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REVISIÓN

Development of a uml framework for smart cities with forecasting electrical consumption in Colombia

Desarrollo de un marco de referencia uml para ciudades inteligentes con predicción de consumo eléctrico en Colombia

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ABSTRACT

The following article describes a proposal that aims to plan and develop a framework for Smart cities using modeling by UML through the Colossus software tool. Further design analysis applied to Smart cities based on wireless sensor networks is developed. The analysis is proposed using ARIMA time series for finding a correlation of consumption of electricity in 50 Colombian homes and a possible forecast if it were used iInternet of things (IoT) as a possible method to save on electrical energy consumption.

Keywords: ARIMA, Framework, Gretl, Smart cities, UML, WSN.

Palabras clave: ARIMA, Ciudades inteligentes, Framework, Gretl, UML, WSN.

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INTRODUCTION

The scientific investigation has a method, and this one has, your approaches and exceptions as well as your dimensions, with the possibility of using one or another way of the method. When an investigation is done in the technological field, it is necessary to use technological strategies, which validate the results obtained across a software development of software;. This article they presents the results of the utilization of the Unified Language Unified of Shaped UML (Bolaños, Gonzaález, Sanjuan & Easter, s. f.) to shape the graphs of case of use, sequence, of class and activities with support in the tool named Coloso (Bolaños, González, Sanjuan, & Pascual) (Bolaños, Medina, & Carrión, LACCEI, 2011).; Thise paper presents an analysis relationing the Engineering software (IS) using the Language of Shaped of Processes and Methodologies of Software [LMMPS] (Bolaños, Medina & Carrión, LACCEI, 2011). The approach to realizing carry out will combine the investigation and technology, with IS technics of the (IS).

LANGUAGE MODEL AND METODOLOGIC PROCESS OF SOFTWARE (LMMPS)

The concepts of grammar are described to construct words of a certain language. The intention aim is generating a vocabulary of expression for the frame of a (SC).

1) The gGrammar with phrases structure consists of a vocabulary V, a subset T of V formed by the end effectors and initial symbol S of V - T and a set P of productions (Bolaños S., 2014; Rosen, 2004).

2) The vVocabulary (V) is a finite set and nonempty, the elements are called symbols, where a word on V is a finite chain of elements of V (Bolaños S., 2014; Rosen, 2004).

It is necessary to define the language generated for G, L (G)

For a consistent set of aspects where IoT (Internet of Things) is, the Internet of the things and FW (Framework) is the working space or referential frame.

Therefore, if WSN SC are elements of the set FW;, then, because each element of C sublies is contained in IoT.

IoT is a function of FW, (Framework) SC , (Smart Cities),and WSN (Wireless Sensor Networks), where it is possible to verify and validate. Wifhere IM is defined as Internet in Movement.

Next, it presents a general graph of the services classification, in the top part appears (IoT), which wraps the (FW), the (SC) and (WSN). The structures WSN sublies before the (SC) and this one sublies before the (FM), which forms a part integral of (IoT).

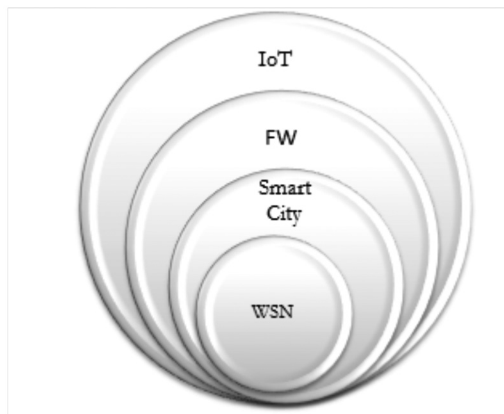

Figure 1. Integration and perspective of Smart Cities (SC) and IoT

Source: Author.

PRECEDENTS AND CURRENT STATE OF THE ART

The conceptual development of this project is necessary to understand four big components: (IoT), (FW), (WSN), (SC); the comprehension and deepening of these subject matters, the props of this offer, will depend ofn the design that is achieved in a great extent with the success of the same one.

Internet of the (IoT)

Defined as a global infrastructure based on standards and communication protocols where the physical and virtual "things" are equally integrated with the network information. Important and essential part of IoT are the sensors (Vergara Carabeño & June, 2013).

Framework (FW)

A frame of reference is used as a development pattern of an application, though it is a wide definition, this designation because it can remove the different levels of software development (Ffor a complete application defined, application web, until focusing in an unique aspect, user interface) (Cavaness, 2003), being versatile without requiring a language of programming. [FW] is defined also as a set of bookshops, designed to give support in the development of sites generating the construction of any web application (Lyman, 2009). A [FW] facilitates with common activities realized carried out during the development of the application (Brandon & Brandon, 2008).

