength Index (RSI) and the Relative Strength Index (RSI).

The panda_ta library allows using a sample of data, in figure 4 10 are used, which will define the strategy of the average of the prices of the sample.

```
df['sma'] = df.ta.sma(length=10)

print(df. drop(columns=['time',
'open', 'high', 'low']))
```

Figure 4 SMA calculation
Source: Own Elaboration

The simple moving average is one of the most used indicators for trading within the markets, as it allows us to measure several factors, the variation of the price of the different crypto-assets, the speed with which they change and the overbought and oversold.

The Relative Strength Index (RSI) is used to measure the volatility of prices in the market, as shown in Figure 5.

$$RSI = 100 - 100/(1 + RS)$$

RS refers to the Relative Strength factor, which is calculated as shown below.

$$RS = AvgU/AvgD$$

AvgU refers to the average of the upward price changes in a given period.

AvgD refers to the average downward price variation over a given period.

```
df['rsi'] = df.ta.rsi(length=14)

print(df. drop(columns=['time',
'open', 'high', 'low']))
```

Figure 5 Calculate RSI
Source: Own Elaboration

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This indicator is made up of three bands, the simple moving average and two more called the upper and lower standard deviation.

Calculate the upper and lower bands by standard deviation. Another indicator is the Bollinger Bands, which are the lower and upper limits at which assets will move over a period of time as shown in Figure 6.

To implement them in the code, as in the previous indicators, the functions provided by the panda_ta library will be used. In this function period and number of standard deviations must be indicated as shown in the previous code. The MACD stands for Moving Average Convergene Divergence.

Figure 6 Bollinger Bands
Source: (Broseta, 2016)

The MACD indicates, at each moment, the separation between the value of two moving averages with different calculation periods. (AvaTrade, 2022)

$$MACD = EMA_{12} - EMA_{26}$$

As can be seen, for this indicator, an exponential moving average with a short period and another exponential average

```
ta_bollinger_bands =
df.ta.bbands(length = 20, std = 20)

print("Bollinger Bars")
print(ta_bollinger_bands)
```

Figure 7 Calculate Bollinger Bands
Source: Own Elaboration

In this function period and number of standard deviations must be indicated as shown in the previous code. The MACD stands for Moving Average Convergene Divergence. The MACD indicates, at each moment, the separation between the value of two moving averages with different calculation periods. (AvaTrade, 2022)

$$MACD = EMA_{12} - EMA_{26} \quad (1)$$

As can be seen, for this indicator, an exponential moving average with a short period and another exponential average with a medium time period must be calculated first. The shorter the calculation period, the more sensitive the moving average is to price variation.

The formula for calculating the exponential moving average is as follows:

$$EMA = Pk + EMAA(1 - k) \quad (2)$$

EMAA refers to the exponential average of the previous day.
P refers to the price.
K equals $2/(N + 1)$
N is the number of days in the moving average. (Saenz, 2020)

Below is the line of code where the MACD is calculated with the help of the pandas_ta library.

```
macd_ta = df.ta.macd()

print("MACD")
print(macd_ta)
```

Figure 8 Calculate MACD
Source: Own Elaboration

To test strategy effectiveness before using it with real money, backtesting will be used, it will be analyzed how it behaves using historical data in order to test its effectiveness. This is called quantitative analysis since the predictability of the model is reviewed. Once this analysis is completed, the actions to be executed by the strategy must be defined. As a strategy, the RSI condition is reviewed and a BUY will be made when the previous candlestick crosses below the lower band and the low of the current candlestick is greater than the lower band.

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A SELL is made when the high of the previous candlestick crosses the upper band and the high of the current candlestick is lower than the upper band.

For the programming of the strategy, see Figure 9, the pandas and pandas_ta libraries are used. A class called "BBStrategy" is declared, which will contain the initial parameters for the strategy:

– Length of bollinger bands: number of standard deviations.
– rsi length: number of periods.
– Limit on overbuying and over selling.

```
def __init__(self, bb_len = 20, n_std
= 2.0, rsi_len = 14, rsi_overbought =
60, rsi_oversold = 40):

        self. bb_len = bb_len
        self. n_std = n_std
        self. rsi_len = rsi_len
        self. rsi_overbought =
rsi_overbought
        self. rsi_oversold =
rsi_oversold
```

Figure 9 Class to program the strategy
Source: Own Elaboration

A method called "setUp" is used to calculate indicators. The function provided by the library was used to obtain the bollinger bands and the rsi, and send the dataframe with the data exported from the Exchange. Once calculations have been performed, they are saved in a dataframe as shown in Figure 10.

```
def setUp(self, df):
        bb = ta. bbands(
            close = df['close'],
            length = self. bb_len,
            std = self. n_std


        df['lbb'] = bb.iloc[:,0]
        df['mbb'] = bb.iloc[:,1]
        df['ubb'] = bb.iloc[:,2] =
bb.iloc[:,2].

        df['rsi'] = ta. rsi(close =
df['close'], length = self. rsi_len)

        self. dataframe = df
```

Figure 10 Method for calculating indicators
Source: Own Elaboration

As can be seen in the second "if" of the code in Figure 11, some conditions are established that must be met to see if a command will be executed or not.

```
def checkLongSignal(self, i = None):
df = self.dataframe

if i == None:
i = len(df)

if (df['rsi'].iloc[i] <
self.rsi_overbought) and \
(df['rsi'].iloc[i] > self.rsi_oversold)
and \
(df['low'].iloc[i-1] < df['lbb'].iloc[i-
1]) and \
(df['low'].iloc[i] > df['lbb'].iloc[i]) :

return True
return False
```

Figure 11 Method to detect signals
Source: Own Elaboration

The function will return True or False according to the following assumptions:

– The rsi must be less than our overbought value.
– Our rsi must be higher than our oversold level.

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– The minimum of the previous candle is less than the band of bolliger i-1 to be the previous one.
– The low of the current candlestick is greater than the bollinger band.

Once the strategy programming is completed, methods are integrated, results are displayed and monitored to the user on the screen, see Figure 12.

```
import ccxt
from utils import ccxt_ohlcv_to_dataframe

exchange = ccxt. binance()
symbol = 'BTC/USDT
timeframe = '1h'
ohlcv = exchange. fetch_ohlcv(symbol,
timeframe)
df = ccxt_ohlcv_to_dataframe(ohlcv)
strategy = BBStrategy()

strategy. setUp(df)

for i in range(len(df)):
    print(strategy. checkLongSignal(i))
```

Figure 12 Data import and execution of methods
Source: Own Elaboration

Figure 13 shows a program code for testing a strategy in simulation mode, with real-time stock market data, before running it with real money. Once variables to work with have been defined, the "open_position" method is implemented, It will open a position. A position can be defined as a type of binding commitment to buy or sell transactions, in this case cryptocurrencies.

As it can be shown in the code in figure 14, the method requires some variables to operate, the price of cryptocurrencies and the "from_opened". Following this is the variable that counts the number of operations that are performed, which must be increased each time the code is executed. If there is an open trade we average the prices and add or subtract the profit or loss to the variable "amount". If there is nothing open we update the variable "is_long_open" to "True" which indicates that a trade has been opened, we also update the variable "long_open_price" by the new currency price (this happens every time this code is executed) and update the amount.

Finally, if a percentage loss was set and the value of the variable "from opened" will be updated.

```
class Backtester():
    def __init__(self, initial_balance =
1000, leverage = 10, trailing_stop_loss =
False):
        self.initial_balance =
initial_balance
        self.balance = initial_balance
        self.amount = 0
        self.leverage = leverage
        self.fee_cost = 0.02 / 100
        self.inv = self.balance * 0.01 *
self.leverage
        self.profit = []
        self.drawdown = []
        self.winned = 0
        self.lossed = 0
        self.num_operations = 0
        self.is_long_open = False
        self.trailing_stop_loss =
trailing_stop_loss
        self.from_opened = 0
```

Figure 13 Backtester Class
Source: Own Elaboration

A method will be created that does the opposite action to open a position, i.e. close it. It will be called "close_position" and will need to receive only the price to perform the calculation. See figure 15.

```
def open_position(self, price,from_opened =
0):
        self. num_operations += 1

        if self. is_long_open:
            self. long_open_price = (self.
long_open_price + price)/2
            self. amount += self. inv/price
        else:
            self. is_long_open = True
            self. long_open_price = price
            self. amount = self. inv/price

        if self. trailing_stop_loss:
            self. from_opened = from_opened
```

Figure 14 Method opening a position
Source: Own Elaboration

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```
def close_position(self, price):
        self. num_operations += 1

        if self. is_long_open:
            result = self. amount *
(price - self. long_open_price)
            self. is_long_open =
False
            self. long_open_price = 0

        self. profit. append(result)
        self. balance += result

        if result > 0:
            self. winned += 1
            self. drawdown. append(0)
        else:
            self. lossed += 1
            self. drawdown.
append(result)

        self. take_profit_price = 0
        self. stop_loss_price = 0
```

Figure 15 Method of closing a position
Source: Own Elaboration

At the very begging the number of operations will be incremented, then it is requested if a long operation is open, if this is true we will start calculating the results, for this the amount is multiplied by the result of the difference between the current price of the currency and the price it had when the operation was opened. We also change the value of the variable that indicates if there is something open to "False" and the variable that stores the price returns to be 0.

As for the list called "profit", the results will be added to it and the balance will be incremented in the same way. If results are greater than zero, it means that there was a profit, therefore, the variable "winned" will be incremented and a 0 will be added to the "drawdown". On the other hand, if it is not, it means that there was a loss and the "lossed" variable will be incremented and the results will also be added to the drawdown.

Finally, the variables "take_profit_price" and "stop_loss_price" return to a value of 0.

Now the methods that will set the "profit" and "stop_loss" will be defined.

The first method to create will be called "set_take_profit" which must receive as parameter the price (from which we will calculate the profit) and the percentage of that price that we want to earn.

```
def set_take_profit(self, price,
tp_long = 1.05):

        self. take_profit_price =
price * tp_long
```

Figure 16 Method that establishes a profit percentage
Source: Own Elaboration

As shown in Figure 16, the percentage assigned in this case was 5%, concluding with the operation of the current price multiplied by the percentage, assigning this value to the variable "take_profit_price".

To calculate the "stop_loss" the "set_stop_loss" method will be created which will receive the current price of the currency and the percentage of that price willing to lose.

```
def set_stop_loss(self, price, sl_long
                = 0.98):

        self. stop_loss_price = price
                * sl_long
```

Figure 17 Method that establishes a percentage of loss
Source: Own Elaboration

In this case, the loss was set at 2% below the price, calculated by multiplying the price by the percentage, assigning this value to the variable "stop_loss_price".

In order to have a better management of the strategy's operation, the data must be visualized, and a method will be created that will show the results of the strategy's bakctesting. This method should receive as a parameter the symbol of the desired cryptocurrency, the start date of the period in which you want to test the end date.

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```
def return_results(self, symbol,
start_date, end_date):
        profit = sum(self. profit)
        drawdown = sum(self. drawdown)
        fees = (abs(profit) * self.
fee_cost * self. num_operations)
        results = {
        'symbol' : symbol,
        'start_date': start_date,
        'end_date': end_date,
        balance' : self. balance,
        profit' : profit,
        drawdown: drawdown,
        profit_after_fees': profit - fees,
        'num_operations' : self.
num_operations,
        'num_long' : self.num_longs,
        'num_shorts': self.num_shorts,
        'winned' : self. winned,
        lossed' : self. lossed
        }
        if self. num_operations > 0 and
(self. winned + self. lost) > 0:
            winrate = self. winned /
(self. winned + self. lossed)
            results['winrate'] = winrate
            results['fitness_function'] =
(self.num_longs + self.num_shorts) *
(profit - abs(drawdown)) * winrate / self.
num_operations
        else:
            results['winrate'] = 0
            results['fitness_function'] =
0
        return results
```

Figure 18 Method that returns results
Source: Own Elaboration

In the last mentioned method some variables will be used and their value will be the sum of the lists that are generated during the operations, as well as the cost that is paid for these operations. After this,values will be added to "results", among them the "winrate" and "fitness_function" that must be calculated first.

For the "winrate" it must be asked if the operations performed are greater than zero and that the sum of the won and lost operations is also greater than zero, if this is true, the variable will be assigned the value of the won operations between the sum of the won and lost operations, once calculated it is added to the results.

The fitness_function will be calculated as the sum of the number of operations multiplied by the subtraction of the profit minus the absolute value of the drawdown multiplied by the division of the winrate by the number of operations. If no operation was performed, only the value of zero is added to "results" in both fields. The return of the information is finished.

Now a function will be created which will be in charge of executing the backtesting. This function would receive the dataframe and the strategy that needs to be tested. This backtesting will be based on the highest, lowest and closing price of a candle.

First we will check an individual that is positive, we will go through the dataframe with a cycle to do this. After this we check if there is a buy signal, if this is true we open a purchase that will be equal to the closing price, that is, we call the method that opens a position by sending it the necessary arguments. This is also done in the same way with the functions for setting the profit and stop loss.

If there is nothing on the current candlestick, make sure that there is an open trade, in order to update the stop loss by comparing the previous prices with the current ones. We ask if the variable that indicates whether a stop loss was set is "True" and if a trade is open. If the above is true with the help of a variable we will save the maximum price reached, this to check if it is necessary to set a new stop loss.

To conclude a conditional is made which operates to calculate if it is a good time to close the position because it has been possible to obtain some profit or instead there was a loss and the stop loss should be activated.

Finally, we need a method that simply returns all variables to their initial value for further operations. The code for this function is as follows.

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```
def reset_results(self):

        self. balance = self.
initial_balance
        self. amount = 0
        self. profit = []
        self. drawdown = []
        self. winned = 0
        self. lossed = 0
        self. num_operations = 0
        self. num_longs = 0
        self. num_shorts = 0
        self. is_long_open = False
        self. is_short_open = False
        self. from_opened = 0
```

Figure 19 Method performing backtesting
Source: Own Elaboration

An algorithm is a series of organized steps that describes the process to be followed, to provide a solution to a specific problem. A genetic algorithm (or GA for short) is a programming technique inspired by the reproduction of living beings and mimics biological evolution as a strategy to solve optimization problems.

In general, genetic algorithms (GAs) are part of the so-called artificial intelligence, i.e., problem solving using computer programs that mimic the functioning of natural intelligence. (Garduño Juárez, 2018).

```
def __backtesting__(self, df, strategy):
        high = df['high']]
        close = df['close']]
        low = df['low']]
        for i in range(len(df)):
            if self. balance > 0:
                if
strategy.checkLongSignal(i):
                    self.
open_position(price = close[i], side =
'long', from_opened = i)
                    self.
set_take_profit(price = close[i], tp_long
= 1.03)
                    self.
set_stop_loss(price = close[i], sl_long =
0.99)
                else:
                    if self.
trailing_stop_loss and (self.
is_long_open):
                        new_max =
high[self. from_opened:i].max()
                        previous_stop_loss
= self. stop_loss_price
                        self.
set_stop_loss(price = new_max)
                        if
previous_stop_loss > self.
stop_loss_price:
                            self.
stop_loss_price = previous_stop_loss
                    if self. is_long_open:
                        if high[i] >=
self. take_profit_price:
                            self.
close_position(price = self.
take_profit_price)
```

Figure 20 Method returns variables to their initial values
Source: Own elaboration

In summary, a GA consists of the following steps:

– Initialization: an initial population of possible solutions to a problem, also called individuals, is randomly generated.
– Evaluation: application of the evaluation function to each individual.
– Evolution: application of genetic operators (such as selection, reproduction and mutation).

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– And term: the GA should stop when the optimal solution is reached, but this is usually unknown, so several stopping criteria are used.

In this project we will make use of genetic algorithms to optimize the parameters of the trading strategies following using the above mentioned steps, being these variables the population.

To start with the implementation of these algorithms, a file called "GA" is created in which some methods will be programmed to carry out each of the necessary steps to calculate the most optimal option or also called "the best individual".

Initially, the class called individual is declared, there we will create a data structure is used to access the methods, data and properties of individuals once the population has been created. This should receive as parameter the number of genes it will have and the range of those genes, that is, the parameters used by the indicators of the strategy.

```
class Individual:
    def __init__(self, n_genes,
gene_ranges):
        self. genes = [np. random.
randint(gene_ranges[x][0],
gene_ranges[x][1]) for x in
range(n_genes)]]

        self. backtester = Backtester(
            initial_balance = 1000,
            leverage = 10,
            trailing_stop_loss = True
```

Figure 21 Individual class
Source: Own Elaboration

The variable "genes" is matched to a random number generated in a range from the first interval to the last in each of the defined tuples, which at the end is stored as a list. The backtester attribute is also added to be able to access all the characteristics of each individual, as well as to analyze how each one of them behaves with the historical data of the Exchange.

To continue he defined the class "Population", and within it a constructor, since in this class the individuals will be defined. This constructor must receive some parameters, such as the number of individuals per population named "generation_size" which will be a list according to the size required, the number of genes in "n_genes", the rank, the number or percentage of best individuals found and a parameter that indicates the probability that a gene mutates.

