Human beings, viewed as behaving systems, are quite simple. The apparent complexity of our behavior over time is largely a reflection of the complexity of the environment in which we find ourselves

Herbert A. Simon

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE AND INTERACTIVE MULTIMEDIA

Editor's Note

The International Journal of Interactive Multimedia and Artificial Intelligence provides an interdisciplinary forum in which scientists and professionals can share their research results and report new advances on Artificial Intelligence and Interactive Multimedia techniques.

The research works presented in this issue are based on various topics of interest, among wich are included: AI for Software Engineering, Education, Computer Vision, Augmented Reality, Natural Language Understanding, Data Mining, Knowledge-Based/Expert Systems, Image Processing, Location systems, Internet of Things, Multiobjective Evolutionary Algorithms and Software architectures.

Barahona et al. presents an architecture and implementation for mobile application that use Augmented Reality techniques to get information while interacting with real objects in the physhical world. The presented application allows the creation of new context aware content for collaborative applications in different fields of knowledge [1].

Solís-Martínez et al. defines a methodology that allows the reduction of the complexity on the common processing modeling notations. The proposed level oriented bussines process methodology is intended for being used by domain experts that will model the domain business processes outside the technical details [2].

Cueva-Fernandez et al. proposes a framework which significantly simplifies the development process of the smartphone applications that require a high degree of interoperability between device sensors. The proposed framework is illustrated with a fuctional prototype that demonstrates the feasibility of creating multidisciplinary applications with several different approaches [3].

Nuñez-Valdez et al. have developed a graphical tool based on domain-specific languages that simplifies the development of 2D games for mobile devices. The proposed tool allows modeling games abstracting from technical details and implementations. The modeled games can be exported to popular mobile platforms, thus allowing to develop games quickly and saving development costs [4].

Puértolas et al. present a new location indoor system that combines the use of Smartphones with location tags. The location tags are based in QR codes and NFC tags and serve for determine the user's position and orientation. The proposed system can use the information to calculate the optimal toure to the destionation [5].

Rodriguez et al. presents a revision and an analysis of the Open Data initiative situation in Spain. The analysis looks at origins and concepts, the legal framework, current Initiatives and challenges that must be addressed for the effective reuse of public information industry [6].

Fuente et al. proposes a novel approach to empower domain experts in developing adaptability solutions by using automated sets of production rules in a friendly way. This approach is focused on the expert's domain knowledge, allowing them to evolve and adapt the software focusing on business logic and not on technical aspects. This approach is particularly useful for very dynamic or changing sectors with rules closely linked to the domain [7].

Sandra Garcia presents a resume of her doctoral thesis called: "Application of Multiobjective Techniques for Robust Portfolio Optimization". Supervised by Dr. David Quintana Montero and Dr. Inés M. Galván León and defended at Carlos III of Madrid (Spain) [8].

Dubey et al. presents a novel algorithm, specially designed to detect defects in fruits. The manual identification of fruits defects is a very slow and expensive process. This research work proposes a segmentation of fruits based on color features with K-means clustering unsupervised algorithm. The authors apply their proposal to a real case in identifying defects in apples; this real case is useful to validate the effectiveness and quality of the proposed approach [9].

Gil et al. analyzed and reviewed several of the technologies of knowledge exchange and dissemination, putting particular emphasis on technologies that affect the field of education. This article focuses in the question emerging from the clash of the rights to education in a wide sense and the rights derived from authorship [10].

Daniel Burgos presents an innovative adaptation of eLearning model which supports user behaviour, user interaction, and personalised counselling by a tutor to improve the usual model. Also he shows the built eLearning module that implements this conceptual model in a real application case [11]

Dr. Jordán Pascual Espada
Dr. Rubén González Crespo

REFERENCES

[1] Neri, R.B., Gustavo, M.G., et al.; "Annotation and Visualization in Android: An Application for Education and Real Time Information"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 7-12

[2] Jaime, S., Natalia, G., et al.; "BPLOM: BPM Level-Oriented Methodology for Incremental Business Process Modeling and Code Generation on Mobile Platforms"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 13-27