Some characteristics are evaluated in the table 1:

Table 1. Characteristics are evaluated in the selection of Framework (FW)

FEATURES	DESCRIPTION	AUTHORS
Domain (FW):	has as purpose recognize the requirements and concepts that the (FW) needs (Shafer, Prieto, & Matsumoto)	
Security FW	FW Support and security in the infrastructure	(Bae, 2014) (Rasmussen & Dara, 2014).
Interoperability	Interact with other platforms	(Ahamed, Milwaukee, & Pezewski, 2004) (Jin Oh & Youl Park, 2014)

Source: Own work.

The Framework (FW) design is necessary to take in mind allowing total access and control at sensors network, for any device with connectivity.

Wireless Sensor Network (WSN)

WSN are networks for small nodes that working to obtain a common objective with resources of accused and computation limited. In the beginning of this evolution, the nodes were big distant stations, spatially and the communication would take place across an infrastructure wired up (Akyildiz, Weilian, Sankarasubramaniam, and & Cayirci, 2002). Since then different investigations have been developed in order to improve of the sensors in caps: physic, link and network optimizing for the processes of transmission with the objective, diminishing the energy consumption (AUTELSI (Association), 2006). Nowadays, the communication is wireless and when exists an exchanges of information between nodes conforms a networks (Hao, Xue, Yan, and & ChunLi, 2012). It is necessary to take control that supervises the connections between the net, as the information is caught by the sensors networks; in general, the information is bidirectional for user to the net and vice versevice versa. This scheme is shown in Figure 2.

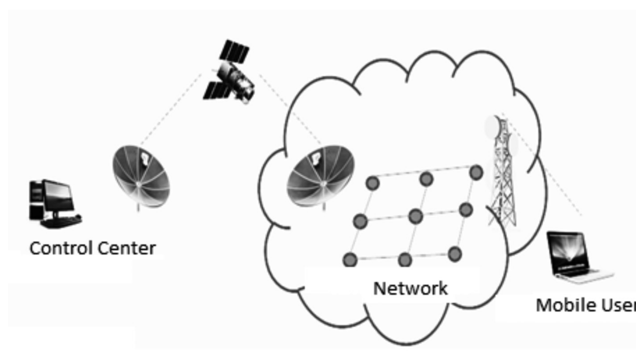

Figure 2. Basic scheme for a WSN

Source: Own work.

Some considerations to bearing in mind for designinged a WSN are described in table 2.

Table 2. Considerations to bearing in mind for designinged a WSN

Characteristics:	Definition:
Tolerance for failures	Some nodes sensors can fail or be blocked due to the lack of energy, or to receive physical damages or environmental interferences. The failure of nodes sensors must not compromise the global function global in the net of sensors.
Scalability.	The designs must be capable of working with a number of nodes in order of hundreds, thousands, and depending onf applications, millions. Also take in mind the high density, which can take have relation to some hundreds of nodes sensors in a region that can be minor than 10 meters by diameter.
Costs of production	Provided that the sensors networks consist of a great number of sensors nodes, the cost of an individual node is very important to justify the complete cost of the network.
Topology	The topology can suffer changes due to function mistakes, involuntary changes in position of nodes sensors, interferences with objects for the environment. Later, it is possible to precede methods like repair, substitution or amplification at network.
Environment	The sensors networks meet are affected for the environment. Normally they are opened in remote areas, the difficult or impossible access being nearby or inside with phenomenon where wants to be measure.
Hardware limitation	A sensor network is constituted for four basic components: sensor unit, a processor, transmitter, and energy unit.

Source: Own work.

Authors whom works in this topics are: (Liyanage & Marasinghe, (2013), (Kehua, Jie, & Hongbo, (2011), (Elmangoush, Coskun, Wahle, & Magedanz, (2013), (Karnouskos & de Holanda, (2009) (Chourabi, y otroset al., (2012), (Chaonan, Liudong, Vinod, & Yan Lindsay, (2014).

Smart City (SC) and Digital City

Knowning as Digital or Intelligent City, is considered as an city "intelligent"" city when the investments in the human and social capital, and a traditional infrastructures in a traditional communication (transport) and modern (ITC), they foment an economic development and a high quality of life, knowing the management of natural resources, across a participative government (AUTELSI (Association), 2006) (Hao, Xue, Yan & ChunLi, 2012) (Liyanageand Marasinghe, 2013).

Digital city: is a virtual space of interaction between all the actors whom take part in the life of a city, citizens, companies, administrative, visitors, - using the support of the electronic and the information, and communication technologies and communication (TicsICTs), offering the above mentioned actors, the access like an innovative way of relation and communication, across the channel that they choose, in any moment and place (Kehua, Jie & Hongbo, 2011; Elmangousch, Coskun, Wahle & Magedanz, 2013; Kamoouskos & Holands, 2009; Chourabi et al., 2012).