```
class Population:
    def __init__(self,
generation_size, n_genes,
gene_ranges, n_best,
mutation_rate):

        self. population =
[Individual(n_genes, gene_ranges)
for _ in range(generation_size)].
        self. n_genes = n_genes
        self. gene_ranges =
gene_ranges
        self. n_best = n_best
        self. generation_size =
generation_size
        self. mutation_rate =
mutation_rate
```

Figure 22 Population Class
Source: Own Elaboration

In this class we will perform the whole process to calculate the best individual using genetic algorithms, so to continue we will create a method called "selection" which will return the best individuals, as shown below.

```
def selection(self):
        return sorted(
            self. population,
            key = lambda individual:
individual. backtester.
return_results(
                symbol = '-',
                start_date = '-',
                end_date = '-',

)['fitness_function'],
            reverse = True
```

Figure 23 Method for selecting individuals
Source: Own elaboration

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The next method is called "crossover", as its name suggests, its function is to combine the best individuals to obtain "offspring", trying to obtain the best combinations of these. First of all, we have the variable "selected" in which the best individuals are saved, followed by "point" which will be the genetic cut-off point between parents and offspring, and finally the "father" list in which the parents will be saved. Now, with a cycle all the individuals will be cycled through to reproduce them, to continue with the selection of two parents and the elimination of these once they are selected, to conclude by saving the individual object in the list of the parents. Continuing with the process, a "crossover" point must be calculated, looking for a random point between the first element of the genes and the last one.

Once the point is calculated, we proceed to replace the first value of the list up to the calculated point by the values of the parent list in the same way, that is, from the first value to the calculated point. This is repeated, only now it is to be done as well from the calculated point to the end. By the end of this process the population will be reproduced.

The last method used with genetic algorithms is the one that will perform mutation. This function will randomly add new genes to the population.

```
def mutation(self):
        for i in range(self.
generation_size):
            point = 0
            for j in range(self.
n_genes):
                point = np.
random. randint(0, self. n_genes)
                if np. random.
random() <= self. mutation_rate:
                    new_gen = np.
random. randint(self.
gene_ranges[point][0], self.
gene_ranges[point][1])
                    while new_gen
== self. population[i].
genes[point]:
                        new_gen =
np. random. randint(self.
gene_ranges[point][0], self.
gene_ranges[point][1])
                    self.
population[i]. genes[point] =
new_gen
```

Figure 24 Method that generates the mutation
Source: Own Elaboration

Initially, all the elements of the population will be run through and a variable will be declared which will store a randomly calculated point. With a cycle we will mutate "n" number of times according to the number of genes we have. After this, the random point mentioned above will be calculated, and then a conditional will be made that will ask if a random number is less than or equal to the mutation point, a new gene will be created and we must ensure that it is not equal to the one that is being replaced, so a cycle will be used that will be repeated while the new gene is equal to the previous one performing the same action over and over again until they get different, once this is fulfilled, the "point" gene will be changed by the "new_gen".

Finally, we will use a tool called Pyjuque, this name comes from Py-thon Ju-ju Qu-ant E-ngine, which is oriented to the crypto world, it has everything you need to start doing algorithmic trading, it helps us save time in creating databases, code functions and other things. To use it just enter the command "pip install pyjuque" in the terminal. Once this is done we can start using it.

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A file must be generated in which some parameters necessary for the bot to operate must be declared, then it can be better appreciated.

```
from pyjuque. Bot import defineBot
from BBStrategy import BBStrategy
import pandas as pd
import time
bot_config = {
    'name' : 'cryptobot9',

'exchange' : {
   'name' : 'binance',
    'params' : {
'api_key':
'PC6UTw1cX5BB4p0I5nGWZJgaoo1iSW2glsnr
FMC9WcuCWSFLxAmRsXylR1UnycQ7',
'secret':
'B28IOjlIWCDD41FdWIvn3gkrf1Scu6bWGptM
BUS5vhpPdTF2PuGjggd982fccgUWG'
        },
    },
'symbols' : ['CLV/USDT', 'ADA/USDT',
'VET/USDT',
    'MINA/USDT'],

    'starting_balance' : 20.00,

    'strategy': {
        'class': BBStrategy,
        'params': {
            'bb_len' : 20,
            'n_std' : 2.0,
            'rsi_len' : 14,
            'rsi_overbought': 60,
            'rsi_oversold' : 40,
        }},
```

Figure 25 Pyjuque file
Source: Own Elaboration

Initially the necessary imports are made, such as the "defineBot", the strategy, the panda library and the time. Following this, a dictionary where certain parameters are established that are required to operate in a certain Exchange, i.e. the name of the Exchange, the keys provided to access its api, one public and one private. The symbols of the currencies to be operated, an initial balance and the strategy that was developed are also declared. For the strategy you must send parameters with which you want the indicators to operate.

```
'timeframe' : '5m',
  'entry_settings' : {
   'initial_entry_allocation': 75,
   signal_distance': 0.001
    },
'exit_settings' : {
   'take_profit' : 0.2,
   stop_loss_value': 1
    },
display_status' : True
}
def main():
    bot_controller =
defineBot(bot_config)
    to True:
        try:
            bot_controller.
executeBot()
        except KeyboardInterrupt:
           return
        time. sleep(15)
```

Figure 26 Execute Bot
Source: Own Elaboration

To complement this, you must also declare some other parameters, among the most important in which. We have the frequency with the candles that are analyzed, the percentage of profit you expecting and the percentage of the loss limit that you are allowed to lose. And finally the method "main" that will execute everything mentioned above.

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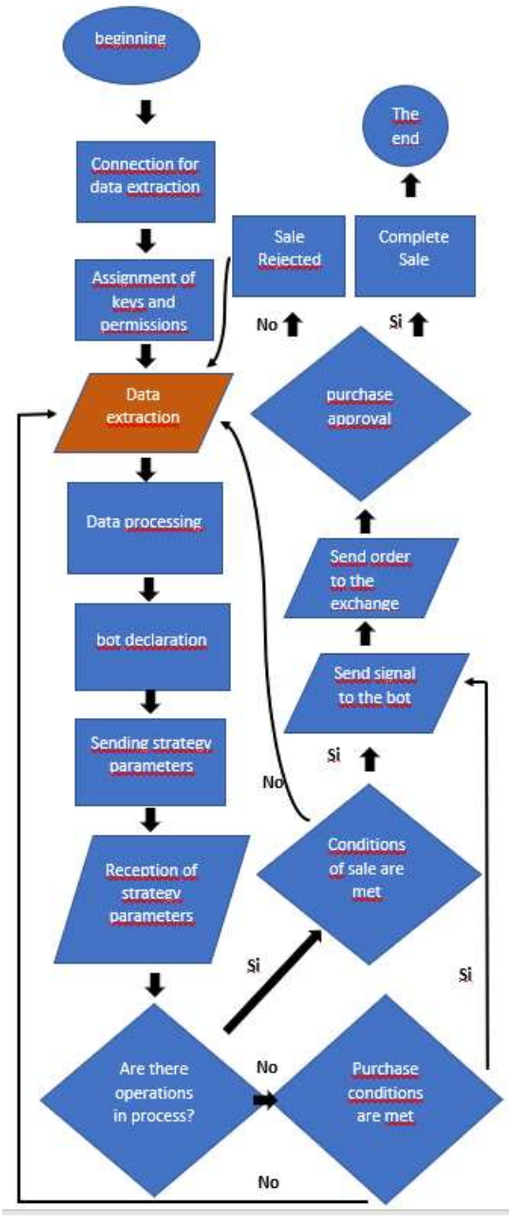

Figure 27 Flow diagram
Source: Own Elaboration

Results

It was concluded that working with a safe strategy and with enough time to try different and better options It is very likely to get beneficial incomes.

To evaluate the proper functioning of the indicators and the strategy, "backtesting" will be performed, It consists of taking historical information of the prices that a certain cryptocurrency has had and calculates the indicators of the program to compare the results obtained with those observed in that historical data. As for the strategies, they can also be executed and then you can check if they correctly execute the operations at the most appropriate time.

In order to perform the backtesting, historical data from cryptocurrency exchanges was required, which, as mentioned in the previous chapter, was obtained with the "ccxt" library through some code sentences. The result is shown below

```
PS C:\Backtesting> python 01get_data.py

['aax', 'acx', 'aofex', 'ascendex', 'bequant', 'bibox',
'bigone', 'binance', 'binanceus', 'bit2c', 'bitbank',
'bitbay', 'bitcoincom', 'bitfinex', 'bitfinex2', 'bitflyer',
'bitforex', 'bitget', 'bithumb', 'bitkk', 'bitmart',
'bitmax', 'bitmex', 'bitpanda', 'bitso', 'bitstamp',
'bitstamp1', 'bittrex', 'bitvavo', 'bitz', 'bl3p',
'bleutrade', 'braziliex', 'btcalpha', 'btcbox',
'btcmarkets', 'btctradeua', 'btcturk', 'buda', 'bw',
'bybit', 'bytetrade', 'cdax', 'cex', 'chilebit', 'coinbase',
'coinbaseprime', 'coinbasepro', 'coincheck',
'coinecheck', 'coinegg', 'coinex', 'coinfalcon',
'coinfloor', 'coingi', 'coinmarketcap', 'coinmate',
'coinone', 'coinspot', 'crex24', 'currencycom', 'delta',
'deribit', 'digifinex', 'equos', 'eterbase', 'exmo', 'exx',
'fcoin', 'fcoinjp', 'flowbtc', 'foxbit', 'ftx', 'gateio',
'gemini', 'gopax', 'hbtc', 'hitbtc', 'hollaex', 'huobijp',
'huobipro', 'idex', 'independentreserve', 'indodax',
'itbit', 'kraken', 'kucoin', 'kuna', 'lakebtc', 'latoken',
'lbank', 'liquid', 'luno', 'lykke', 'market', 'mixcoins',
'ndax', 'novadax', 'oceanex', 'okcoin', 'okex',
'paymium', 'phemex', 'poloniex', 'probit', 'qtrade',
'rightbtc', 'ripio', 'southxchange', 'stex', 'surbitcoin',
'therock', 'tidebit', 'tidex', 'timex', 'upbit', 'vbtc', 'vcc',
'wavesexchange', 'whitebit', 'xbtce', 'xena', 'yobit',
'zaif', 'zb']
```

Figure 28 ccxt library test
Source: Own Elaboration

As shown in the previous example, it was possible to extract from the "ccxt" library the names of the different exchanges from which information about their cryptocurrencies can be obtained. With this test we can check which library was installed and is being used correctly. A test was also performed for the Simple Moving Average indicator.

```
[500 rows x 5 columns]
PS C:\Backtesting\ema> python 01_sma.py
      close      volume                 date   sma_ours  sma_target
0  39519.93  276.27537 2022-04-22 20:30:00        NaN         NaN
1  39623.54  331.47312 2022-04-22 20:45:00        NaN         NaN
2  39607.32  192.40663 2022-04-22 21:00:00        NaN         NaN
3  39663.83  263.35132 2022-04-22 21:15:00        NaN         NaN
4  39622.90  135.49320 2022-04-22 21:30:00        NaN         NaN
..      ...        ...                 ...        ...         ...
495 39264.44  230.15400 2022-04-28 00:15:00  39188.188   39188.188
496 39314.78  434.34164 2022-04-28 00:30:00  39195.629   39195.629
497 39385.87  416.49159 2022-04-28 00:45:00  39212.505   39212.505
498 39543.96 1049.09013 2022-04-28 01:00:00  39258.701   39258.701
499 39519.72   43.49674 2022-04-28 01:15:00  39303.239   39303.239
```

Figure 29 Simple Moving Average
Source: Own Elaboration

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The calculation was made with a certain number of candles from the historical data, and this was the result. As it can be seen the code that generates this indicator all together with the table of the other information works correctly calculating the SMA only where it is indicated. This can be seen in the last column called "sma_target", and you can also check that this is correct with the other data being printed on the screen.

For the "RSI" indicator, a test was performed in the same way as the previous one, taking historical data from the Exchange.

```
PS C:\Backtesting\ema> python 03_rsi.py
       close      volume                 date    rsi_ours  rsi_target
0   43380.94   929.11382 2022-04-07 06:00:00         NaN         NaN
1   43445.33  1246.42515 2022-04-07 07:00:00  100.000000         NaN
2   43521.92   964.22773 2022-04-07 08:00:00  100.000000         NaN
3   43457.98  1191.87092 2022-04-07 09:00:00   66.449650         NaN
4   43409.73   954.90136 2022-04-07 10:00:00   52.213586         NaN
..       ...         ...                 ...         ...         ...
495 39221.97   827.47953 2022-04-27 21:00:00   54.709268   54.709268
496 39074.34   884.48570 2022-04-27 22:00:00   51.736436   51.736436
497 39235.72   629.92794 2022-04-27 23:00:00   54.638184   54.638184
498 39385.87  1321.56279 2022-04-28 00:00:00   57.215608   57.215608
499 39612.20   948.03094 2022-04-28 01:00:00   60.828594   60.828594
```

Figure 30 RSI
Source: Own Elaboration

Figure 30 shows the extracted data to verify that the calculation is correct. The "RSI" can be visualized in the last two columns, the reason why we have two columns is because one was calculated manually with code statements and the other column was calculated by the pandas_ta library function. By observing both columns you can deduce that both are the same and therefore correct.

The last indicator we used was the Bollinger Bars. For this one, the calculation was made in the same way as the previous ones, i.e., with the same data. The result is shown below.

```
PS C:\Backtesting> python 04_bollbands.py

Target

    BBL_20_20.0 BBM_20_20.0 BBU_20_20.0
BBB_20_20.0 BBB_20_20.0 BBP_20_20.0
BBP_20_20_20.0

0 NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN

1 NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN

2 NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN

3 NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN

4 NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN

495 32962.502780 38884.6720 44806.841220
30.460173 0.528478

496 33333.655724 38917.0615 44500.467276
28.693871 0.514084

497 33880.167303 38961.6885 44043.209697
26.084707 0.526964

498 34277.228335 39010.4355 43743.642665
24.266364 0.539660

499 34486.951875 39070.5765 43654.201125
23.463307 0.559164

[500 rows x 5 columns] [500 rows x 5 columns

Ours

BBL MID BBU

0 NaN NaN NaN NaN

1 NaN NaN NaN NaN NaN

2 NaN NaN NaN NaN

3 NaN NaN NaN NaN NaN

4 NaN NaN NaN NaN NaN

495 32808.654583 38884.6720 44960.689417

496 33188.608043 38917.0615 44645.514957

497 33748.157756 38961.6885 44175.219244

498 34154.267413 39010.4355 43866.603587

499 34367.876861 39070.5765 43773.276139
```

Figure 31 Bollinger Bars
Source: Own Elaboration

As we can see in the results we have two different tables showing the calculation of the Bollinger Bars, the first one is calculated by the pandas_ta library and the second one was calculated manually with code statements. In this case the first one shows more complete information of the bars, but nevertheless the calculations coincide and both are correct.

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To analyze the behavior of the programmed strategy, the test was carried out with historical data of some cryptocurrencies, and thus establishing percentages of profit, loss, time periods, among other things, in order to observe if the operation is correct or if certain parameters, variables, indicators, etc. had to be adjusted.

```
PS C:Backtesting> python backtester.py

{'symbol': '-', 'start_date': 0 2022-04-27 23:25:00

1 2022-04-27 23:26:00

2 2022-04-27 23:27:00

3 2022-04-27 23:28:00

4 2022-04-27 23:29:00

95 2022-04-28 01:00:00

96 2022-04-28 01:01:00

97 2022-04-28 01:02:00

98 2022-04-28 01:03:00

99 2022-04-28 01:04:00

Name: date, Length: 100, dtype: datetime64[ns],
'end_date': '-', 'balance': 1000, 'profit': 0,
'drawdown': 0, 'profitG_after_fees': 0.0,
'num_operations': 2, 'num_long': 2, 'winned': 0,
'lost': 0, 'winrate': 0, 'fitness_function': 0}
```

Figure 32 Strategy backtesting results
Source: Own Elaboration

The results show some data such as the dates on which the execution of the strategy was simulated, start and end dates, total number of trades, win-loss, this execution was carried out for a short time and the conditions for opening orders were not met, but the actions carried out are the most appropriate for the scenario proposed.

In the genetic algorithms, all the indicators used for the strategy were taken as parameters and the most optimal combination of these indicators was searched for 20 generations. The result is shown below.