[3] Guillermo, C., Jordán, P., et al.; "Kuruma: The Vehicle Automatic Data Capture for Urban Computing Collaborative Systems"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 28-32

[4] Edward, R.N., Oscar, S., et al.; "Gade4all: Developing Multi-platform Videogames based on Domain Specific Languages and Model Driven Engineering"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 33-42

[5] José, A.P., Adriana, M., et al.; "Smart Indoor Positioning/Location and Navigation: A Lightweight Approach"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 43-50

[6] Luz, A.R., Juan, M.C, et al.; "Open Data as a key factor for developing expert systems: a perspective from Spain"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 51-55

[7] Juan, F.A., Benjamin, L., et al.; "Using rules to adapt applications for business models with high evolutionary rates"; International Jorunal of

Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 56-62

[8] Sandra, G.; "Application of Multiobjective Evolutionary Techniques for Robust Portfolio Optimization"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 63-64

[9] Shiv, R.D., Pushkar, D., et al.; "Infected Fruit Part Detection using K-Means Clustering Segmentation Technique"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 65-72

[10] Eugenio, G., Andrés, C., et al.; "P2P networks evolution and their influence in education"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 73-78

[11] Daniel, B.; " L.I.M.E. A recommendation model for informal and formal learning, engaged"; International Jorunal of Interactive Multimedia and Artificial Intelligence vol 2 (2). (2013); pp 79-86

WELCOME TO NEW MEMBERS

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JOURNAL COVER

We want to thanks the cover of this issue to the professional photographer Michael "Mike" L. Baird (bairdphotos.com)

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Annotation and Visualization in Android: An Application for Education and Real Time Information

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Abstract — By using Augmented Reality applications, users can get more information while interacting with real objects. The popularity of the Smartphones and the ubiquity of an Internet connection within modern devices, offer the best combination for these kind of applications, which can pull content from heterogeneous sources. The goal with this work is to show the architecture and a basic implementation of a prototype for an AR application that displays information (opinions) about physical places as comments overlaid to the place left there by other users, but that also encourage in-situ content creation for collaboration. These applications can also be used in order to improve the interaction between students and physical places, getting facts, or associating quizzes to a specific location; tourism guides, promotions of products, just to mention a few.

Keywords — Augmented Reality, Android, Interaction, Annotation, Visualization, Smartphones, Education

Fig. 1. Four types of AR Systems [5].

I. INTRODUCTION

AUGMENTED Reality (AR) applications let the user get more information about a real object by overlaying computer generated content. This is different from a Virtual Reality approach in which both the world, and thus the objects are completely computer generated [2].

AR applications are not new and since the 1960's there have been some investigations like the ones conducted by Ivan Sutherland [27], Jun Rekimoto [22], Hirokazu Kato and Mark Billinghurst [7] which began to lay the basis of what can possibly be achieved with the available hardware [3], [10].

Emmanuel Dubois proposed taxonomy for AR (Fig. 1) in which there can be two types of systems: Task Focus and Nature of Augmentation. The former refers to the object (real or virtual) involved in the user's task, while the latter to the amount of actions can be done with the object (execution or evaluation).

Almost all AR systems available today have a main focus on annotating real objects, which is the main premise upon which applications like Layar [13], and this prototype are built. Users can get more information, but they not modify the object.

There are also applications like *Expedition Schatzsuche* [26] that displays virtual content over the real world and let the user interact with these objects, these are the basis for AR digital publications, like the one released by the German newspaper Süddeutsche Zeitung [12].

These image overlay has been used in museums like the Louvre [16] or in Wien [26] highlighting the role of education for AR applications. On the other hand, games like *ARQuake* [30] or *Time Warp* [6] highlight the use of the technology not within a room or a building, but in a city in which the user must use special hardware to "see" the augmented information available.

Nowadays both Smartphones and mobile Internet connections are mainstream; these two factors open the door to an improvement in the quality and quantity of the information available to the user depending on his/her location and which he/she is also capable of sharing, instantly, with others.

Modern lifestyle is related to ubiquity, expectation and the will to consume information immediately (Fig. 2); this is the reason all these mobile devices offer more ways to be on-line and let us, via a social web, share, consume and interact with other people.