PROBLEM DEFINITION

The high consumption of electrical energy with in the big cities and every time scanty generation of the same one, generating a crisis in the energetic sector; it is not enough to create saving policies, saving but also it is necessary the implementation of intelligent networks that allow manage the energetic saving (Krishnamachari & Ordónez, 2003). Some disadvantages could be nowadays exists and is related to the energy consumption.

METODOLOGY:

Metaprocess definition:
"The significant problems we have cannot be solved at the same level of thinking with which we created them". Albert Einstein.

For the development of reference frame was used UML that is a language that allows shape, construct and document the elements that form a system in object orientated software.; iIn the present article - there will develop the model of software Metaprocess (Bolaños, González & Easter, s. d.; Bolaños, Medina &Carrión, LACCEI, 2011). The Metaprocesos (Gracanin, Eltoweissy, Olariu & Wadaa, 2004), is defined as process models who which are going to serve as referential frame, and they help with a graphical scheme of representation. Three big processes are distinguished: management, structure and innovation.

The process management, is shaped by the strategy, organization, production and documentation. In Coloso is possible to estimate in a graphical and pedagogic way 3 processes that shape a Metaprocess. (figure 3).

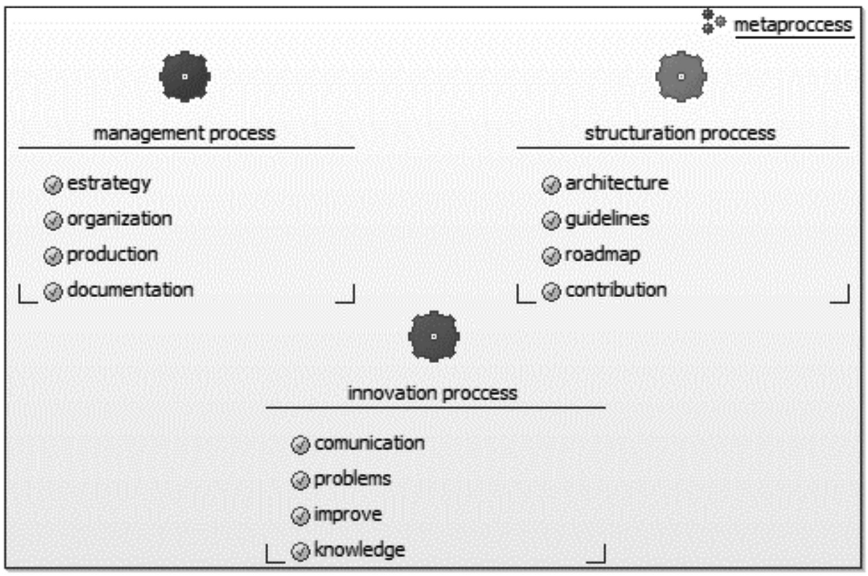

Figure 3. Metaprocess from Coloso software

Source: Bolaños, González, Sanjuan, & Pascual.

As a strategy, the holistic looks about problem and the hypothesis; the strategy or process selected RUP (Rational Unified Rational Process) (Peng, Wang, Have & Zhao, 2012), the life cycle is usesd in cascade (Royce, 1970), allowing the generation of a software in an UML environment UML, design, develop and visualize processes;, simplifying the complexity of the designs, processes and creating a development without equally. The process RUP assigns tasks and responsibilities,; shaped by the strategies: business models, requirements, analysis and design, implementation, checking, between among others.

Additionally, the RUP administrates the requirements, which are dynamic during the project, develops the iterative software, develop sand the software visually, evaluates the system quality with regards to the functionality, uses an architecture based on components and establishes repetitive processes to manage the changes of software (Flórez, 2009; Abranson, 2002; Kasaju, 2013) This process is shown in the Figure 4 shows this process.

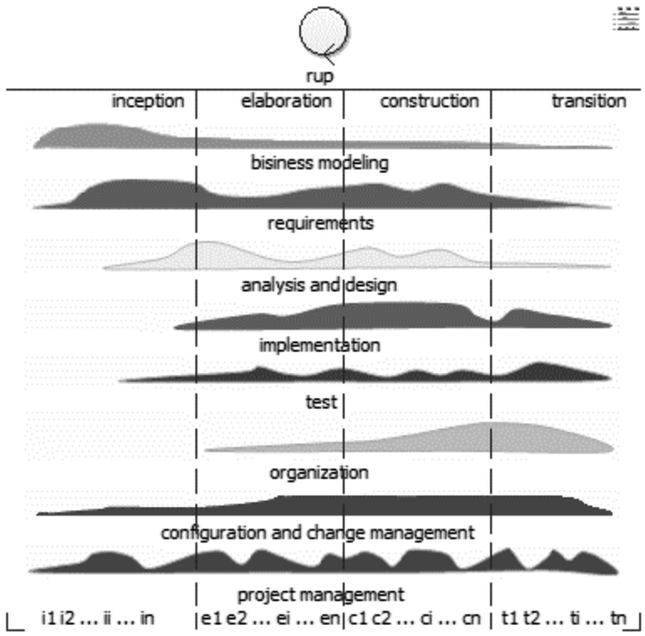

Figure 4. Methodology RUP

Source: Bolaños, González, Sanjuan, & Pascual.