```
BEST INDIVIDUAL:

{'symbol': 'ETH/USDT', 'start_date': '', 'end_date': '',
'balance': 1001.9941859261842, 'profit':
1.9941859261841413, 'drawdown': 0,
'profit_after_fees': 1.983816161593679837,
'num_operations': 26, 'num_long': 25, 'winned': 1,
'lossed': 0, 'winrate': 1.0, 'fitness_function':
1.917484864674847512}

[58, 15, 79, 93, 42]

WORST INDIVIDUAL:

{'symbol': 'ETH/USDT', 'start_date': '', 'end_date': '',
'balance': 986.1943896971227, 'profit': -
13.805610302877293, 'drawdown': -
16.06259249743904, 'profit_after_fees': -
13.888443964694694556, 'num_operations': 30,
'num_long': 28, 'winned': 1, 'lossed': 1, 'winrate': 0.5,
'fitness_function': -13.9384949464014762}

[76, 15, 79, 81, 42
```

Figure 33 Results of genetic algorithms
Source: Own Elaboration

As it can be seen in Figure 33, we ran from 0 to 19 generations, followed by the best individual along with the results obtained by looking for the best and worst combination of the indicators This helps to optimize the strategy by finding the best conditions to say whether it is time to buy or sell. The test of the bot with real money was performed on Monday, April 4 of this year at 13:00 hours in the Binance Exchange with the cryptocurrencies CLV, ADA, VET, MINA with an initial balance of 20 dollars, a profit percentage of 2% and a loss percentage of 1%. The time this test lasted was approximately one hour in which the bot was trading and detecting signals in order to know when to enter or exit, finding a buy opportunity and a sell opportunity a few seconds after the cryptocurrency "VET", obtaining a profit of approximately 2%. in the chart below a trade can be seen saved in the order history in Binance.

Figure 34 Order history of the 1st execution
Source: Own Elaboration

After this execution it was possible to deduce that the bot could open and close operations correctly depending on how it was configured. So it was decided to perform a full 24-hour test starting that same day at approximately 4 pm and ending the next day at the same time. Below is a screenshot showing most of the operations performed during that period of time, in this screenshot We can see some data about the orders, among the most important we have gotten the time and date that was executed, the type of order (buy or sell), the price at which it was bought or sold and its status. The complete results of this test can be seen in Annex A.

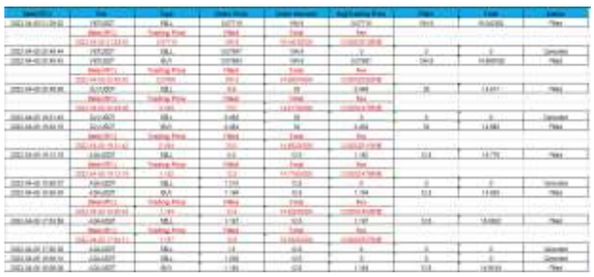

Figure 35 Order history of the 2nd execution
Source: Own Elaboration

When analyzing the results carefully and at the same time seeing how cryptocurrency prices behaved, it is observed that the program had lost profit opportunities since the purchase was made, the price of some cryptocurrencies rose enough to make a profit, but the percentage initially indicated to the bot was somehow ambitious and therefore complicated to fulfill. therefore it was decided to modify that value for one that was not so high in order to take advantage of all possible opportunities. Once the parameter was changed, another test was performed on the same day (April 5, 2022). The following image shows some of the operations performed during that time. The complete results of this test can be seen in Annex B.

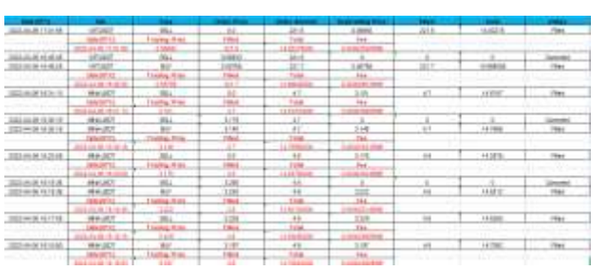

Figure 36 Order history of the 3rd execution
Source: Own Elaboration

Finally, on this test it was observed that the price of some assets was falling and when this happened the bot would have to activate the maximum percentage of loss and close the operation to protect the trader from loss, but apparently that percentage of loss was too low, so there was a considerable loss of assets. That is why it was decided to stop the test execution so as to change that parameter.

Currently (date of preparation of this report) the bot continues to operate with the above mentioned adjustments. This project will continue to be developed to improve, optimize and/or create new trading strategies to maximize investor's profitability.

Conclusion

Algorithmic trading is a tool that allows to automate processes that sometimes may be done better by a machine than by a human, however, it may not always be so. This tool is rather used to automate strategies and to study which things work in the market and which ones do not. It is something that may be very helpful, but it does not make anyone rich overnight whatsoever.

A cryptobot is very useful in many aspects compared to a human, for instance when calculating indicators quicker, opening and closing orders, does not affect the factor of emotions that in humans is very common to influence decisions made when trading, they can also be operating 24 hours a day 7 days a week without resting and then taking advantage of all the opportunities that may occur at any time.

In this bot we introduced a basic strategy that operates well in the Exchange sending the most optimal possible parameters according to the situation that arises, however, we could improve its efficiency to operate with minimal human supervision, as well as increase the ability to predict the market through mathematical models, and the correct use of some indicators to find patterns or any other advantage that can be exploited that cannot be detected at a naked eye or if is very difficult to calculate for a person.

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Algorithmic trading of cryptocurrencies is an environment where you can take advantage of several factors that may help increase the profitability of a investor, this all through taking advantage of all the tools that are available today such as programming languages, libraries to calculate indicators and extracting data, among many others that can be used in the most convenient way. This project is planned to improve it and continue it. In a near future we will create new strategies and ways to increase efficiency when predicting the market.

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Annex A

Table of Results

Date(UTC)	Pair	Type	Order Price	Order Amount	AvgTrading Price	Filled	Total	status
2022-04-05 21:29:02	VETUSDT	SELL	0.07718	194.9	0.07718	194.9	15.042382	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 21:29:42	0.07718	194.9	15.042382000	0.00002513BNB			
2022-04-05 20:49:44	VETUSDT	SELL	0.07847	194.9	0	0	0	Canceled
2022-04-05 20:49:42	VETUSDT	BUY	0.07693	194.9	0.07891	194.9	14.986759	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 20:49:42	0.07891	194.9	14.98975900	0.00002592BNB			
2022-04-05 20:49:08	CLVUSDT	SELL	0.0	33	0.449	33	14.817	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 20:49:08	0.449	33.0	14.81700000	0.00002475BNB			
2022-04-05 19:21:43	CLVUSDT	SELL	0.463	33	0	0	0	Canceled
2022-04-05 19:20:15	CLVUSDT	BUY	0.454	33	0.454	33	14.982	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 19:21:42	0.454	33.0	14.98200000	0.00002511BNB			
2022-04-05 19:12:19	ADAUSDT	SELL	0.0	12.5	1.182	12.5	14.775	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 19:12:19	1.182	12.5	14.77500000	0.00002479BNB			
2022-04-05 18:50:07	ADAUSDT	SELL	1.218	12.5	0	0	0	Canceled
2022-04-05 18:50:04	ADAUSDT	BUY	1.194	12.5	1.194	12.5	14.925	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 18:50:04	1.194	12.5	14.92500000	0.00002493BNB			
2022-04-05 17:59:59	ADAUSDT	SELL	1.197	12.6	1.197	12.6	15.0822	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 17:54:11	1.197	12.6	15.08220000	0.00002507BNB			
2022-04-05 17:50:30	ADAUSDT	SELL	1.2	12.6	0	0	0	Canceled
2022-04-05 16:06:10	ADAUSDT	SELL	1.208	12.5	0	0	0	Canceled
2022-04-05 16:06:08	ADAUSDT	BUY	1.184	12.6	1.184	12.6	14.9184	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 16:06:08	1.184	12.6	14.91840000	0.00002497BNB			
2022-04-05 13:33:29	VETUSDT	SELL	0.0	189.3	0.07829	189.3	14.820297	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 13:33:29	0.07829	189.3	14.82029700	0.00002445BNB			
2022-04-05 07:02:36	VETUSDT	SELL	0.08081	189.3	0	0	0	Canceled
2022-04-05 07:02:34	VETUSDT	BUY	0.07823	189.3	0.07823	189.3	14.986239	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 07:02:34	0.07823	189.3	14.98623900	0.00002495BNB			
2022-04-05 06:55:50	ADAUSDT	SELL	0.0	12.4	1.196	12.4	14.8304	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 06:55:50	1.196	12.4	14.83040000	0.00002463BNB			
2022-04-05 04:55:23	ADAUSDT	SELL	1.233	12.4	0	0	0	Canceled
2022-04-05 04:54:47	ADAUSDT	BUY	1.209	12.4	1.209	12.4	14.9916	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 04:55:09	1.209	12.4	14.99160000	0.00002478BNB			
2022-04-05 04:11:21	MINAUSDT	SELL	3.21	4.7	3.21	4.7	15.087	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 04:54:33	3.210	4.7	15.08700000	0.00002468BNB			
2022-04-05 03:52:15	MINAUSDT	BUY	3.147	4.7	3.147	4.7	14.7909	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 04:11:09	3.147	4.7	14.79090000	0.00002436BNB			
2022-04-04 22:36:40	CLVUSDT	SELL	0.467	32.7	0.467	32.7	15.2709	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 01:28:36	0.467	32.7	15.27090000	0.00002557BNB			
2022-04-04 22:35:09	CLVUSDT	BUY	0.458	32.7	0.458	32.7	14.9766	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-04 22:36:35	0.458	32.7	14.97660000	0.00002523BNB			

Annex B

Table of Results 2

Date(UTC)	Pair	Type	Order Price	Order Amount	AvgTrading Price	Filled	Total	status
2022-04-06 17:01:59	VETUSDT	SELL	0.0	221.5	0.06692	221.5	14.82278	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 17:01:59	0.06692	221.5	14.82278000	0.00002632BNB			
2022-04-06 16:45:45	VETUSDT	SELL	0.06833	221.6	0	0	0	Canceled
2022-04-06 16:45:25	VETUSDT	BUY	0.06765	221.7	0.06765	221.7	14.998005	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:45:28	0.06765	221.7	14.99800500	0.00002661BNB			
2022-04-06 16:31:13	MNAUSDT	SELL	0.0	4.7	3.101	4.7	14.5747	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:31:13	3.101	4.7	14.57470000	0.00002585BNB			
2022-04-06 16:30:19	MNAUSDT	SELL	3.179	4.7	0	0	0	Canceled
2022-04-06 16:30:18	MNAUSDT	BUY	3.148	4.7	3.148	4.7	14.7956	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:30:18	3.148	4.7	14.79560000	0.00002641BNB			
2022-04-06 16:20:09	MNAUSDT	SELL	0.0	4.5	3.175	4.5	14.2875	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:20:09	3.175	4.5	14.2875000	0.00002524BNB			
2022-04-06 16:18:38	MNAUSDT	SELL	3.258	4.5	0	0	0	Canceled
2022-04-06 16:18:36	MNAUSDT	BUY	3.226	4.6	3.222	4.6	14.8212	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:18:36	3.222	4.6	14.82120000	0.00002614BNB			
2022-04-06 16:17:09	MNAUSDT	SELL	3.229	4.5	3.229	4.5	14.5305	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:16:18	3.229	4.5	14.53050000	0.00002568BNB			
2022-04-06 16:16:50	MNAUSDT	BUY	3.197	4.6	3.197	4.6	14.7062	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:16:53	3.197	4.6	14.70620000	0.00002590BNB			
2022-04-06 16:16:17	MNAUSDT	SELL	0.0	4.5	3.19	4.5	14.355	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:16:17	3.190	4.5	14.35500000	0.00002533BNB			
2022-04-06 16:15:22	MNAUSDT	SELL	3.263	4.5	0	0	0	Canceled
2022-04-06 16:15:04	MNAUSDT	BUY	3.231	4.6	3.231	4.6	14.8526	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:15:10	3.231	0.4	1.29240000	0.00000229BNB			
	2022-04-06 16:15:17	3.231	4.2	13.57020000	0.00002409BNB			
2022-04-06 15:35:06	CLVUSDT	SELL	0.408	37.1	0.408	37.1	15.1368	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 16:08:06	0.408	37.1	15.13680000	0.00003668BNB			
2022-04-06 15:35:04	CLVUSDT	BUY	0.404	37.1	0.404	37.1	14.9884	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 15:35:04	0.404	37.1	14.98840000	0.00002646BNB			
2022-04-06 15:28:55	CLVUSDT	SELL	0.0	36.7	0.402	36.7	14.7534	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 15:28:55	0.402	36.7	14.75340000	0.00002611BNB			
2022-04-06 15:25:20	CLVUSDT	SELL	0.411	36.7	0	0	0	Canceled
2022-04-06 15:25:16	CLVUSDT	BUY	0.407	36.8	0.407	36.8	14.9776	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 15:25:16	0.407	36.8	14.97760000	0.00002632BNB			
2022-04-06 14:10:26	ADAUSDT	SELL	1.115	13.5	1.115	13.5	15.0525	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 14:32:52	1.115	13.5	15.05250000	0.00009540BNB			
2022-04-06 14:10:23	ADAUSDT	BUY	1.104	13.5	1.104	13.5	14.904	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 14:10:23	1.104	13.5	14.90400000	0.00009229BNB			
2022-04-06 13:05:17	ADAUSDT	SELL	1.116	13.4	1.116	13.4	14.9544	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 13:27:55	1.116	13.4	14.95440000	0.00009568BNB			
2022-04-06 13:05:15	ADAUSDT	BUY	1.114	13.4	1.114	13.4	14.9276	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 13:05:15	1.114	13.4	14.92760000	0.00009553BNB			
2022-04-06 12:59:13	ADAUSDT	SELL	1.111	13.5	1.111	13.5	14.9985	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 13:00:28	1.111	13.5	14.99850000	0.00009585BNB			
2022-04-06 12:59:11	ADAUSDT	BUY	1.109	13.5	1.109	13.5	14.9715	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 12:59:11	1.109	13.5	14.97150000	0.00009581BNB			
2022-04-06 12:56:32	ADAUSDT	SELL	1.111	13.5	1.111	13.5	14.9985	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 12:56:36	1.111	13.5	14.99850000	0.00009584BNB			
2022-04-06 12:55:19	ADAUSDT	BUY	1.109	13.5	1.109	13.5	14.9715	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 12:56:21	1.109	13.5	14.97150000	0.00009577BNB			
2022-04-06 11:35:12	ADAUSDT	SELL	1.119	13.4	1.119	13.4	14.9946	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 12:18:27	1.119	13.4	14.99460000	0.00009574BNB			
2022-04-06 11:34:52	ADAUSDT	BUY	1.117	13.4	1.117	13.4	14.9678	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:34:54	1.117	13.4	14.96760000	0.00009569BNB			
2022-04-06 11:34:18	VETUSDT	SELL	0.07152	210	0.07152	210	15.0192	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:34:37	0.07152	210.0	15.01920000	0.00009588BNB			
2022-04-06 11:33:56	VETUSDT	BUY	0.07138	210.1	0.07138	210.1	14.996938	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:33:59	0.07138	210.1	14.99691880	0.00009577BNB			
2022-04-06 11:33:21	ADAUSDT	SELL	1.119	13.4	1.119	13.4	14.9946	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:33:57	1.119	13.4	14.99460000	0.00009586BNB			
2022-04-06 11:33:17	ADAUSDT	BUY	1.117	13.4	1.117	13.4	14.9678	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:32:17	1.117	13.4	14.96780000	0.00009581BNB			
2022-04-06 11:27:54	ADAUSDT	SELL	0.0	13.3	1.111	13.3	14.7763	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:27:54	1.111	13.3	14.77630000	0.00009453BNB			
2022-04-06 11:21:41	ADAUSDT	SELL	1.125	13.3	0	0	0	Canceled
2022-04-06 11:21:38	ADAUSDT	BUY	1.123	13.3	1.123	13.3	14.9359	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:21:38	1.123	13.3	14.93590000	0.00009571BNB			
2022-04-06 11:21:20	MNAUSDT	SELL	3.092	4.7	3.092	4.7	14.5324	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:21:31	3.092	4.7	14.53240000	0.00002607BNB			
2022-04-06 11:21:19	MNAUSDT	BUY	3.086	4.8	3.086	4.8	14.8128	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:21:20	3.086	4.8	14.81280000	0.00002651BNB			
2022-04-06 11:02:43	ADAUSDT	SELL	0.0	13	1.122	13	14.586	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 11:02:43	1.122	13.0	14.58600000	0.00009264BNB			
2022-04-06 10:45:08	ADAUSDT	SELL	1.136	13.1	0	0	0	Canceled
2022-04-06 10:45:06	ADAUSDT	BUY	1.134	13.2	1.134	13.2	14.9688	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:45:06	1.134	1.7	1.92780000	0.00000329BNB			
	2022-04-06 10:45:06	1.134	11.5	13.04100000	0.00002227BNB			
2022-04-06 10:40:29	VETUSDT	SELL	0.073	205.9	0.073	205.9	15.0307	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:45:04	0.07305	205.5	15.03270000	0.00002659BNB			
2022-04-06 10:40:27	VETUSDT	BUY	0.07285	205.9	0.07285	205.9	14.999815	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:40:27	0.07285	205.9	14.99981500	0.00002652BNB			
2022-04-06 10:33:51	VETUSDT	SELL	0.07337	204.8	0.07337	204.8	15.026176	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:34:48	0.07337	204.8	15.02617600	0.00002659BNB			
2022-04-06 10:24:42	VETUSDT	BUY	0.07322	204.8	0.07322	204.8	14.995456	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:33:45	0.07322	204.8	14.99545600	0.00002656BNB			
2022-04-06 10:20:43	VETUSDT	SELL	0.0732	205.3	0.0732	205.3	15.02796	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:24:23	0.07320	205.3	15.02796000	0.00002662BNB			
2022-04-06 10:20:21	VETUSDT	BUY	0.07305	205.3	0.07305	205.3	14.997165	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:20:25	0.07305	205.3	14.99716500	0.00002660BNB			
2022-04-06 09:58:16	VETUSDT	SELL	0.07377	203.6	0.07377	203.6	15.019572	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 10:00:17	0.07377	203.6	15.01957200	0.00002654BNB			
2022-04-06 09:58:13	VETUSDT	BUY	0.07362	203.7	0.07361	203.7	14.994357	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 09:58:13	0.07361	203.7	14.99435700	0.00002653BNB			
2022-04-06 09:36:37	ADAUSDT	SELL	1.142	13	1.142	13	14.846	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 09:50:06	1.142	13.0	14.84600000	0.00002626BNB			
2022-04-06 09:35:22	ADAUSDT	BUY	1.14	13.1	1.14	13.1	14.934	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 09:36:22	1.140	13.1	14.93400000	0.00002644BNB			
2022-04-06 08:22:39	MNAUSDT	SELL	3.272	4.5	3.272	4.5	14.724	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 08:26:02	3.272	4.5	14.72400000	0.00002603BNB			
2022-04-06 08:22:37	MNAUSDT	BUY	3.265	4.5	3.264	4.5	14.688	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 08:22:37	3.264	4.5	14.68800000	0.00002492BNB			
2022-04-06 08:20:50	MNAUSDT	SELL	3.269	4.5	3.269	4.5	14.7105	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 08:22:07	3.269	1.8	5.88420000	0.00001502BNB			
	2022-04-06 08:22:10	3.269	2.7	8.82630000	0.00001503BNB			
2022-04-06 08:20:16	MNAUSDT	BUY	3.262	4.5	3.262	4.5	14.679	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 08:20:40	3.262	4.5	14.67900000	0.00002488BNB			
2022-04-06 08:13:46	CLVUSDT	SELL	0.0	34	0.435	34	14.79	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 08:13:46	0.435	34.0	14.79000000	0.00002519BNB			
2022-04-06 08:01:18	CLVUSDT	SELL	0.442	34	0	0	0	Canceled
2022-04-06 07:55:14	CLVUSDT	BUY	0.441	34	0.441	34	14.994	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 08:01:08	0.441	34.0	14.99400000	0.00002545BNB			
2022-04-06 04:47:18	CLVUSDT	SELL	0.449	33.3	0.449	33.3	14.9517	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 05:07:14	0.449	33.3	14.95170000	0.00002529BNB			
2022-04-06 04:46:43	CLVUSDT	BUY	0.448	33.4	0.448	33.4	14.9632	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 04:47:04	0.448	17.4	7.79520000	0.00001338BNB			
	2022-04-06 04:47:16	0.448	16.0	7.16800000	0.00001226BNB			
2022-04-06 04:10:31	ADAUSDT	SELL	1.141	13	1.141	13	14.833	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 04:11:43	1.141	13.0	14.83300000	0.00002526BNB			
2022-04-06 04:10:29	ADAUSDT	BUY	1.139	13.1	1.139	13.1	14.9209	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 04:10:29	1.139	13.1	14.92090000	0.00002542BNB			
2022-04-06 03:21:30	ADAUSDT	SELL	1.145	13	1.145	13	14.885	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 03:47:32	1.145	13.0	14.88500000	0.00002536BNB			
2022-04-06 03:21:26	ADAUSDT	BUY	1.143	13.1	1.143	13.1	14.9733	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 03:21:26	1.143	13.1	14.97330000	0.00002545BNB			
2022-04-06 03:20:14	VETUSDT	SELL	0.07351	204.4	0.07351	204.4	15.025444	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 03:21:21	0.07351	204.4	15.02544400	0.00002557BNB			
2022-04-06 03:20:11	VETUSDT	BUY	0.07336	204.4	0.07336	204.4	14.994784	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 03:20:12	0.07336	204.4	14.99478400	0.00002548BNB			
2022-04-06 03:12:09	MNAUSDT	SELL	0.0	4.7	3.125	4.7	14.6875	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 03:12:09	3.125	3.4	10.62500000	0.00003690BNB			
	2022-04-06 03:12:09	3.125	1.3	4.06250000	0.00001091BNB			
2022-04-06 03:05:18	MNAUSDT	SELL	3.165	4.7	0	0	0	Canceled
2022-04-06 03:05:16	MNAUSDT	BUY	3.159	4.7	3.158	4.7	14.8426	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-06 03:05:16	3.159	4.7	14.84260000	0.00002516BNB			
2022-04-05 23:42:41	ADAUSDT	SELL	0.0	12.5	1.172	12.5	14.65	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 23:42:41	1.172	12.5	14.65000000	0.00002454BNB			
2022-04-05 23:00:05	ADAUSDT	SELL	1.186	12.5	0	0	0	Canceled
2022-04-05 23:00:03	ADAUSDT	BUY	1.184	12.6	1.184	12.6	14.9184	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 23:00:03	1.184	12.6	14.91840000	0.00002490BNB			
2022-04-05 21:29:02	VETUSDT	SELL	0.07718	194.9	0.07718	194.9	15.042382	Filled
	Date(UTC)	Trading Price	Filled	Total	Fee			
	2022-04-05 21:29:42	0.07718	194.9	15.04238200	0.00002513BNB			

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Design of a WEB application to create a repository of medicinal plants used by the Nahuas of the Huauchinango region

Diseño de una aplicación WEB para crear un repositorio de plantas medicinales usadas por los nahuas de la región de Huauchinango

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Abstract

The communication problem that the Nahua population of the state of Puebla currently have about medicinal herbs and alternative therapies is increasingly complicated, given that several cultural values are being lost, so it is an important opportunity to use digital media to rescue some remedies. The objective of this project is to develop an application to create and maintain a data repository that contains information on the medicinal plants used by the Nahua communities of the Huauchinango region. This project was born out of the need to communicate to future generations about the knowledge that is currently practiced in the Nahua communities about the properties of medicinal herbs in the region. The research work is carried out with the specialists of traditional peasant medicine with whom the diversity, use and management of medicinal plants classified by specialists of the Nahua peoples that they use to solve multiple diseases within their communities are documented. By having the system finished, the end user will be able to make queries about the medicinal plants, as well as the formula or recipe of the remedies. The administration of the repository can be done from a progressive WEB application.