Based on unknown surroundings, how can a person gather information of the place? How can this content be viewed?

How can the person can interact and/or generate this content?

Since "technology becomes an important means of both constructing and revealing the reality of a contemporary city" there are "substantial potential of media architecture and interactive spaces to extend human perception" [28].

Context awareness let the user pre-fetch some information based on the physical location of a user, which is a great benefit for both outdoor and indoor AR Applications. Thanks to the information gathered from the sensors (WiFi, GPS) information can be presented to the user based on his/her surroundings.

Although there are context aware applications that let the user "discover" or get information of the surroundings, and also studies have been carried to define methods to gather data for an application to provide a service of interest for the user based on context information [1], the information lives within the scope of the application and it doesn't overlap into the real objects.

One of the first attempts at displaying information to a user in which could be seen as a Mobile Augmented Reality (MAR) application in a city is the *Touring Machine* [8] which offered information to the users via an HUD. Most recently we have applications like *Arbela Layers Uncovered* [24], and, *Astrid's Steps*[18], which rely on historical sites to let people undercover the secrets in the concrete places these applications are designed to work.

There have been advances in the way the information can be organized, maintained and fetched [23], how to get better identification of geotagged images [31][11], how to better navigate based between GPS locations [15][9], and also some example applications of how to use geotagged data in order to leverage the education in Architecture [25] or for virtual tourism [21].

Studies for user expectations on AR Systems and geo localized games [19][29][17] have yielded the importance not only in context awareness and useful information for the user, but also a sense of collaboration both between trusted contact and unknown contacts.

It is interesting to note that in most cases, users expressed the opinion for "creating personalized augmented views of the shopping centre, e.g., by making the environment more cheerful with decorations" or "interested in other users' comments, specially the local people's comments while abroad" [19].

Work done by De Michelis [4] and Ramírez [20] denotes the importance in the use of technology and reality augmentation for collaboration; the fact that the people could access the needed content (perhaps also based on a role, which is out of the scope of this prototype) is important for the collaboration (place annotation, touristic/academic/commercial knowledge base maintenance) to be as smooth as possible.

Applications like the ones mentioned, have specific roles for the people who create content and the ones who consume it, marking a clear line between the place in which the content is created and the actual physical place in which it is consumed.
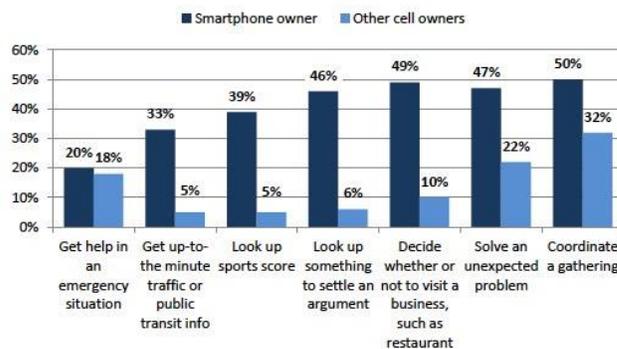
Fig. 2. Real time information in Smartphones [14]

The goal of this work is to demonstrate the basic architecture for an outdoor AR application that encourages the user to annotate in-situ a place based on the GPS coordinates.

The basic annotation for the world will be represented as a yellow square (like a Post-it© note). That way another user can look at these notes and decide on whether the place is worthy of his/her time or not.

In some restaurant is commonplace to let the users mark the walls with comments, however this wouldn't be acceptable in a museum or a store, and that's why AR solves the problem, because all the notes won't be physically attached to a place, but virtually to a location.

These kind of annotations could be viewed both as a mean to gather information, but also as an interactive art installations that "provokes social interactions and their potential to transform existing configurations of public space" [28].

The rest of the article is organized as follows: In Section II we select the development framework. In Section III the architecture for the prototype is described and in Section IV the implementation is showed. Finally Section V has the Conclusions and the future applications that can be based in the prototype.

II. DEVELOPMENT FRAMEWORK

There are quite some tools available for AR content; from the SDK for Android, up to the complex applications and ecosystems in which AR Browses live, fetch data and overlay it to the user.