For the particular case that occupies us, the model of business is represented in Figure. 4.

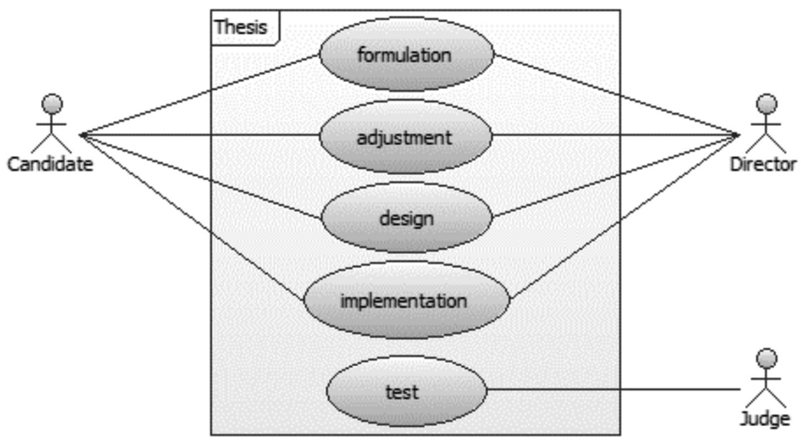

Figure 5. Use case activities

Source: Bolaños, González, Sanjuan, & Pascual.

The use case, describes the general activities in the development of the (FW)] for - SC - (Elmangoush, Coskun, Wahle & Magedanz, 2013). Three actors decided the Ph.dD candidate, the director and judge, where are represented the general activities that will allow to develop and give solution to the project;, this one is composed for five activities:, formulation, adjustments, design, implementation, tests and socialization for the results in the academic community.

The following provides developments of the formulation activity, in which the thesis taking part in problem approach and investigation hypothesis who will find be resisted. These processes are shown in the Figure 6 shows these processes.

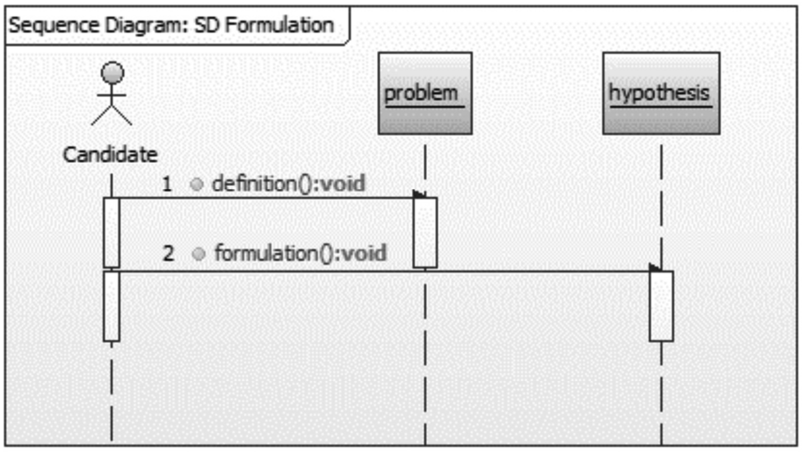

Figure 6. Problem and hypothesis formulation

Source: Bolaños, González, Sanjuan, & Pascual.

Taking again the Sstrategy about Metaprocess, begins the specification of the activities, which will be orientated to project objective, which is developed in a Frame of Reference for Intelligent Cities controlling a sensor wireless network in Smart City applications,. tThis allows the energetic saving, ias shown in figure 7.