Application, Repository, Medicinal plants

Resumen

La problemática comunicacional que tienen actualmente la población nahua del estado de Puebla sobre las hierbas medicinales y terapias alternativas, está cada vez más complicado, dado que se están perdiendo varios valores culturales, por lo que es una oportunidad importante usar medios digitales para rescatar algunos remedios. El presente proyecto tiene como objetivo desarrollar una aplicación para poder crear, y dar mantenimiento a un repositorio de datos que contenga información sobre las plantas medicinales usadas por las comunidades nahuas de la región de Huauchinango. Este proyecto nace por la necesidad de comunicar a las generaciones futuras sobre el conocimiento que actualmente se practica en las comunidades nahuas sobre las propiedades de las hierbas medicinales en la región. El trabajo de investigación se realiza con los especialistas de la medicina tradicional campesina con quienes se documenta la diversidad, uso y manejo de plantas medicinales clasificadas por especialistas de los pueblos nahuas que usan para resolver múltiples enfermedades dentro de sus comunidades. Al tener el sistema terminado el usuario final será capaz de poder realizar consultas sobre las plantas medicinales, así como a la fórmula o receta de los remedios. La administración del repositorio se podrá realizar desde una aplicación WEB progresiva.

Aplicación, Repositorio, Plantas medicinales

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Introduction

Who of us has never suffered from an upset stomach, a sore throat or perhaps a slight scratch, and when that happened, usually an older relative would run to the kitchen and prepare a home remedy for us, whether it was a tea, an infusion or an ointment. Medicinal plants, whether crushed for plasters, macerated in a spirit for tonics, stewed for vaporizations or prepared in teas and infusions, roots, barks, fruits, seeds, bulbs and peels offer remedies to alleviate, cure or maintain physical, emotional, mental or spiritual health, improve our quality of life at a lower cost, and even provide great longevity (Secretaría de Medio Ambiente y Recursos Naturales, 2021).

Medicinal plants are the cultural heritage of diverse peoples (Lindholm et al, 2019). This heritage is the result of a close link with nature, expressing a way of life (Vargas, 2010) that has been inherited between generations through oral transmission and is part of their collective memory (Ward, 2016). In recent years, this cultural heritage has become a research priority for the scientific community (Whitehorn et al, 2019), on the one hand, due to the pharmacological importance of medicinal plants against both existing and emerging diseases, and, on the other hand, due to the risk of their loss due to land use change, deforestation, poverty, and migration (Herrera, 2018).

Herbal medicine is a basic resource of folk medicine, but our knowledge of it is scarce and imprecise. We are far from ensuring a proper rescue of this flank of culture, as mentioned in the study "Conocimiento y uso de las plantas medicinales en la zona metropolitana de Guadalajara" (Knowledge and use of medicinal plants in the metropolitan area of Guadalajara).

The current problem is that over the years these customs and botanical knowledge have been lost little by little and nowadays it is difficult to find a reliable source of knowledge of this type of remedies in a simple way. Although there are countless recipes on various websites, many of them are not so reliable and do not have any way of guaranteeing their veracity, nor is there a reliable database to support the information published.

According to the Ministry of Health, 90% of the Mexican population has opted for one of the 4,500 medicinal plants found in Mexican territory at least once in their lifetime (Secretaría de Medio Ambiente y Recursos Naturales, 2021). Roberto Campos Navarro, an academic from the Faculty of Medicine of UNAM, mentions that our country occupies the second place worldwide in this type of documented flora.

Botany has been the most accessible and effective medicine for the peoples and communities of Mexico. The pre-Hispanic Codex de la Cruz-Badiano, chronicles and other documents of the colony and countless modern exhaustive investigations developed by prestigious universities and other national and foreign centers of knowledge account for the knowledge of national medicinal plants and their use in towns and cities.

For example, the National Commission for the Knowledge and Use of Biodiversity (Conabio) mentions the Mexican Social Security Institute's registry of 3,000 species of plants with medicinal attributes, of the 4,000 estimated to exist in Mexico, representing 15% of the total Mexican flora (Secretaría de Medio Ambiente y Recursos Naturales, 2021). It specifies that pharmacological analysis has only been carried out on 5% of the total number of these plants. Of this universe, 250 are commercialized on a daily basis, 85% are extracted from the wild without sustainable management plans, and 80% of the Mexican population has made use of them.

Thus, the need has arisen to create a repository of medicinal plants used by the Nahua communities of the Huauchinango region. Having as objectives to document the diversity of plants among the specialists of traditional medicine of the Nahua communities and to understand the system of categorization by systems of the human body. The application will allow us to add the medicinal plants used by the Nahua people of the Huauchinango region, as well as their classification, description, preparation, storage and use for each of the plants. In this way, by feeding the repository of medicinal plants, users will be able to access each of its parts and make detailed queries of each of the medicinal plants that are registered there.

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The development of this project is divided into the following sections:

1. Methodology: The steps followed for the development of the project are described.
2. Results: This section analyzes the results to determine whether the aforementioned objective has been achieved.
3. Acknowledgments: We would like to thank the people and institutions that allowed the development of this research.
4. Conclusions: The objectives satisfactorily achieved are discussed.

Methodology

The region of Huauchinango is located in the northwestern part of the state of Puebla, in the Sierra Madre Oriental. Figure 1 shows the location of the municipality, i.e. it is located in the northwestern part of the State of Puebla (Plan de Desarrollo Municipal, 2018).

Figure 1 Geographic location of the municipality of Huauchinango in the state of Puebla
Source:https://planeader.puebla.gob.mx/pdf/Municipales 2020/Huauchinango.pdf

The Nahua group of the Huauchinango region is one of the ethnic groups with the largest population of speakers of the three indigenous languages present in the region: Nahua, Totonac and Otomi.

In recent years, the percentage of speakers of some indigenous language in the region has been decreasing, among the main causes that have decreased the population is migration for work, family, education, insecurity, among others. Table 1 shows the population of 5 years and older who speak an indigenous language in the municipality of Huauchinango (INEGI, 2020).

Year	Total population (Inhabitants)	Population 5 years old and over speaking an indigenous language in the municipality of Huauchinango	Percentage of the population aged 5 years and older speaking an indigenous language in the municipality of Huauchinango
1995	75000	18933	25.24%
2000	83537	20781	24.87%
2005	90846	19878	21.88%
2010	97753	21934	22.43%
2020	103946	19579	18.83%

Table 1 Decrease in the number of indigenous language speakers in the municipality of Huauchinango
Source: Own Elaboration

The present project consists of presenting a design of a progressive web application to create, consult and maintain a data repository containing information on medicinal plants used by the Nahua people of the Huauchinango region, using information technologies, the diversity of medicinal herbs, as well as the knowledge of specialists in traditional medicine of the Nahua people of the Huauchinango region.

A. Use of medicinal plants

There is a different and special preparation for each herb, since each one activates its healing potential with different procedures. Among the most common types of preparation, within the herbs, we find the infusion, decoction, syrup, vaporization and baths, being the most used the infusion, for its convenience, speed of preparation and ease of consumption. There are many methods through which we can use medicinal plants, but it is important to emphasize that most medicinal plants are ingested and the digestive system is involved.

Decoction: It consists of maintaining the boiling point so that the active principles of hard, woody plants or roots are released; it is important in this method that the cooking is adequate so that the components do not deteriorate.

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Infusion: One of the most known and used methods is to heat the water, once it is at boiling point, soft plants, flowers, leaves should be added.

*Syrup***:** It consists of dissolving mainly water with honey or sugar, put it on the fire until the water evaporates and then add the medicinal plants.

Vaporization: It consists of adding a fistful of the plant (eucalyptus, pennyroyal, menthol, basil or camphor) to a liter of boiled water, cover and let stand ten minutes. Cover the person's head with a towel and uncover the preparation; this method is effective to decongest the respiratory tract and expel phlegm, the temperature change should be taken care of. After the vaporizations, the water can be used for bathing.

Baths: It consists of adding the plants and letting them boil in a large pot with water; wait until the water is warm and take a bath, they can be immersion in a bathtub or in a bath with a jug.

B. Selection of the most popular medicinal plants

In order to select the most popular medicinal plants, we considered the plants known and used by the majority of the Nahua population, that is, those that are most deeply rooted in the culture and customs of the people of the region, and therefore are easily accessible and consumed.

In order to obtain relevant information regarding herbs, infusions, herbal treatments, descriptive images, benefit or cultivation information, a small study was conducted consisting of the following activities:

– Visit of the adults of the Nahua population.

– Interviews with adults in the region.

– We interviewed farmers in the region.

– A field study was conducted in the town of Tenango, Huauchinango, Puebla.

– The plant markets of Tenango de las Flores and Colonias de Hidalgo, belonging to the municipality of Huauchinango, were visited.

For this study, specialized literature on popular herbs was not taken into account, since when talking specifically about this topic, the - information we can find is very extensive, complete, detailed, scientific and deep. They explain at a professional level, and talk about all kinds of herbs and seasonings.

C. Requirements of the graphical interface for the application

The graphic interface was created for a web application in which a repository of the most used medicinal plants was developed. In Table 2 we see an example of a medicinal plant "Siempreviva (Tetzmitl)" with the following information: description, uses, forms of preparation, routes of administration, scientific evaluation and a photograph of the medicinal plant, with the objective of making known and giving more credibility to this type of medicinal alternatives, approaching the general public and the Nahua group. For this it is necessary to generate the appropriate channels of information and dissemination, solving the existing communication problems in the Nahua community in the region. The application is a visual tool to identify and distinguish the most popular medicinal plants.

Siempreviva (Tetzmitl)	
Description	Small plant between 30 and 50cm high, with juicy, thick and brittle stems and yellowish-greenish leaves, has yellow flowers and nuts.
Uses	Meaty and clean eyes.
Forms of preparation	Extract in drops
Route of administration	One drop is applied directly to each eye
Scientific evaluation	Correa Arzate et al. (2015) mentioned that one of the plants used in traditional medicine to treat cold sores is S. dendroideum and studied the effect of the aqueous extract on the cell proliferation of gingival fibroblasts, obtaining that certain concentrations of the extract increase cell apoptosis and recommends a detailed analysis of the effects of each component.
Image	

Table 2 Main medicinal plant information.
Source: Own Elaboration

D. Requirements of the graphical interface for the application

For the realization of this project we used the Waterfall methodology which consists in the sequential development of the project. This methodology consists in the fact that each of its phases are executed one after the other, that is to say, we do not move to another phase without finishing the previous one, this methodology promotes the step by step philosophy.

1. System and software requirements analysis:
– Based on the consultations with the Nahua people, requirements were established for the creation of records for the design of the database, hardware to be acquired, as well as the scope of the application.
– The software requirements specification document was created.

2. Design:
– Application flow diagrams.
– Sequence diagram.
– Entity-relationship diagram of the database.
– The system has a content manager to be able to make modifications to the design of the progressive web application, without the need of modifying the code and resorting to the additional expense of hiring a programmer for this task.
– The system has an administrator user with which you can perform CRUD operations to the plant repository.
– The system has a user that can be used to make queries to the repository; this user will be the default user to access the application.

3. Implementation and unit testing:
– All the elements that make up the developed software were integrated and the recurrent connection to the database was verified.
– Unit tests were developed for each of the modules created in the development of the system to verify their optimal operation.

4. System integration and testing:
– The system and the connection to the database were tested to verify its operation.
– System tests were performed on different devices to verify the performance of the application.

5. Maintenance:
– After the installation and start-up of the system, the errors reported by the users were verified in order to resolve them and leave the system in optimal conditions.

Results

Finally, for the design of the web application, an image alluding to the theme of medicinal plants (in Nahuatl tlazol patli) was considered. Figure 2 shows the image of the logo, the word patli was chosen in the Nahuatl language, which means medicine, and the colors are characteristic of nature.

Figure 2 Logo of the web application "Patli"
Source: Own Elaboration

Within the web application, the main screen shows the specific contents taken from the requirements of the graphic interface for the application: description, uses, forms of preparation, routes of administration, scientific evaluation and photograph of the medicinal plant. The web application displays a list of images showing the name of the plant, as well as its name in Nahuatl, as shown in Figures 3 and 4.

Figure 3 List of plants in the repository
Source: Own Elaboration

Figure 4 Plant name in Spanish and in Nahuatl language
Source: Own Elaboration

Clicking on the image shows a detailed general description of the plant (see Figure 5), as well as its use and instructions for use

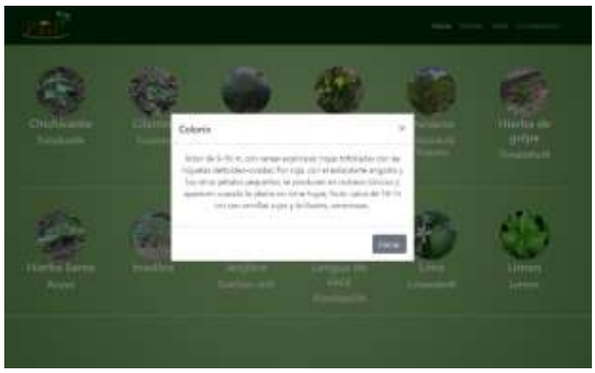

Figure 5 Description of the medicinal plant
Source: Own Elaboration

In Figure 6, Patli shows a quick reference table of medicinal plants showing the disease they can help alleviate

Figure 6 Quick reference table for medicinal plants
Source: Own Elaboration

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Conclusions

From the beginning, the ideas to define the Patli repository were generated thanks to a research on medicinal plants. In this process, field studies, interviews to farmers, surveys to people from the Nahua group and visits to plant markets located in the region of Huauchinango were carried out.

Patli is a web repository, which shows the medicinal use of plants used by the Nahua people of the region, the creation of this repository allows transmitting knowledge to future generations about the knowledge that is currently practiced in the communities of this ethnic group about the medicinal properties of plants. The information contained in the repository has been compiled with specialists in traditional medicine who have provided knowledge on the use and management of medicinal plants. These have been carefully classified to treat various diseases such as: stomach aches, kidney, headaches, eye ailments, among others.

The project can generate a great impact, as it encourages the Nahua ethnic group to join to participate and cooperate with the knowledge they have about medicinal plants. In addition to encouraging the general population to use medicinal plants.

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Perception of the use of Blockchain and its impact on transparency in public institutions

Percepción del uso de Blockchain y su impacto en la transparencia de las instituciones

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Abstract

The arrival of Blockchain provides solutions to institutions in different sectors such as finance, also in other areas, such as accounting, audits, legal aspects, smart contracts, the supply chain and the transparency of institutions, which contributes in better management. Hence, this work was focused on investigating 2 objectives, the perception of Blockchain and its impact on the transparency of information in institutions, as well as the existing correlation of both variables. In this work, a descriptive and correlational analytical methodology was used, the sample was made up of 33 university professors and 142 students who have entered the labor sector through their internships and internship processes or are already working and are recent entrants. . The information was collected through a structured questionnaire, with alternatives of multiple answers. The findings showed regarding one of the objectives that the perception of Blockchain is acceptable, understanding its potential that it offers. Regarding the second objective, a correlation of 0.771 was evidenced at a significance level of 0.029, indicating that there is a high and statistically significant relationship between the perception variables on Blockchain and its impact on the transparency of information in institutions.

Transparency, Correlation, Findings

Resumen

La llegada de Blockchain brinda soluciones a las instituciones en diferentes sectores como el financiero, también en otras áreas, como la contabilidad, las auditorías, los aspectos legales, los contratos inteligentes, la cadena de suministro y la transparencia de las instituciones, lo que contribuye a una mejor gestión. De ahí que este trabajo se enfocó en investigar 2 objetivos, la percepción de Blockchain y su impacto en la transparencia de la información en las instituciones, así como la correlación existente de ambas variables. En este trabajo se utilizó una metodología analítica descriptiva y correlacional, la muestra estuvo conformada por 33 docentes universitarios y 142 estudiantes que han ingresado al sector laboral a través de sus pasantías y procesos de pasantía o ya están laborando y son de reciente ingreso. La información fue recolectada a través de un cuestionario estructurado, con alternativas de respuesta múltiple. Los hallazgos mostraron respecto a uno de los objetivos que la percepción de Blockchain es aceptable, entendiendo el potencial que ofrece. Respecto al segundo objetivo, se evidenció una correlación de 0.771 a un nivel de significancia de 0.029, indicando que existe una relación alta y estadísticamente significativa entre las variables de percepción sobre Blockchain y su impacto en la transparencia de la información en las instituciones.

Transparencia, Correlación, Hallazgos

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Introduction

The purpose of this research is to provide insight into the perception of the impact that Blockchain has on the transparency of institutions, as a tool in the use of Information and Communication Technologies, as well as to know the correlation between two study variables (Blockchain and transparency of information).