These tool are different and although the concept may seem the same, the way the information is showed to the user, the OS in which the applications can be used and the freedom to create content. For this prototype we evaluated several existing frameworks taking into consideration the following aspects:

Openness. Is the framework open for development without royalties?

Location via GPS. Can the framework use the GPS information to know the location of the user?

Content Generation. Can the user generate his/her own content?

In-situ annotation. Can the user generate the content in the place he intends the content to be shown?

Based in these characteristics we evaluated the following frameworks: *Wikitude*, *TagWhat*, *Metaio/Junaio*, *Layar*, and *KHARMA*. The results can be summarized in the following table (Fig. 3):

Aspect Framework	Openess	GPS Localization	Freedom of content	In-situ annotation
Wikitude	X	X	X	
TagWhat	X	X		X
Metaio/Junaio	X			
Layar		X		
KHARMA	X	X	X	

Fig. 3. Frameworks

None of the evaluated frameworks offers the whole range of aspects needed to the development of the prototype, and although TagWhat and KHARMA were really close in what they offered, the former is only available in the US and the second is not available for the Android OS.

Since none of the evaluated frameworks could be used the SDK for the Android OS was the development tool chosen for the prototype based on the following:

• Most of the frameworks are closed. Content creations is based on on-line templates and the interaction is limited, because the user doesn't have control over which he/she wishes to annotate.
• Most of the frameworks are capable of more than is needed for the application and, as in a closed system, they are dependent on third party DBs to get all the information.
• Developing a prototype without a framework is an opportunity to delve into the SDK and get to know all the tools available for the user; these knowledge can be used for future projects.
• Getting to know first-hand the way to implement all the requirements for the applications can be translated to solving similar problems in all kinds of applications for the OS.
• This prototype can be the groundwork for a bigger application, which could leverage the information to offer the user touristic information or an education tool for field trips.

III. ARCHITECTURE

In order to meet the goals of building the prototype of an AR application that let the user "annotate" places and interact with the notes, we must leverage the tools available in the SDK to communicate with the sensors, both location (GPS) and orientation, which are almost in every mobile phone.

The user will be able to, given his/her location, create a place (in case it is not in the DB) and associate a note to the place. These notes will be visible to other users as yellow squares overlaid on the actual physical object. The user can also interact with the notes by reading them.

The proposed Architecture has five components which are grouped within the Model View Controller pattern (Fig. 4).

The Model includes all the relative information of the state of the system in any given moment. Within the Model we can find the *Data Storage* which can be hosted inside or outside the device. Ideally it should be in a server, in order for every user to access it. Here is where the information created by the user is stored.

For the prototype, this component will reside inside the mobile phone; however all the access methods are exposed via an interface, so we are decoupling the implementation, so these module could be implemented in a server without modifying the actual structure.

For the DB we used the SQLite DBMS, although as stated, any RDBMS can be used.

For each of the tables we defined a POJO (Plain Old Java Object) so we can translate the information in the DB into the Objects needed in the application.

The *Location* component has all the elements related to the orientation and location of the device, which are also part of the system's state. When we speak of Location we are talking about the position of the device within Earth's surface. This information is acquired via the GPS satellites. Based on the location, a user can define a new place, which would later be annotated.

As for the Orientation, it refers to the information regarding the way into which the user is pointing the device, in which direction the user is rotating it or holding it. This information is then used to let the notes be displayed as if they were really attached to the place.

Android has built-in interfaces for communication with the sensors. For the GPS we implement both a `LocationListener` and a `GpsStatus`.

Within the Android API there are some guidelines on the usage of these interfaces and also best practices, which let let the developers make the most efficient use of the both the date of the sensors, and the resource systems (i.e. the battery).

For the prototype, since the application should be location aware all the time, we are asking for a change in the position of the phone every moment. This is useful also if, in a future upgrade, a user wishes to record a walking route highlighting and annotating places as he/she walks.