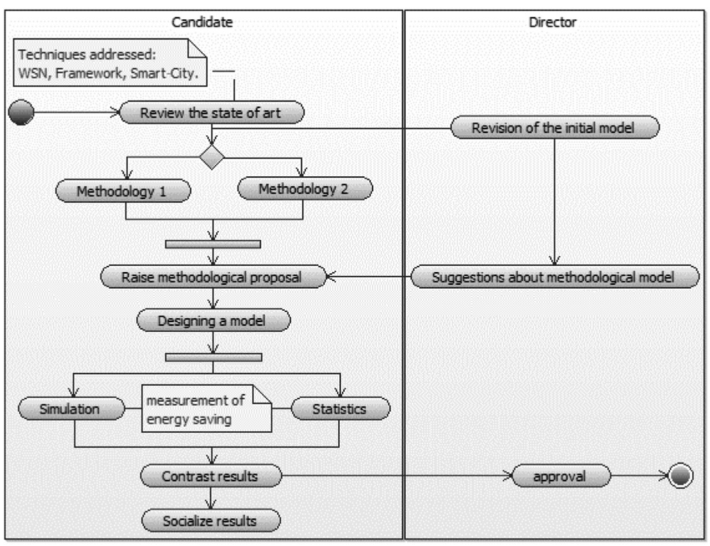

Figure 7. Developing activities about methodology

Source: Bolaños, González, Sanjuan, & Pascual.

In the project developing of project are definite two actors:, the director and the candidate Ph.D; with the following function review the state of the art state condition, including the approached subject matters (WSN), (FW) and (SC). Once the previous task has been realized carried out and agreement with results obtained, it will be decided, by mutual agreement, a specific methodology to identify the methodological offer that will include the suggestions realized given by the director, the bidder will realize carry out part of design in a model (FW) who will be used in the simulations accomplishment and statistics which have information about energy consumption in homes respect to the level; the contrasting results will be realizedmade. This point is important because here culminatingends the traceability reached by the director; later, results obtained will socialize previous approval by the director.

The activity appears the contrasts Figure 8 in which present the results, conclusions and confronts with the judge for your checking. This activity is conducted through checking the hypothesis of investigation.

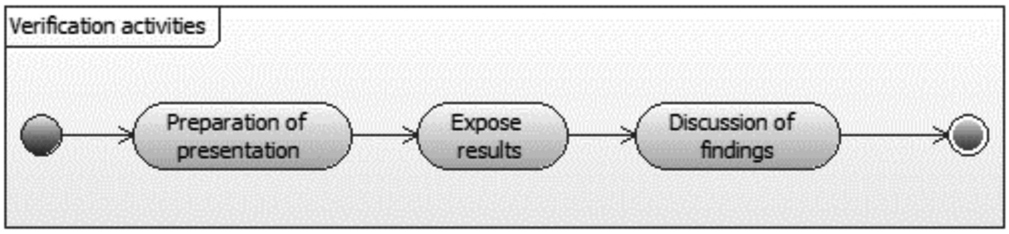

Figure 8. Verification activities and conclusion

Source: Bolaños, González, Sanjuan, & Pascual.

STUDY OF AN APPLICATION OF ENERGY SAVING AT HOME AND FORECAST

The first forecast, the home energy consumption performed measurements of 50 home conformed by 4 persons who consumed around 4-6 kWh per day, there were extracted from the samples to be included in the Autoregressive Integrated Moving Average (ARIMA) model (Pulido, 2001). Mathematical models are a class of stochastic processes used to analyze time series is dueaccording to Box and Jenkins model., wWe used a GRETL free software, which to analyzed the statistical behavior and represented through a graphical interface will be used.

Table 3. Sample for 50 real home user´s from Codensa

Day	kWh-Mount	kWh-day	Variation
0	157	5,2	
1	190	6,3	33
2	165	5,5	-25
3	171	5,7	6
4	180	6,0	9
5	175	5,8	-5
6	169	5,6	-6
7	173	5,8	4
8	161	5,4	-12
9	152	5,1	-9
10	188	6,3	36
11	165	5,5	-23
12	194	6,5	29
13	199	6,6	5
14	174	5,8	-25
15	160	5,3	-14
16	159	5,3	-1
17	152	5,1	-7
18	164	5,5	12
19	167	5,6	3
20	186	6,2	19
21	147	4,9	-39
22	180	6,0	33
23	158	5,3	-22
24	169	5,6	11
25	175	5,8	6

26	149	5,0	-26
27	172	5,7	23
28	189	6,3	17
29	171	5,7	-18
30	166	5,5	-5
31	190	6,3	24
32	174	5,8	-16
33	197	6,6	23
34	149	5,0	-48
35	182	6,1	33
36	204	6,8	22
37	233	7,8	29
38	181	6,0	-52
39	141	4,7	-40
40	112	3,7	-29
41	145	4,8	33
42	193	6,4	48
43	103	3,4	-90
44	111	3,7	8
45	207	6,9	96
46	195	6,5	-12
47	161	5,4	-34
48	217	7,2	56
49	193	6,4	-24
50	**133**	**4,4**	**-60**

Source: Own work.