With Blockchain, money is sent directly and securely from one person to another without being physically in a bank, now, the financial world uses hybrid systems such as the Bank of England (Allison, 2015), Visa (Arnold, 2016), systems for streamlining and improving the security of real estate transactions, such as property registration or applications for improving transparency in public accounts (Goswami, 2016), thus enabling the user to clearly understand the status of the operations carried out, at least with respect to the information that is recorded in a structured manner, hence the need for organisations to orientate processes in line with technological progress.

The digitalisation of information management in companies, especially in smaller ones, is still in progress, mainly due to factors such as lack of knowledge and implementation of the technological infrastructure. In this sense, an analysis is required on the restructuring of procedures and methods according to the new scenarios of public institutions with technology and transparency, which means that every company is called upon to implement and take advantage of technological resources. Blockchain provides confidentiality of the identity of operators, an indelible record of each of the transactions and thus avoids risks in the non-secure and permanent identity, as well as the use of encrypted transfers to achieve secure communication of data (Atencio Flores & Mamani Machaca, 2017).

Blockchain makes it possible to certify the authenticity of all kinds of objects and acts, and to combat fraud, as in the case of the company Provenance, which aims to control the life and history of its wines to allow consumers to know the entire journey until they reach their table (Parker, 2015) or the case of the company Ujo Music, which ensures the management of the copyright of musical productions (Capps, 2016).

Likewise, blockchain helps in activities such as generating and knowing updated account statements in real time from a mobile device, automatic accounting of recurring expenses and invoices or bank reconciliation with a single click. Another application is smart contracts, which are automatically executed when the conditions specified and agreed in the contract with the user are met (Padilla, 2020).

With the use of Blockchain, access to information is facilitated, which has a significant impact on the basis for the construction of knowledge, so one element that must be considered at the institutional level is to have competent staff in the efficient use of technologies (Guitert, 2013).

In addition, when correct use is mentioned, it refers to the access, management and processing of information, so that it is presented in the appropriate format, achieving the automation of processes, which facilitates decision-making in real time, improving the internal logistics of a company, times in activities of different internal processes, the attention with certainty to problems that require help for the handling of private information, taking advantage of the security it provides that such information cannot be modified by a third party and there are no people who act as intermediaries who manage to violate the security of the information.

On the other hand, society requires institutions to generate transparency in the information on the management of public funds, this concern exists and the effects can be positive in terms of transparency and public innovation.

However, the principle of transparency in public institutions becomes an incomplete ideal if there are no agencies or institutions with the capacity to sanction and enforce accountability. As Jonathan Fox (2008: 174) points out, transparency confuses the normative with the analytical. In public administration, for example, records are observed in various procedures, but how to certify information such as the nationality of a citizen, the ownership of a house or an identity, so that it becomes a database to be used in public administration.

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Through the management of data, it is possible to infer some act of corruption or embezzlement, it is precisely in the processes where the evidence lies, which generates the search for greater levels of transparency in the processes of public administration, it means raising one more step on the road to greater accountability and that is where the use of technology is required (Naser, Ramírez-Alujas and Rosales, 2017).

Blockchain enables the creation of a disruptive political and governance model, allowing for transparency and fostering the creation of social trust, helping to eliminate corruption and cutting out intermediaries. The exchange of data, where transfers of value are made through the use of smart contracts, is accompanied by savings, immediacy, increased security, flexibility and optimisation of processes. The European Union, for example, analyses the application of Blockchain through an observatory, the European Union Blockchain Observatory & Forum (EUBOF), and provides a series of reports on features and guarantees (EUBOF, 2018).

De Filippi (2017) reports on transparency with pseudonymity for transactions on a Blockchain, as each user and node is identified by a unique numerical address, pseudonymous with an identity that, due to technical characteristics, is not known if the user so chooses. All transactions are immutably recorded in the distributed database, i.e. a significant set of participating nodes keep encrypted copies of each previously agreed transaction, so that it is technically impossible to delete or falsify the historical record of executed transactions (Brandom, 2019).

Blockchain, therefore, is a technology that makes it possible to create an environment of transparency, so that technology and public administration are not mutually exclusive but complementary; it is possible to achieve mechanisms of trust and improve traceability and transparency. With this tool, the institutions will be able to generate mechanisms that do not require trust in the public administration, as it is capable of eliminating the discretionality of the officials on duty, ensuring that who controls the one who controls is everyone, i.e., it makes it possible to create trust in a mechanism without the need to trust people.

Unfortunately, there is still a lack of knowledge about the potential of this technology in public institutions and this is where universities provide graduates with knowledge oriented towards technological competences so that they can develop efficiently in their professional and work context, hand in hand with technological tools such as Blockchain and the companies that demand, above all, aspects of transparency, which leads us to think that, from educational institutions, more research and use of technologies that impact areas with the possibility of counting and using financial resources. This will allow for real-time information, with feedback for the fulfilment of goals, productivity and development of new strategies to improve the logistics of the company's activities and create a culture of transparency with mechanisms of trust and improve traceability.

Metodology

Considering the objectives of the study, a combination of research methods was assumed, mainly involving descriptive analytical research procedures; this is a preliminary stage of data processing that creates a historical summary of the data to provide useful information and prepare it for further analysis, which helps to answer the question, i.e. a descriptive analytical methodology supports organisations to understand what happened in the past. By understanding the relationship between two variables, e.g. customers and products, it aims to gain an understanding of the approach to be taken in the future: learning from past behaviour in order to influence future outcomes.

For Garza-Mercado (2007) this type of research directs procedures to a study phenomenon in its entirety and interconnections to discover what accounts for its integration. This research suggests that analysis as the processing of qualitative information and statistical data is carried out in descriptive research, however, it depends on the level of research with which the researcher concludes.

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On the other hand, according to the objectives of the study, which seeks to determine the relationship between the perception of Blockchain and its impact on the transparency of information in institutions, a correlational methodology was established to measure two variables (Blockchain and Transparency of information in institutions) and its purpose is to study the degree of correlation between them, therefore, this methodology seeks to discover how one variable varies when the other does. Tamayo and Tamayo (2009) consider that this methodology seeks to determine the degree to which variables in one or several factors are concomitant with the variation of one or more other factors. Therefore, this research identifies, describes and defines the characteristics, properties and behaviours of the variables Perception of the Blockchain and its impact on information transparency in institutions.

In the same vein, Méndez and Astudillo (2008) consider that correlational research examines the relationships between variables or their results, but without explaining that one is the cause of the other. The importance of these lies in measuring the level of relationship between the two. At the end of the study, the level of correlation was established by applying Spearman's Rho formula. As for the data collection technique, a questionnaire with 10 multiple-choice items was elaborated and applied to a population of 33 university teachers and 142 students. Once the data had been collected using the instruments designed for this purpose, it was necessary to process them, that is, to elaborate them mathematically, since quantification and their statistical treatment allow conclusions to be drawn. According to Tamayo and Tamayo (2008), whatever the technique used for this, it is nothing more than the recording of the data obtained by the instruments used, by means of an analytical technique in which the conclusions were obtained.

For the analysis of the data provided by the instrument, descriptive statistics were used, by means of which the data were presented in a double-entry matrix, where the items grouped by blocks were located in the upper part, according to the indicators. Dimensions and the variable, on the left side, the research subjects were noted.

The degree of correlation between the perception of Blockchain and its impact on transparency from the information in the institutions was established using Spearman's Rho formula. These results were then contrasted with the theories underpinning the study, reviewing the conclusions to which they gave rise, and presenting the recommendations relevant to these results.

The Rho Spearman formula is described below.

Where:
Rho= Spearman's correlation coefficient.
Di= Difference between the ranks of i
N= Sample size
1= Constant

Results

The perception of Blockchain and its impact on information transparency in institutions

The innovative aspect of Blockchain is that the register is distributed among each of the members that form part of the process and, as it is not a centralised base, it is impossible to modify it, noting that once a piece of data has been published and linked to a previous block, the block is validated by the entire network in real time, giving confidence and certainty to all the nodes that form part of the network.

Similarly, Rodríguez, Acuña, Rojas & Lobato (2015), consider that technologies such as Blockchain are a way to lead companies to optimise production and services. Hence, their use requires skills and abilities to intervene in the construction and production of new services, according to the interests and desires of organisations and individuals.

Today, the proper management of these tools has a positive impact on public and private organisations, for example, bureaucracy is mainly a record that confirms facts, giving the opportunity that when there are doubts or there is no consensus, the record is reviewed, hence thinking about these distributed is a different possibility in the areas of organisations. Blockchain has the power to make the operational strategies of any institution more efficient, regardless of their scope of action, that is, to serve as a mechanism for the efficient use of resources, their measurement and control.

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This directly influences the quality of products, since the appropriate use of technologies becomes a competitive advantage for companies, which channels better ways of exercising and guiding the course of the organisations, all in search of improving services.

According to Mochi (2012), for companies to generate innovation through technology, it is not enough to install sophisticated computer programmes; it is also necessary to acquire techniques and skills in the handling of hardware and software. In addition, developing capabilities to address the specific needs of people in each area in which it operates to improve their living, working, professional and social conditions. Social benefits are linked to the work aspect, which means that as individuals develop personally, they also improve professionally and this translates into higher productivity and work performance in companies.

Concepts such as public innovation and new government processes, generate what is known as the open government ecosystem, where Blockchain can start with a simple and scalable registration to more complex processes involving more organisations or areas of government, which gives the possibility to experiment in a suitable environment to be replicable to other more complex processes.

In line with the objectives of this work, particularly the one that aims to investigate the perception of Blockchain and its impact on the transparency of information in institutions, Gargallo-Castel & Pérez-Sanz (2009) consider that the mastery that users can have of technologies adapted to each procedure and objective of the institution, generates a more efficient management to optimise productivity and compete in many sophisticated markets, Therefore, Blockchain provides innovation in the transparency of information in institutions, which confirms that mastery in the use of technological resources by companies requires productive development aimed at satisfying the current needs of societies, seeking a balance between economic growth and social welfare.

In this order of ideas, universities as institutions managing knowledge and professional training of citizens, must contribute with professionals capable of developing in a globalised world, impregnated with technological and scientific advances with the obligation to transmit new ways of learning and for the construction of knowledge, contributing to economic development, in this sense, all educational process and its levels must be directed, which is why the updating of knowledge of teachers is an imperative and to implement new models of education according to their cultural, economic, technological, among others, particularities.

Therefore, it is necessary for teachers to formulate the use of pedagogical strategies and resources based on the generation of competences that enable the appropriation and integration of the digital tools required in organisations. In this regard, Almenara-Cabero & Romero-Tena (2010) point out that the management and mastery of technologies must be a constant competence in all teaching professionals and to integrate them as part of the training processes, as it is not possible to train a person in a particular area and obtain knowledge about what they were trained for and in practice be limited by not knowing how to grasp the tools that the markets offer.

The Blockchain is a way of coping with social realities and the advances that globalisation has driven at a dizzying pace. Every company or organisation must be competitive, and to do so, it must adhere to cutting-edge, modern production systems. It must adapt its organisational and procedural structure to computerised methodologies, programmes that facilitate access to information, and break down the limitations of time and space.

Furthermore, unlike digital signatures, the Blockchain also makes it possible to certify the existence of a document or file existence of a document or file. The data contained in the blockchain comes with its own history its own history and this is a fundamental part of proving its integrity, which is a very powerful quality. Digital provenance, i.e. proof that a digital event occurred, is the most valuable contribution of this technology.

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Another strength is that it simplifies the traceability of a process and can be audited in a simpler way, which in turn provides transparency, so that third parties can audit and control the actions of the public or private company thanks to the distributed information of the Blockchain.

Implications of the Blockchain

The use of Blockchain implies that people develop a more open, flexible, critical and conscious way of thinking about their personal and social responsibilities when making use of this technology, for example, one of the central functions of governments over the centuries, from its beginnings to date, has been to certify or guarantee certain goods or processes, Therefore, the integration of this technology together with the potential and mastery of the users to use it in the work field, allows the creation of new work channels and procedures, that is to say, it contributes with innovation in the transparency of the institutions by facilitating the exchange of information, which represents a start for planning and projections in relation to the direction in which the companies should be directed and to be able to satisfy the demands of consumption and service.

Based on the values obtained from the application of the research instruments, the analysis and discussion of the results obtained in the data collection process is carried out. The data (see Table 1) are presented following the order of appearance of each of the indicators and dimensions of the variables.

Response Indicator	High	High	Media	Media	Under	Under	Minimum	Minimum
Population	Teachers	Students	Teachers	Students	Teachers	Students	Teachers	Students
Percentage	%	%	%	%	%	%	%	%
Use of Blockchain for Information Transparency Innovation	54.5	45.1	30.3	42.3	12.1	9.9	3	2.8
Elimination of Intermediaries to Simplify Processes	81.8	46.5	18.2	48.6	0	2.1	0	2.8
Accessing Documents Quickly and Reliably	72.7	43.7	21.2	47.2	6.1	5.6	0	3.5
Use of Blockchain for Reporting	57.6	41.5	36.4	52.1	0	4.9	6.1	1.4
Blockchain to Avoid Rudimentary Activities and Paper Usage	63.6	45.1	30.3	47.9	3	3.5	3	3.5
Streamlining Processes With Blockchain	75.8	45.8	21.2	49.3	3	2.8	0	2.1
Average	67.67	44.62	26.27	47.9	4.03	4.8	2.02	2.68
Percentage	56.14		37.08		4.42		2.35	

Table 1 General Data of the Blockchain Perception Dimension
Own source

Analysed Table 1 reflects the results that sought to investigate the perception of Blockchain, in relation to which a series of questions were asked to university professors and students who have ventured into the productive labour sector, noting that a 56. 14% of respondents consider that they have a high degree of perception of the Blockchain and its advantages in the use in the innovation of information transparency, elimination of intermediaries to simplify processes, access to documents quickly and reliably, use of Blockchain to generate reports, to avoid rudimentary activities and the use of paper, as well as the agility of procedures with the Blockchain.

Likewise, 37.08% stated that they have a medium perception about the Blockchain and its advantages in the use in transparency innovation, 4.42% stated that they have a low perception, 2.35% expressed that their perception is minimal.

Likewise, taking into account the teachers' average of 67.67%, they present strengths with respect to the elimination of intermediaries to simplify processes with 81.8%, agility of procedures with Blockchain with 75.8%, access to documents quickly and reliably with 72.7%, with reference to their average response rate of 44.62%, strengths can also be observed.

With regard to the relatively low percentages presented in the indicators, it is identified that on the part of teachers and students, the indicator on the use of Blockchain for innovation of transparency in information is presented as the percentage of 54.5% in the opinion of teachers and as for students with 45.1% respectively, evidencing in both opinions the lowest percentages in the High Category. With regard to the Medium Category, taking into account the average of 26.27% of teachers, it is observed that the lowest values of the indicators Elimination of intermediaries to simplify processes, Access to documents quickly and reliably, Agility of procedures with Blockchain with 21.2% and 18.2% are presented.

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Concluding this analysis, it is highlighted that the highest preference of answers by teachers and students is presented in the alternatives High and Medium, which means that the dimension Perception of the Blockchain is acceptable within the variable under study.