For the orientation sensors the interface `SensorEventListener` let the user interact with the sensors, which in turn, use the accelerometers and the magnetic field information to know how the user is moving/holding the device and, translate this information to the coordinate system of the device.
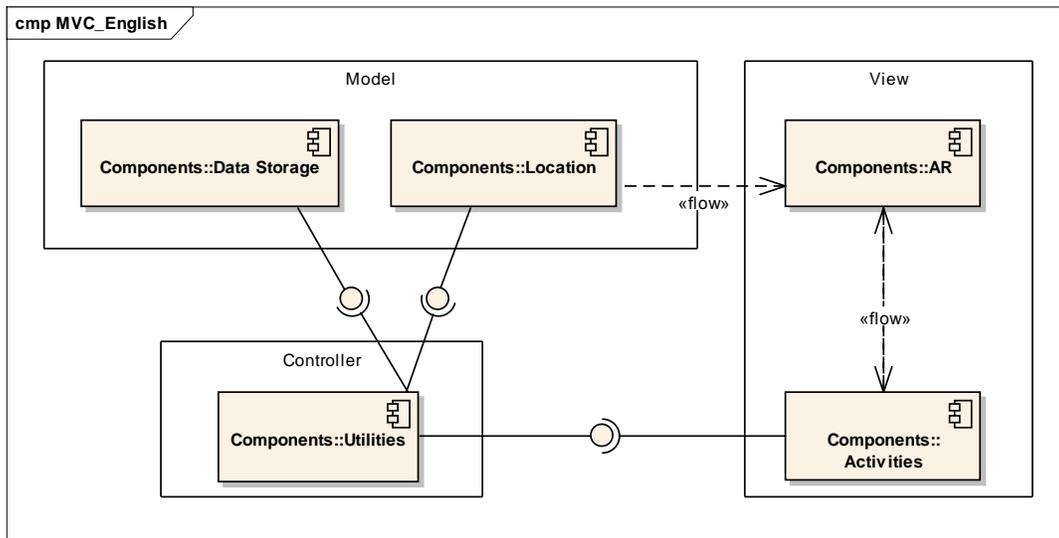
Fig. 4. Proposed Architecture

This is important because it lets the application calculate how the notes should be presented, so the user can really think that they are sticked there. As we progressed with the development we found out that, since the sensor points to the top of the device, so pointing to the North in vertical position and the rotating the phone to a landscape mode, since the "top" of the phone would point to east or west we needed to make some corrections.

The **View** includes the *Augmented Reality* component and this is the one in which all the information is presented to the user and he/she can interact with it.

Based on the GPS information, a place is retrieved and in turn, all the notes are then displayed to the user. As the user pans his device through the place, the notes might be in place thanks to the information of the orientation sensors.

All this is within an `Activity`, base for all the screens in the Android OS. This `Activity` holds all the information of the sensors and starts a View based on the information captured in real time from the camera, via a `SurfaceHolder.Callback interface`.
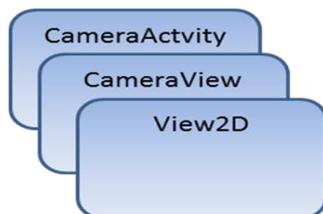
Fig. 5. AR Component overview

Once we can see what the camera sees, we can display our notes, 2D objects, with the possibility of using more complex ways of representing the notes, from images to 3D objects. In order to display all the objects the notes should extend from `View` and on the `onDraw()` method we define how the objects

should be rendered according to the position of the device.

The way we use the layers for viewing and showing the context can be summarized in (Fig. 5)

As we can see, we are using two views, one over the other. This way, when the user touches the screen, the upper layer can detect the position of the finger and know if the user is touching a note or not. If he/she is indeed trying to interact with a note (for the prototype clicking on a note is the only way to read it) it triggers the actions defined by the programmers. With these approach we can guarantee that if the

user clicks on note "1", then the content for such note will be available and not a random behavior.

Also the *Activities* (which are the name given in Android to all the screens) are enclosed within the View since they are part of the way the user communicates with the system.

Finally in the Controller we define a *Utility* component in which we group the common elements to all the applications and the actions which control the flow of information within the prototype.