The Table 3 data kWh-day for 50 home user´s, are represented in the following GRETL graphic:

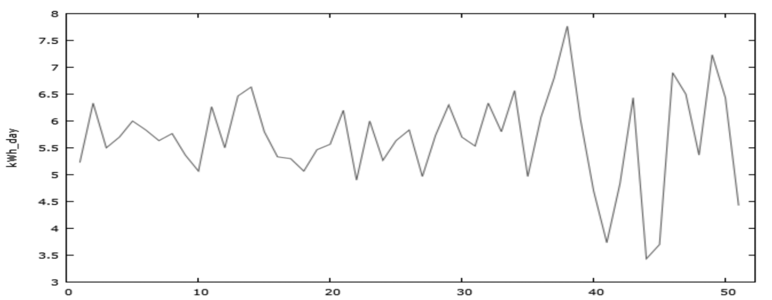

Figure 9. Time series original function in GRETL

Source: Own work.

After analyzing the statistical behavior, it is necessary to take the first difference occursas shown in the Figure 10:

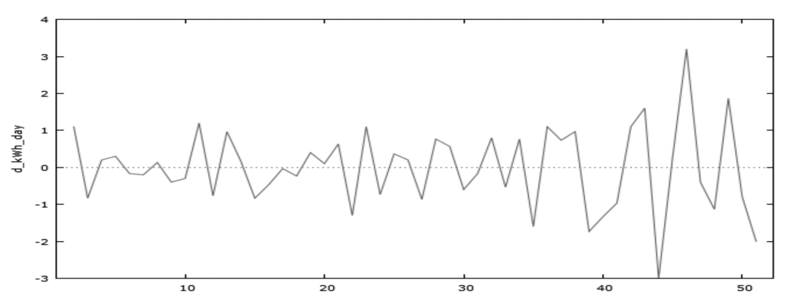

Figure 10. Plot time series function and his first derivate

Source: Own work.

Autocorrelation function for d_kWh_day

LAG	ACF		PACF		Q-stat.	[p-value]
1	-0.2406	*	-0.2406	*	3.0719	[0.080]
2	-0.3664	***	-0.4503	***	10.3431	[0.006]
3	0.1561		-0.1067		11.6913	[0.009]
4	0.1111		-0.0420		12.3893	[0.015]
5	-0.1869		-0.1595		14.4065	[0.013]
6	0.0355		-0.0380		14.4810	[0.025]
7	-0.0552		-0.2355	*	14.6654	[0.041]
8	-0.0763		-0.2414	*	15.0259	[0.059]
9	0.1632		-0.0556		16.7159	[0.053]
10	-0.0539		-0.1897		16.9050	[0.076]
11	0.0181		0.0250		16.9268	[0.110]
12	0.0447		-0.0468		17.0633	[0.147]

Figure 11. Correlogram values, about ACF (Auto Correlation Function) point and PACF (Partial Auto Correlation Function)

Source: Own work.

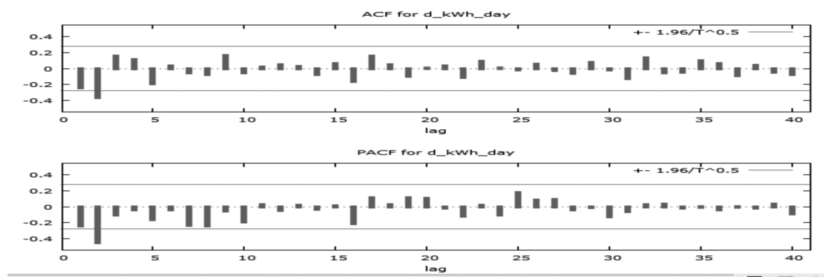

Figure 12. Correlogram time series function ACP and PACF

Source: Own work.

This difference gives the graph of its Correlogram, which has ACF (Auto Correlation Function) point and PACF (Partial Auto Correlation Function) points.

To perform observation users are taken as samples 40 crews is 80% and 20% is left to perform the prediction is shown in figure 12 Correlogram.

According to the coefficients obtained from the autocorrelation functions and partial autocorrelation prediction models based on the coefficients p (Rho) AR(2) = -0,.3664 , q1 q2 MA(2) = -0, 4503, and q2 MA(7) = -0, 2355, with and their ARIMA model combination ARIMA (2,1,2) from the equation 1:

$$(1\text{-}0.3664L)(1\text{-}L)Y_t = (1\text{-}0{,}4503L\text{-}0{,}2355)u_t \qquad (1)$$

```
Function evaluations: 239
Evaluations of gradient: 59

Model 2: ARIMA, using observations 3-51 (T = 49)
Estimated using Kalman filter (exact ML)
Dependent variable: (1-L) d_kWh_day
Standard errors based on Hessian

             coefficient    std. error      z         p-value
  -------------------------------------------------------------
  const      -0.000373701   0.00107873    -0.3464    0.7290
  phi_1       0.270962      0.146853       1.845     0.0650     *
  phi_2      -0.214507      0.144957      -1.480     0.1389
  theta_1    -1.99486       0.0958515    -20.81      3.37e-096 ***
  theta_2     0.999999      0.0958415     10.43      1.74e-025 ***

Mean dependent var  -0.063265   S.D. dependent var   1.693783
Mean of innovations -0.054715   S.D. of innovations  0.820609
Log-likelihood      -65.65294   Akaike criterion     143.3059
Schwarz criterion    154.6568   Hannan-Quinn         147.6124

                        Real  Imaginary    Modulus  Frequency
  -----------------------------------------------------------
  AR
    Root  1           0.6316    -2.0647     2.1591    -0.2028
    Root  2           0.6316     2.0647     2.1591     0.2028
  MA
    Root  1           0.9974    -0.0717     1.0000    -0.0114
    Root  2           0.9974     0.0717     1.0000     0.0114
  -----------------------------------------------------------
```

Figure 13. ARIMA Model I (2.1.2) function evaluation

Source: Own work.

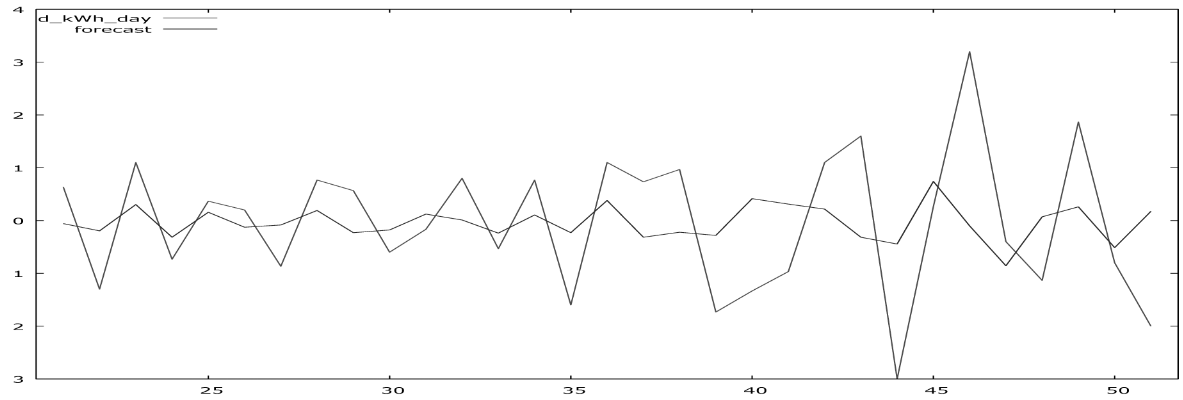

Figure 14. Graph ARIMA model 1 Forecast prediction

Source: Own work.

From the data provided in Figure 14 may function prediction plot for 50 samples in red differentiated function is presented and the corresponding forecast.

The Figure 15 presents the exact data for the differentiated function and data for function prediction also calculated the RMSE (Root Mean Square Error):

	d_kWh_day	prediction
21	0.633333	-0.058241
22	-1.300000	-0.195725
23	1.100000	0.302655
24	-0.733333	-0.316023
25	0.366667	0.156578
26	0.200000	-0.126983
27	-0.866667	-0.084019
28	0.766667	0.190949
29	0.566667	-0.230096
30	-0.600000	-0.178539
31	-0.166667	0.122207
32	0.800000	0.010501
33	-0.533333	-0.238689
34	0.766667	0.105022
35	-1.600000	-0.230096
36	1.100000	0.379990
37	0.733333	-0.316023
38	0.966667	-0.221503
39	-1.733333	-0.281652
40	-1.333333	0.414361
41	-0.966667	0.311248
42	1.100000	0.216727
43	1.600000	-0.316023
44	-3.000000	-0.444915
45	0.266667	0.740885
46	3.200000	-0.101204
47	-0.400000	-0.857367
48	-1.133333	0.070651
49	1.866667	0.259691
50	-0.800000	-0.513657
51	-2.000000	0.173764

Forecast evaluation statistics

Mean Error	0.017594
Mean Squared Error	2.9804
Root Mean Squared Error	1.7264
Mean Absolute Error	1.4669
Mean Percentage Error	51.383
Mean Absolute Percentage Error	-1.3902
Theil's U	1.0858
Bias proportion, UM	0.00010386
Regression proportion, UR	0.0060519
Disturbance proportion, UD	0.99384

Figure 15. Model I ARIMA (2,1,2) function evaluation

Source: Own work.

From the data provided in the Figure 15 may function prediction plot for 50 samples in red differentiated function is presented in the Figure 16 red and the corresponding forecast.