Table 2 shows that according to the opinion expressed by the teachers and students surveyed, the transparency of information in the institutions is Good and is a function of public debate and participation rights in the institution, use of the processes in the institution and value through the networks with Blockchain with 50.22%, followed by Excellent with 25.98%, then the option Regular with 20.6%, followed by 3.18% of Bad about the information in the institutions being transparent.

Response indicator	High	High	Media	Media	Under	Under	Minimum	Minimum
Population	Teachers	Students	Teachers	Students	Teachers	Students	Teachers	Students
Percentage	%	%	%	%	%	%	%	%
Transparency of information in the institution (without the use of blockchain)	33.3	17.6	33.3	59.2	30.3	22.5	3	0.7
Use of processes in the institution	24.2	10.6	45.5	71.8	30.3	16.2	0	1.4
Accountability in the institution	27.3	19	42.4	62	24.2	17.6	6.1	1.4
Potential of blockchain as a tool for transparency	69.7	34.5	30.3	47.9	0	15.5	0	2.1
Oversight tasks in the institution	36.4	21.8	42.4	62	21.2	14.8	0	1.4
Public debate and participation rights in the institution	24.2	19.7	48.5	59.2	24.2	19.7	3	1.4
Free access to open data in the institution	24.2	16.9	36.4	61.3	36.4	19.7	3	2.1
Transparent disclosure of data in the institution	21.2	12	42.4	66.2	30.3	19	6.1	2.8
Use of smart contracts	9.1	17.6	33.3	58.5	33.3	19	24.2	4.9
Value across networks with blockchain	51.5	28.9	45.5	56.3	3	14.8	0	0
Average	32.11	19.86	40	60.44	23.32	17.88	4.54	1.82
Percentage	**25.985**		**50.22**		**20.6**		**3.18**	

Table 2 General data on transparency of information in the institutions
Own source

It can be seen through the average obtained for teachers of 40% the strength for the indicator public debate and rights of participation in the institution with 48.5% and for students it raised its average of 60.44% strengths can be seen in the same indicator with 59.2%. Appreciating a decrease in terms of the indicators Use of processes in the institution and Value through networks with Blockchain for teachers with 45.5% and in the case of students is evident in the indicator Use of processes in the institution with 71.8% and the indicator Value through networks with Blockchain with 56.3%.

When analysing the inclination of the surveyed population, according to the response category, it can be seen that there is a greater incidence towards the Good and Excellent categories, which indicates that the distinction of the indicators of the transparency dimension in the institutions is adequately fulfilled.

Having achieved the descriptive objectives designed to give strength to this research, it is then appropriate to apply a statistic that allows inferring these values or results to the population, therefore, it was decided to apply the method of calculating the Spearman Correlation Coefficient to establish the degree of relationship between the perception of Blockchain and its impact on the transparency of information in the institutions. For this purpose, the measurements were transformed into nominal form by comparing them with the scale, using the values collected in the attached double-entry matrices, with the help of the SPSS version 23 programme.

The procedure used for the test was by means of the following statistical formula and corroborated by the results obtained from the application of the SPSS version 23 statistical programme.

$$P = 1 - \frac{6\sum d^2}{n(n+1)(n-1)}$$

Where:
ρ: Spearman's correlation coefficient.
d: difference between the ranks (X - Y)
n: number of data

Correlations				
			Perception of Blockchain	Impact on the Transparency of Information of the institutions
Spearman's Rho	Perception of Blockchain	Correlation coefficient	1.000	.564**
		Sig. (bilateral)	.	.000
		N	142	142
	Impact on the Transparency of Institutional Information	Correlation coefficient	.564**	1.000
		Sig. (bilateral)	.000	.
		N	142	142
**. La correlación es significativa en el nivel 0,01 (bilateral).				

Table 3 Correlation between the Variables Perception of the Blockchain and the Impact on the transparency of information in institutions (IN TEACHERS). *SPSS software*

Applying the formula, a Spearman correlation coefficient of 0.771 was obtained at a significance level of 0.000, which indicates that there is a high and statistically significant relationship between the variables, its positive sign indicating that as the values of the variable Perception of the Blockchain increase, the Impact on the transparency of information in the institutions increases and vice versa.

Correlations				
			Perception of Blockchain	Impact on the Transparency of Information of the institutions
Spearman's Rho	Perception of Blockchain	Correlation coefficient	1.000	.771**
		Sig. (bilateral)	.	.000
		N	33	33
	Impact on the Transparency of Institutional Information	Correlation coefficient	.771**	1.000
		Sig. (bilateral)	.000	.
		N	33	33
**. La correlación es significativa en el nivel 0,01 (bilateral).				

Table 4 Correlation between the Variables Perception of the Blockchain and the Impact on information transparency in institutions (IN STUDENTS). *SPSS software.*

Applying the formula, a Spearman correlation coefficient of 0.564 was obtained at a significance level of 0.000, which indicates that there is a high and statistically significant relationship between the variables, its positive sign indicating that as the values of the variable Perception of the Blockchain increase, the Impact on the transparency of information in the institutions increases and vice versa.

Discussion

After tabulating the results and describing them statistically from the questions asked by the respondents, it is necessary that in terms of the variable perception of the Blockchain, a significant strength is observed, in terms of the conception of this technology.

This indicates that the integration of this tool and its impact on transparency in institutions is important, even and when the processes for its use are limited, users are aware of the potential of this technology, however, it is imperative that people have skills that allow them to be implemented at a practical level and not only theoretical, which generates innovative processes in response to the challenges that arise today in the transparency of institutions, showing objective advantages of its real application.

With regard to the other variable, it is observed that in terms of the impact on transparency in institutions, the results expose the need for intellectual capital, i.e., that Blockchain knowledge is necessary for the production of goods and services in any the labour field of people's work today.

So it is necessary to generate this competence as part of the development of professionals in universities, i.e. they must contribute in part to the training of professionals who know how to solve problems using the technology that is incorporated into the productive fabric. apparatus in its fullness, as this is part of economic development and the quality of services.

In this sense, specialised training is needed to generalise the use of Blockchain systems and foster a greater culture of security among users because this technology implies a change of mentality and skills, since information transparency is not the same as information transparency. the processes of institutions, a government, for example, can open information on its expenses or contracts, with the drawback that this does not make it transparent in how that process was carried out or whether the parties to the contract were complied with.

Through data it is possible to infer corruption or embezzlement, although it is in the processes where the evidence can be found, so using technology such as Blockchain to generate greater levels of transparency in the processes of institutions means improving on the road to greater accountability (Naser, Ramírez-Alujas and Rosales 2017).

Conclusions

Regarding the objectives of the study it is confirmed based on the results of the perception of Blockchain and its impact for the transparency of information in the institutions, the initial difficulty of its implementation is presented because, even though it can offer great savings to organisations, its implementation in economic terms involves very high disbursements for the adoption of the technology, but also, because of the structural changes of the transition from centralised to decentralised systems.

Apart from the technical, operational and regulatory difficulties, what is certain is that the application of Blockchain requires significant changes in management models, public and private leadership, and even raises the need for a new civic and democratic culture, which is not simple as it directly conflicts with the functioning of institutions, governments and the State.

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As well as with regulations, political processes and customs, and can therefore represent a brake on standardisation.

However, despite the efforts made, there are still gaps in its integration, which are due to the lack of empowerment of users or workers for its proper implementation. However, it has been successfully incorporated in some larger companies; in other smaller companies, digital and technological transformations are required to have an impact on social, political and economic aspects, as well as, especially, on people's lives.

Finally, among the findings, it was confirmed that there is a correlation between the two variables of this research where the relationship coefficient obtained is a positive value, indicating that the relationship between the two variables is strong and positive, i.e. in the perception of the Blockchain as a useful tool in the labour or institutional environment for the streamlining of procedures and monitoring to contribute to transparency, there is a correlation between the two variables (they are dependent).

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Implementation of a workbench platform for the management of smart contracts in BlockChain nodes on Azure Cloud

Implementación de una plataforma workbench para la gestión de smart contracts en nodos de BlockChain sobre Azure Cloud

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Abstract

Objectives: Analyze, design and build backend components (web API, XML web service and database) and frontend (website) with Microsoft technology that allow the integration of a functional workbench platform to automate the launch of compiled smart contracts in blockchain nodes hosted in Azure Cloud so that they can be used by companies in general. Methodology: The SCRUM methodology was applied for the agile development of the technological products of the backend and frontend, because it adapted very well to the nature of this research, since in each iteration there was always an update of the tools, programming components, testing and configuring services to achieve goals. Contribution: It is shown that the development platform integrated by the solidity language, Azure cloud blockchain, the Visual Studio .Net IDE and the SQL Server database manager allowed to design and build a blockchain workbench platform easily exploitable by companies to validate their processes and generate transparency in the handling of their information.

Blockchain, Backend, Frontend

Resumen

Objetivos: Analizar, diseñar y construir componentes backend (web API, servicio web XML y base de datos) y frontend (sitio web) con tecnología Microsoft que permitan integrar una plataforma workbench funcional para automatizar el lanzamiento de contratos inteligentes compilados en nodos de blockchain alojados Azure Cloud para que puedan ser utilizados por empresas en general. Metodología: Se aplicó la metodología SCRUM para el desarrollo ágil de los productos tecnológicos del backend y frontend, ya que se adaptó muy bien a la naturaleza de esta investigación, ya que en cada iteración siempre hubo una actualización de las herramientas, componentes de programación, pruebas y configuración de servicios para lograr los objetivos. Contribución: Se demuestra que la plataforma de desarrollo integrada por el lenguaje solidity, blockchain de Azure cloud, el IDE de Visual Studio .Net y el manejador de bases de datos SQL Server permitió diseñar y construir una plataforma workbench de blockchain fácilmente explotable por las empresas para validar sus procesos y generar transparencia en el manejo de su información.

Blockchain, Backend, Frontend

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Introduction

Currently, smart contract technology based on the management of blockchain nodes has increased the benefits generated for the companies that consume them, but there is also a growing need for a better way to design them, validate them and finally submit them to blockchain in order to take advantage of the functionality of transparency in information transactions and monitoring their evolution over time.

Public and private companies in various countries that have different business models (lucrative or not) have already generated their own technologies, but also in some cases already use technologies based on blockchain nodes and smart contracts on custom designs and that regularly, has a high cost of design and development, without contemplating the rent of blockchain services that also depend on a stable technological infrastructure; the above invariably implies an increase in the total cost of the project (Hegedus, 2018).

However, it is currently considered that blockchain and smart contract technologies do not yet have a profound impact on open source or proprietary development environments to be able to integrate a development platform to design and build backend and frontend environments, resulting in a dependency of companies on software factories to manage this work behind closed doors (Nowinski and Kozma, 2017).

This research work aims to demonstrate that a technology project can have a flexible development platform, integrating the following added values over current applications based on blockchain and smart contracts:

– It is based on open access and open consumption technology (http request, web APIs, web services, websites) so that it can be used by any company regardless of its infrastructure.

– It applies security of use on administrator, business and operational users for each company.

– The backend consists of a relational database for smart contract management including a satellite data module to customise the information for each company. Within the web APIs and web services considered in the backend, there is middleware that allows the control of smart contracts, their launch to blockchain and the control of gas consumption.

– Finally, the use of a Microsoft Azure blockchain node is contemplated, as well as the hosting of the web platform and databases of the same owner, in order to publish the backend and frontend included in the project.

The result of generating a comprehensive platform for the management of a blockchain node applying open middleware (web APIs and web services), allows to have two communication channels: 1) direct to http request interfaces and 2) the frontend to be used by companies and their users; however, this objective allowed generating a flexible blockchain and smart contract workbench, with the lowest rental cost of services in the Azure cloud so that it can be customised to each company and this allows them to generate all the smart contracts they need to consume them in their strategic processes that they must register in blockchain for secure, public and permanent tracking.

The first section describes the agile methodology that was used for the development of this project, the second section mentions the analysis, design and development of the backend that integrates the database and its satellite module, as well as the web service and the web API necessary to develop the open middleware for http requests that allow communication with the Azure blockchain node and the database. Finally, the third section describes the design and development of the frontend that will consume in a structured way the web services and http requests through interfaces that allow the management of the processes in a graphical and secure way. Based on the categorisation of MARVID Mexico, the present work corresponds to area VII of Engineering, in the field of Engineering in the discipline of Systems Engineering, to be applied in the sub-discipline of Information Systems.

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1. Description of the applied Methodology

For the development of this applied research the agile methodology Scrum was used because it was the one that was best adapted to the way of working and conditions of the technological products that were generated; an important aspect is that the project had to be adapted to the circumstances of the context of blockchain, as it always depended on the research and development options that were available based on the development platform chosen, to apply iteratively design, coding and testing, to finally implement each iteration.

Figure 1 Stages of the Agile Methodologies *(Retamosa Santos, 2015)*

In order to validate each iteration of the methodology, it was applied in the context of a university, which needs to generate a smart contract to record information in blockchain about the students who have accredited the training courses it offers, in order to generate valid digital certificates that can be consulted at any time by educational institutions or companies.

2. Analysis, design and development of the Backend

The development platform was selected based on the tools and services applied to smart contracts and the blockchain node, mainly because of the openness found to configure the node and the programming components provided at that time by the selected provider: Microsoft. The list of tools was as follows:

Blockchain tools and components

- Solidity Language (compilation of smart contracts on Ethereum Blockchain)
- Ganache - Truffle Suite (local testing platform for Blockchain nodes)
- Azure Transaction Node - Blockchain
- Nethereum.Web3 and NewtonSoft.Json (Libraries for smart contract interaction, wallet creation and json object manipulation)

Backend tools and services

- Microsoft Visual Studio .Net 2017 Developer (IDE for web API and web service development)
- Microsoft SQL Server 2012 service pack 4
- Server language C#
- Communication standards: XML and Json
- Azure Blockchain node
- Hosting for Web server with ASP .Net technology and for SQL Server DB server, with Microsoft as provider (Plesk Onix Web Host was used).

The backend is made up of the following technology products:

- Blockchain Node (Azure Cloud)
- Web API (Visual Studio .Net 2017)
- Support database and satellite data module (SQL Server 2012 service pack 4)
- Web Service (Visual Studio .Net 2017))

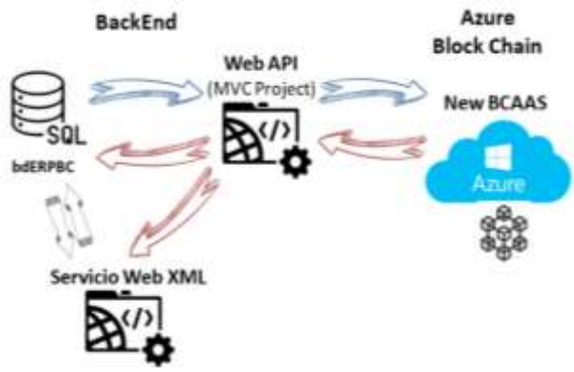

Figure 2 Azure Blockchain functional diagram with backend
Own Design, 2022

The following is a description of the analysis, design and development applied for each backend product.

Blockchain node (Azure Cloud)

The project started with the establishment of the business rules to be able to create the smart contracts, compile them and test launches in local blockchain nodes (Ganache); once the smart contracts were validated and executed in local mode, a real node was generated in Azure Blockchain to test launches of the same contracts.

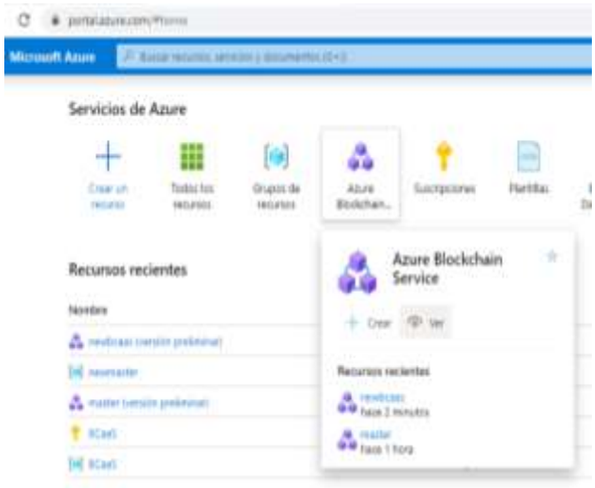

Figure 3 Azure Blockchain Node Configuration
Own design, 2022

The following activities were carried out:

a. The smart contracts were previously designed and compiled in the solidity language in order to have the base files with the required functions (registration, reading, counts, events). Finally, there will be 3 files that will support the backend:

– sol file - This will contain the source code of the smart contract.
– Json file - Will contain the base structure of the smart contract (the interface of functions, events, structures, attributes and their public/private visibility).
– Json file - Will contain the compiled code of the smart contract (programmed in solidity).

b. Having controlled the correct versions of the smart contracts in Json files, the next step was to create a blockchain node in Azure, to configure it and publish it on the internet as a licensed service (only for administrator users). We managed to create wallets to later launch the compiled smart contracts both locally (Ganache) and on the Azure blockchain node, being successful both in the contract launches and in the execution of its functions of reading and writing blocks.

Web API (Visual Studio .Net 2017)

Once the process of compiling smart contracts and testing the launches and executions on the actual blockchain node in Azure was secured, we proceeded to generate the web API in Visual Studio .Net 2017 to achieve communication with the Azure Blockchain node and automatically execute the launches and also the methods defined in the smart contract. The rules applied for the design of the web API are as follows:

a. The Nethereum.Web3 and NewtonSoft.Json libraries were included in the web API configuration to ensure the connection with the Azure Blockchain node and to manipulate the input and output parameters through Json-like structures. The following figure shows the <installed> status of the Nethereum.Web3and NewtonSoft.Json libraries applied in the web API project:

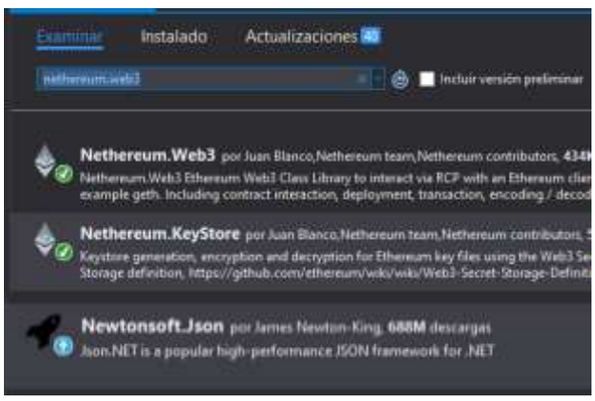

Figure 4 Installation of the Nethereum and NewtonSoft libraries in Visual Studio .Net
Own Design, 2022

The following figure shows the references to the libraries implemented in the configuration web page and in the class files implemented in the developed API.:

```
// Librerias referenciadas Nethereum y Newtonsoft
// Controlador de la Web API <SmartContractController.cs>
using Nethereum.Web3;
using Nethereum.Hex.HexTypes;
using Newtonsoft.Json;
using Newtonsoft.Json.Linq;
using System.Threading.Tasks;
using System.Numerics;

using APILanib.Models;

namespace APILanib.Controllers
{
```

Figure 5 Import of the Nethereum and NewtonSoft libraries into the web API driver
Own Design, 2022

b. The web API methods were created to receive the Json files that integrate the compiled smart contract and the base structure, to validate them through a syntactic and semantic analysis as they must have the same definitions to ensure a successful launch to the Azure blockchain node and finally create a new blockchain based on the sent contract. For this, the connection data to the node must also be configured as follows:

```
// Clase de aplicación global para definir los items para la conexión
// al nodo de Azure block chain
public class Global
{
    public static string url = "https://nombrase.blockchain.azure.com";
    public static string port = "8000";
    public static string publicKey = "sQooKiLarIo_OmtwGfph2pWA";
}
```

Figure 6 Azure blockchain node connection attributes from the web API
Own Design, 2022

c. The web API methods were also built to send the execution of the methods defined in the smart contract that has been launched, as they can receive parameters or not and can also send varied output results (mapping of the whole blockchain, a single block or specific data of a localised block), thus the following methods were generated:

```
// Definición del método para validar y hacer lanzamiento
// del contrato inteligente
[HttpPost]
[HttpGet]
[Route("api/Contract/Deploy")]
public JObject DeployContract([FromBody]Contrato contract)
{
    System.Net.ServicePointManager.SecurityProtocol = SecurityProtocolType.
    int ban = 0;
    JObject res = new JObject();
    JObject datosTrasaccion = new JObject();
```

Figure 7 Definition of the DeployContract method in the web API for launching smart contracts
Own Design, 2022

The following is the header of the Json file containing a smart contract successfully compiled with the Solidity language:

```
{
  "contractName": "certificadoDigital",
  "abi": [
    {
      "inputs": [],
      "payable": false,
      "stateMutability": "nonpayable",
      "type": "constructor"
    },
```

Figure 8 Header of a smart contract compiled with solidity in Json format
Own Design, 2022

d. Tests were designed to validate the connection of the web API in local mode with the Azure blockchain node, which were successful. At this point the release version of the web API was generated so that it could be deployed on a compatible web server. The next step was to mount the web API on the Plesk Onix host, validating the ASP.Net versions and the http request execution configuration to be supported by the server. The execution tests were applied again (creation of wallets, launching of smart contracts to create blockchains and finally execution of methods for block registration, partial and total readings of the blockchains), which were again successful, but now on the host.

```
{
  "ban": "1",
 -"msg": [Array[1]
     0:  "La cuenta fue generada exitosamente"
  ],
  "newAccount": "0xd6e8167021b35660d4f40879452f1d0caf65f1e2"
}
```

Figure 9 Message returned by the Web API on execution of the method to create a wallet
Own Design, 2022

The following figure shows the control panel of the Plesk Onix host where the web API was installed and configured (and subsequently the web service and the project database were also installed):

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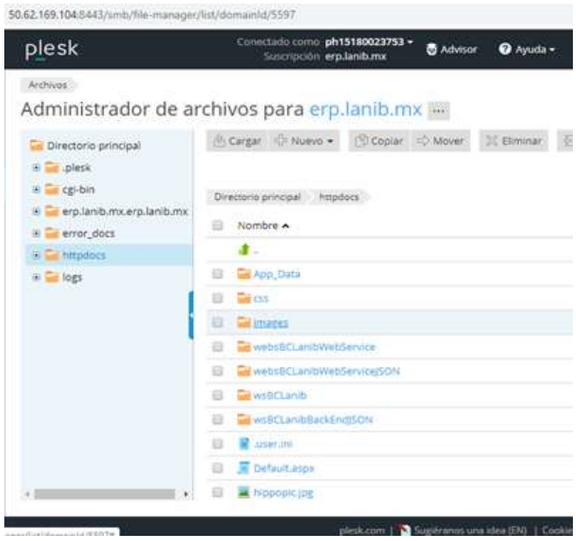

Figure 10 Plesk Onix Host Control Panel
Own Design, 2022

Supporting database and satellite data module (SQL Server 2012 service pack 4)

Having already implemented the Azure blockchain infrastructure and the web API on the host to manage wallets, launch smart contracts and execute blockchain methods, the next step was the generation of the data layer in Microsoft's SQL Server 2012 sp4 database manager, which allowed the management of smart contract information, registration and control of their launches, as well as the execution of the contract methods to manipulate all the blockchains that need to be created; allowing any organisation (regardless of its core business model) to have its own information, users and security in the management of its data. The objective of designing the database to cover the aforementioned requirements was the integration of a module of entities called "satellite", which allowed to store Json formats in its structure so that each company can link additional information to each smart contract launched to the Azure blockchain node and thus achieve to have the official information in blockchains (not modifiable) and also additional data of each block in the satellite database (modifiable).

Finally, stored procedures were generated to manage the database tables and the "satellite" module to encapsulate the data layer and allow the business rules layer to have a secure connection and execution of the processes; finally generating 63 stored procedures.

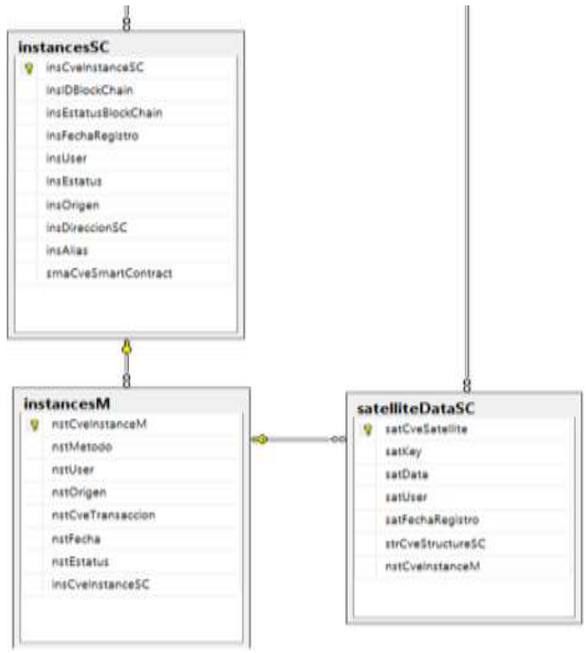

Figure 11 Satellite" database entities module in-house design, 2022

Having the database script and data objects created locally, we proceeded to its migration on the Plesk Onix host under the same version of the database manager (SQL Server 2012 sp4 from Microsoft) succeeding in the creation of all data objects, finally we created the corresponding connection string to apply it in the web service layer.

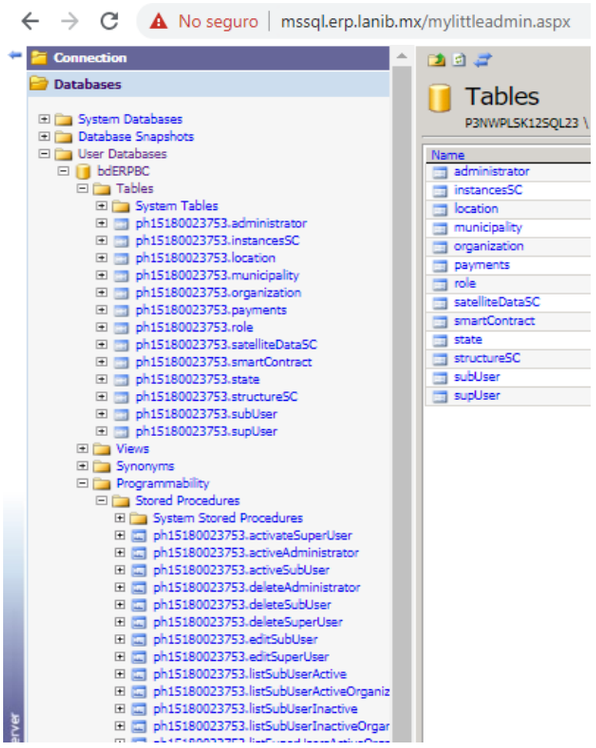

Figure 12 mylittleadmin control panel for Plesk Onix host databases
Own Design, 2022

Web Service (Visual Studio .Net 2017)

Up to this point we have managed to configure and manage the Azure blockchain node through a web API both published on the internet, as well as the design and construction of the database that will have the structure of the information that will be managed by companies, universities or any organisation that requires to launch smart contracts to the Azure blockchain node to generate blockchains on the information they generate and give official validity.

The next step is the last one in the backend and consisted of designing and developing an additional business rules layer to have an alternative connection to the Azure blockchain node and the satellite database but now from websites and mobile platforms: an XML web service to encapsulate the execution of the web API and the web methods needed to manage the execution of the database's stored procedures.

The XML web service aims to centralise the execution of the web API and the database management to support the frontend platform (web and mobile) that will be responsible for giving a complete view of the workbench platform operation to companies, universities or any organisation that needs to implement Azure blockchain in their IT processes.

The construction of the XML web service had two important modules:

a) Configuration of the necessary references:

– Reference to the public url of the Plesk Onix host web API.
– Connection string to the database and its satellite module, located on the Plesk Onix host.
– Reference to the connection url to the Azure blockchain node.