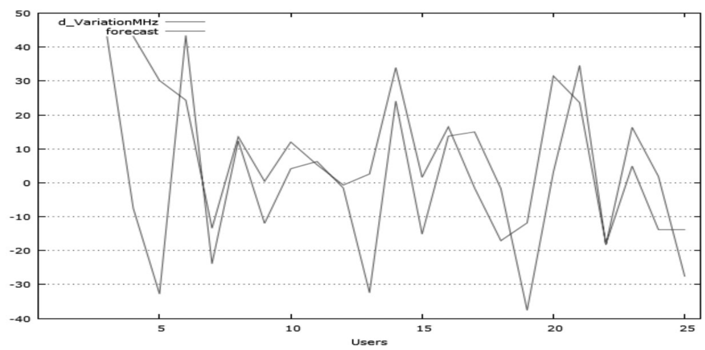

Figure 16. ARIMA second model graph and forecast prediction

Source: Own work.

The Figure 17 presents shows the exact data for the differentiated function and data for function prediction also calculated the RMSE (Root Mean Square Error):

	d_Variation	prediction
2009-09-18	-55.00	-27.00
2009-09-19	33.00	9.79
2009-09-20	-5.00	-6.26
2009-09-21	-32.00	-15.04
2009-09-22	49.00	29.02
2009-09-23	-6.00	-20.72
2009-09-24	-35.00	-34.32
2009-09-25	13.00	16.48
2009-09-26	29.00	15.16
2009-09-27	-40.00	-29.41
2009-09-28	39.00	10.83
2009-09-29	-71.00	-21.16
2009-09-30	81.00	54.10
2009-10-01	-11.00	-21.07
2009-10-02	7.00	-43.79
2009-10-03	-81.00	-44.69
2009-10-04	12.00	61.29
2009-10-05	11.00	81.02
2009-10-06	62.00	56.34
2009-10-07	15.00	-34.02
2009-10-08	-138.00	-82.08
2009-10-09	98.00	96.58
2009-10-10	88.00	27.74
2009-10-11	-108.00	-136.98
2009-10-12	-22.00	-29.80
2009-10-13	90.00	52.34
2009-10-14	-80.00	-58.22
2009-10-15	-36.00	7.87
2009-10-16		94.42

Forecast evaluation statistics

Mean Error	-9.3269
Mean Squared Error	1272.2
Root Mean Squared Error	35.668
Mean Absolute Error	34.434
Mean Percentage Error	63.638
Mean Absolute Percentage Error	63.638
Theil's U	0.30464
Bias proportion, UM	0.06837
Regression proportion, UR	0.35904
Disturbance proportion, UD	0.57258

Figure 17. Model to data for function prediction l

Source: Own work.

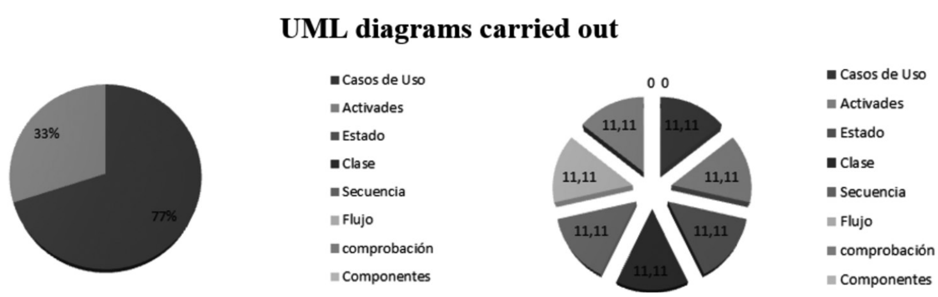

Figure 18. UML diagrams results from Coloso

RESULTS

In the graphs Figure 18 appears the percentage used from UML perspective;, the approach was guided by percentage of utilization, which was 77 %, versus the total graphs of UML language, as well as the use diagram disaggregated that is 11 %.

The ARIMA models have been applied to predict the behavior energy consumption in home, from a growing number de of peoples in a city, respectively. The Figures 12 and 13 corresponds to the Autocorrelation function for ACF, PACF. Behavior prediction is similar and is in agreement with the data included for the 50 samples submitted monthly consumption in households. Thus it is possible to make predictions much larger and that they are commensurate with the energy savings that can be estimated in the future near future.

CONCLUSION

A formal investigation process, can be realized carried out using IS's methodology, with Coloso protocol A key search is utilization of approach based on independent components from technology, accompanied along with of a methodology that facilitates the model interpretation combines the (IS) with our offer. The mixed investigation methodologies and generating models software (IS) who which explain the problem.

The integration of software engineering UML diagrams and modeling engineering problems based on efficient as those used by software developers methodologies, can integrate these aspects with problems related to smart cities., iIn our case, to predict consumer behavior of electrical energy in homes and predicting them in and near future and thus achieving create predictive models of behavior.

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