```
<connectionStrings>
    <add name="cnn" connectionString=
        "data source=184.168.194.77; Initial Catalog=bdERPBC;
        User Id=ph15180023753; Password=Chintelolo.1"
        providerName="System.Data.SqlClient" />
</connectionStrings>
```

Figure 13 Plesk Onix host database connection string
Own Design, 2022

b.-) The encapsulation classes with all the web methods that handle communication with the web API and the database

```
[WebMethod]
public String SmartContractDeploy(string json)
{
    JObject obj = JObject.Parse(json);
    var web3 = new Web3("https://newbcaas.blockchain.azure.com:3200/cQooXiLxrIo Dv4w6FpA2pK4");
    var accountPublicKey = obj["account"].ToString();
    var accountPassword = obj["password"].ToString();
    Task<bool> unlockResult = web3.Personal.UnlockAccount.SendRequestAsync(address:accountPubli
    unlockResult.Wait();
    string abi = obj["abi"].ToString();
    var byteCode = obj["bytecode"].ToString();
    JArray parametros = JArray.Parse(obj["parameters"].ToString());
    JObject validacion = validarDatos(abi, parametros);
```

Figure 14 XML Web Service "SmartContractDeploy" web method
Own Design, 2022

3. Frontend design and development

This section describes the design and functionality applied in the presentation layer built to consume the XML web service of the backend in order to give users of this Azure blockchain workbench platform control and security over the handling of their information; it also covers user types, permissions, tracking of smart contract releases and blockchain creation for their internal processes.

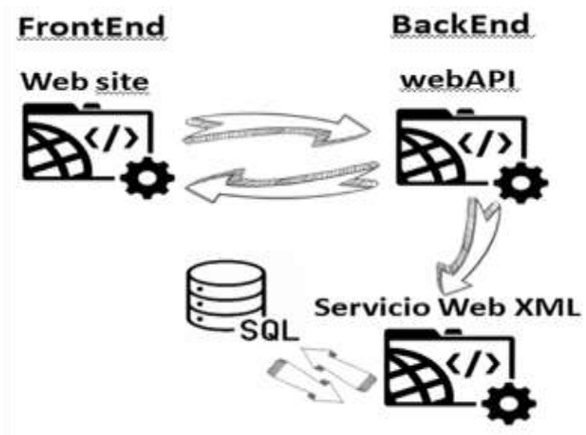

Figure 15 Functional diagram of frontend and backend
Own Design, 2022

The presentation layer is a website that covers the following design and functional characteristics:

a) Contains the configuration in XML format of the secure connection string for the migrated database on the Plesk Onix host.

b) Contains the XML web service and web API references in the same configuration file, to be applied in the method encapsulation classes, this ensures the information and execution of the XML web service or web API.

Figure 16 Frontend references for XML web services
Own Design, 2022

c) The design of the web interfaces is functional, practical and responsive to be deployed on any display dimension (standard PC, tablet or smartphone) as it is based on the integration of the bootstrap framework:

Figure 17 Frontend web design
Own Design, 2022

d) It manages three types of users, a) Administrator of the workbench platform, b) Superuser for the T.I.C. or administration area of the organisation, and c) Subuser to be assigned to operational employees.

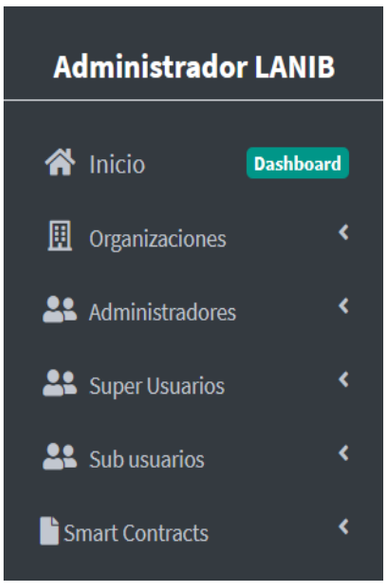

Figure 18 Administrator's options menú
Own Design, 2022

e) It contains a menu of functions to configure the company and the generation of its password wallet on the Azure blockchain node which will be unique for each company registered on the blockchain workbench platform, finally each smart contract release and blockchain creation will be linked to the enterprise wallet for monitoring.

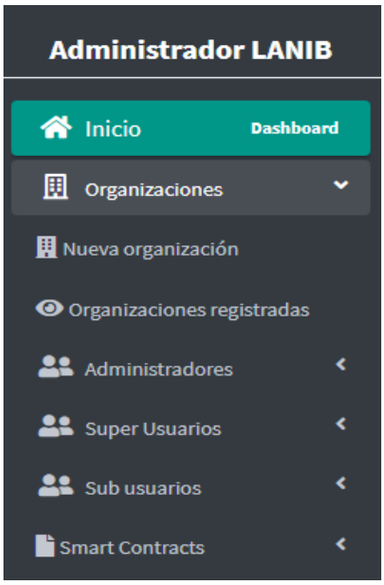

Figure 19 Detailed options for organisations
Own Design, 2022

f) The "smart contracts" menu options have full tracking over the launch of a smart contract in a company, to be used by superusers or sub-users of each registered company.

Figure 20 Interface for registering and uploading smart contracts
Own Design, 2022

g) It includes a register and control for each smart contract launched to the Azure blockchain node to generate blockchains and also has a control over the execution of the methods of each blockchain, allowing to apply an online analysis of the execution requirements depending on each defined smart contract (the web interface for methods execution is dynamic and is configured so that the user captures the necessary parameters for validation of data types and correct execution).

Figure 21 Interface for launch tracking and method execution of all smart contracts
Own Design, 2022

Each successful launch of a smart contract to the Azure blockchain node will allow the execution of the methods it contains to generate the required blockchains of the process the company needs to secure. The following figure shows the dynamic interface used for smart contract launches on the frontend:

Figure 22 Interface for configuring the launch of a smart contract
Own Design, 2022

4. Results

Backend analysis, design and development

a) It was possible to build a programming algorithm to manipulate a smart contract compiled in the solidity language; also allowing the application of parsing in its structure so that a web API can launch it to an Azure blockchain node and thus finally generate blockchains with minimal or no gas consumption.

b) Nethereum.Web3 and NewtonSoft.Json libraries were successfully applied in the Visual Studio .Net IDE to create web API and web services projects to communicate with Azure blockchain nodes.

c) Automated the launching of smart contracts to Azure blockchain nodes based on the Json file of the contract previously compiled in solidity language and also the Json format of the base structure of the contract in order to apply the syntactic analysis that validates the content of methods, attributes, events and mappings of the contract.

d) A web API was built to communicate with the Azure blockchain node to validate the execution of methods via http request with input parameters in Json format; this process allowed the automation of the launching of smart contracts and the execution of methods integrated in the generated blockchains.

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e) A database was created to manage the information of the companies that will consume the services of the workbench platform, however, a module of "satellite" entities was also integrated to ensure that the smart contracts only register the official information that will not change and finally in the "satellite" module, the information related to the blockchain is registered, which can be modified, as it will be stored in Json format.

f) An XML web service was implemented that allowed the execution of all the methods of the built web API and also integrated the execution of the methods that manipulate the database and the "satellite" module included in the data layer.

g) Successfully generated and configured an Azure blockchain node in Azure Cloud; to access it with the call and send methods integrated in the execution of smart contract launches.

h) The web API, XML web service and database were published on the Plesk Onix host using a configuration compatible with the Microsoft development platform that was used to build the technology products of this research.

Frontend design and development

a) The website was built with the frontend function for the blockchain workbench platform by applying client frameworks such as bootstrap to generate the necessary web interfaces.

b) Successfully migrated and configured the website on the Plesk Onix host to publish to the internet and allow communication with the web API and XML web service, configured on the same host.

5. Annexes

This section shows evidence of source code and data models that support the design and execution of the backend (web API and web service XML), and also shows evidence of execution on the services built via http request to check the correct validation of the smart contracts before their launch or during the execution of their methods.

The following figure shows the structure of the Json format to send to the web API the structure that the smart contract compiled in solidity should have, this allowed the XML web service to validate the execution interfaces of the methods it contains.:

```
String jsonSmartContract = @"{
   'name' : 'Certificado',
   'consParams' : [ ],
   'metodos' : [
    { 'nombre': 'creaCert',
      'params' : ['id':'string']
      'sateliteIn' : [ 'key': ['id'],
                  'data' : [  'nombrealumno' : 'string',
                              'nombrecurso' : 'string',
                              'fechaIngreso' : 'string',
                              'fechaVigencia' : 'string'
                           ]
                ]
    },
    {  'nombre' : 'consultaCert',
       'params' : { 'id' : 'string'},
       'returns ' : 'string'
                }
            ] ,
  'pubData' : [  ]
} ";
```

Figure 23 Json structure of a university's compiled smart contracts for digital certificate control
Own Design, 2022

The following figures show the results of the execution of two methods of the web API via http request, the outputs are handled in Json format in order to send the data resulting from the validations defined in the method; the parameters received from Azure blockchain that integrate the execution status in the node are also integrated: a.-) the first figure indicates the successful registration of a wallet in blockchain and b.-) the second figure shows the successful launch of a smart contract to blockchain

```
{
   "ban": "1",
  -"msg": [Array[1]
      0:  "La cuenta fue generada exitosamente"
   ],
   "newAccount": "0xd6e8167021b35660d4f40879452f1d0caf65f1e2"
}
```

Figure 24 a.-) Json resulting from the web API for registering a wallet on blockchain
Own Design, 2022

Figure 25 b.-) Json resulting from the web API for the successful launch of a smart contract
Own Design, 2022

The following figure shows the XML web service execution interface with the list of web methods published on the host to be consumed by the frontend:

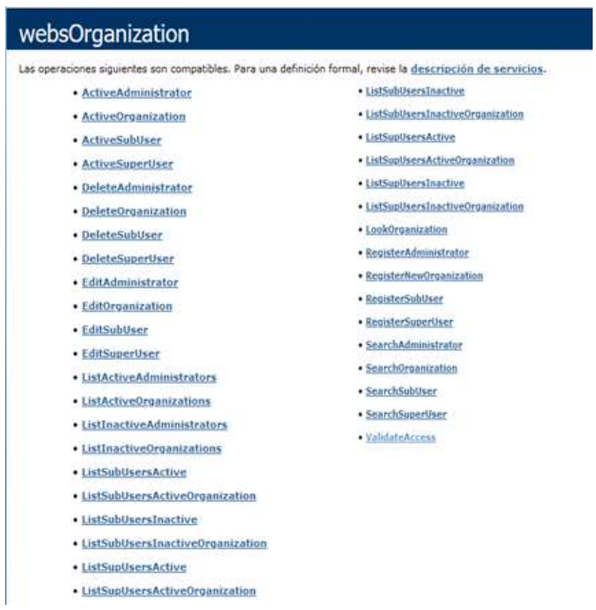

Figure 26 XML web service published web methods console
Own Design, 2022

The following figures show the results of the execution of two web methods of the XML web service via standard http, the outputs are handled in XML format in order to send the data to the frontend; in each web method the communication with the web API is executed internally to send requests to the Azure blockchain node and also to the database to generate the required communication between the layers that integrate the workbench platform: a.-) the first figure indicates the successful registration of a wallet in blockchain and b.-) the second figure shows the successful launch of a smart contract into blockchain.

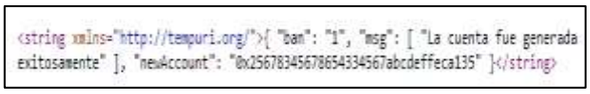

Figure 27 a.-) Xml resulting from the web service for registering a wallet on blockchain
Own Design, 2022

Figure 28 b.-) Xml resulting from the web service for the successful launch of a smart contract
Own Design, 2022

6. Acknowledgement

The research team of this project is grateful to the company Megahabilidades and its Chief Technology Officer, Dr. Raúl Antonio Trejo Ramírez for the technological facilities granted during the development of this applied research and also for the support in the validation of the test scenarios generated in real environments.

7. Funding

This work was not funded by CONACYT, PROMEP or any other funding body for the development of the research contained in this document.

8. Conclusions

a) Successfully completed the construction of the workbench platform on Azure blockchain nodes in the Azure Cloud, having the opportunity to do all the required tests for each layer of the platform (data, business rules and presentation) in the context of a university with the need to generate digital certificates to their students on accredited courses but previously registered on blockchains of the smart certificate launched on the Azure blockchain node (showing the corresponding evidence in the figures, schematics and codes)

b) Definitely, blockchain being a new and abstract technology in its conception and operation, there are very few sources of information and reliable documentation from the technological point of view to be able to have reference (Ahram, Sargolzaei, Sargolzaei, Daniels and Amaba, 2017). However, at the end of this research there are no technological products with the characteristics of workbench platform applying blockchain, so this applied research will serve as evidence of the widespread implementation of blockchain nodes with the lowest cost of development and implementation but that can be applied to any company, industry or organisation in general for the processing of its information.

c) Blockchain is a reliable technology, but at the same time it is new. There are still few vendors, components and documentation in the blockchain field and now with the recent blockchain as a service (BAAS) platform it is imperative to maintain a permanent research on this emerging technology to have the best options for developing and upgrading blockchain workbench platforms in the short and medium term.

d) The workbench platform built in this project has a wide field of application in the integration with the Internet of Things (IoT) to validate and record information generated in large quantities as a result of sensor data management processes at industrial, business or personal level; It can also be applied in the registration and control of people's identity to process personalised transactions or, as a priority, it can be applied in the registration, monitoring and control of vaccination certificates, both the COVID-19 and the vaccination booklet that all Mexican citizens are entitled to have and use throughout their lives.

e) The application areas of blockchain nodes and specifically this workbench platform are numerous, as it can be configured to the processes and transactions required by the company applying this technology.

f) The constructed workbench platform has great opportunities for improvement due to the current development platforms and services provided by the existing compute clouds:

– Currently there is already a blockchain service (Blockchain As A Service - BAAS) which did not exist at the time of this research. Replacing the Azure blockchain node with one of the 10 current BAAS providers on the internet (AWS, IBM, Corda, Nodesmith, Dragonchain, among others) will be a migration of great impact, because now it will be possible to manage the growth in the use of nodes and users (companies) that use the workbench platform, this will allow for greater savings in costs and implementation times.

– As the basis of the backend is the server language and the web development IDE, it is suggested to migrate to the open source languages Python and Java to further decrease the cost of developing and updating the workbench platform (Pilkington, 2016), but it will be necessary to investigate with BAAS providers the release of libraries compatible with the communication towards the BAAS nodes that are built, as the solidity language is still a standard for the development of smart contracts.

– The above suggestion implies considering now open source based web servers: apache, tomcat and derived versions of these in order to migrate the web API and XML web service to these technologies. It is recommended to continue applying XML and Json standards for communication between the business rules layers of the middleware.

– Regarding the frontend module, it is also suggested to migrate the design to open source client tools such as: JSP or PHP web pages that are compatible with current interface design frameworks (bootstrap, angular, among others); they also have server-side functionality to interact with the middleware built.

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– It is recommended to migrate the Database and the satellite entities module to the mySql database manager, this will open up the possibilities of selecting a hosting with lower and more accessible rental costs, since both the backend and frontend would be migrating to open source platforms.

– It is recommended to continue using Ethereum as the base network for enterprise blockchain, but we should not lose sight of the fact that there are currently more enterprise networks whose capacity, reliability, level of security and privacy, as well as transaction transfer speed, must be validated in order to be recognised as a base network for blockchain (Werner, Lawrenz and Rausch, 2020).

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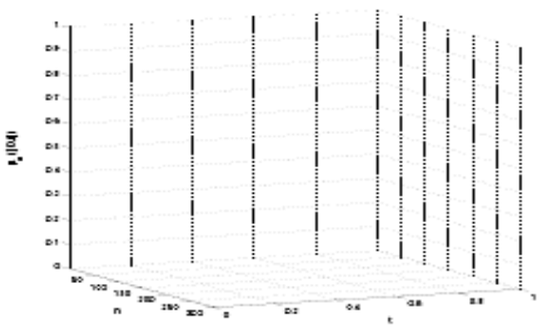

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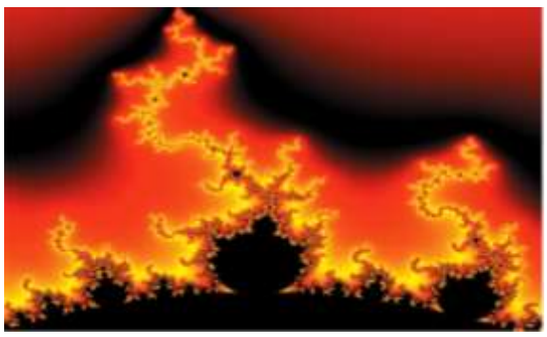

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The description of the peer review processes is made known by the Editorial Board in order that the Authors know what the evaluation criteria are and will always be willing to justify any controversy in the evaluation process. In case of Plagiarism Detection to the Article the Committee notifies the Authors for Violation to the Right of Scientific, Technological and Innovation Authorization.

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The Arbitrators undertake to notify about any unethical conduct by the Authors and to indicate all the information that may be reason to reject the publication of the Articles. In addition, they must undertake to keep confidential information related to the Articles they evaluate.

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The Arbitrators must be conducted objectively, any personal criticism of the Author is inappropriate.

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