Constants. Elements with a fixed value. Interfaces with static variables are used in order to be more efficient. We can find error messages, log messages, etc.

DataSharing. This is the solution to share information between Activities (screens). The most important information shared this way is the location information, that needs to be passed from the sensors to the new note or new place screen and then to the DB.

Listeners. They implement all the behavior for each button in the prototype. For each button an action is triggered and in this listener we can know the button that started the action and then trigger the correct action.

IV. IMPLEMENTATION

Once the prototype was ready, tests were made first to check that all the sensors worked OK and then two phases of tests were made; the first one was to correctly display (both in

landscape and portrait mode) dummy information verifying:
- Image display from the camera.
- Image rotation according to the device rotation.
- Note overlay and interaction with the user input.

In these tests we found out that the notes weren't correctly displayed since the information from the sensors wasn't being correctly translated to the device.

Fig. 6. Place creation
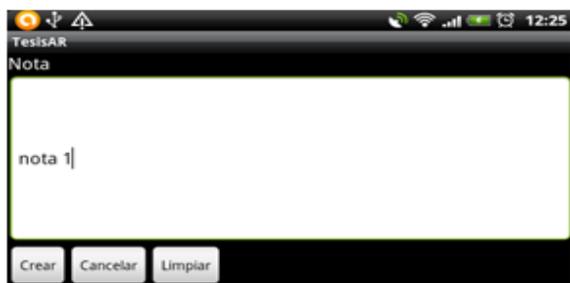
Fig. 7. Note creation
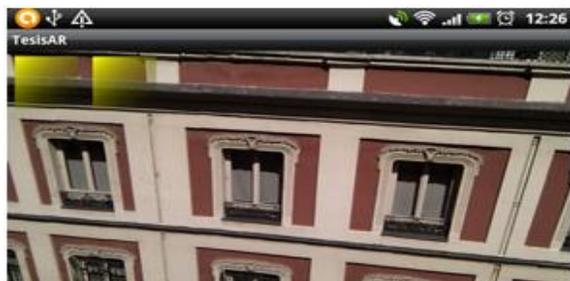
Fig. 8. Notes in Landscape mode

Since they are too fine grained and too sensitive, adjustments were made in order to make them less sensitive so the transition could be smooth enough for the user.

As for the image, corrections had to be made in order to correctly rotate the image, since we found out that we needed to rotate the image to correctly display it when the user switches from the landscape mode to the portrait mode.

For the final test we followed the following steps:
- Creation of a New Place (Fig. 6).
- Creation of Notes for a Place (Fig. 7).
- Overlaying of Notes to the Place (Fig. 8).
- Interaction with the Notes.

All this actions were performed without a flaw. The Place was created, and notes were associated. Once the Notes were retrieved they seemed to be sticked to the walls and the interaction with the user was without a problem. For each note

that the user clicked on, the content of that note would appear before him/her.

V. CONCLUSIONS

AR applications are not limited to mobile devices, however is in this devices that lays the biggest potential to grow, since new SDKs and the popularity of this devices put them in the hands of avid users and developers.

From medical applications, games, collaboration tools and hardware development pave the way to just search an object and it's properties just by looking at it; imagine getting to a store and realizing which size of clothes is the best for you, buying furniture for your house just placing a virtual object from an on-line catalog interacting with your living-room or in education by letting the students know more about objects that aren't available in a common classroom or training new engineers or doctors on how to give maintenance to an engine, or give attention to a virtual patient.

This prototype uses the characteristics of a Smartphone not just to display information about a place, but encourages the user to generate in-situ such context that will be present to other people, and also, letting the user interact seamlessly with virtual objects in a real environment thanks to the touch screen.

The flexibility of the proposed prototype can be the base for a more complex application, for example a tourist guide, that let the user create content about interesting routes, facts about buildings and recommendations about a nice place to stay, eat or buy souvenirs.

Another application can be educational information about historic places, in which just by pointing the device to the desired location can give the student important information or make in-situ tests, letting them interact with real places leveraging the way they can understand and apply the information given to them.

The schema presented can take advantage of all the research done in the areas of data organization and is open to the use of external and static data sources for the AR content that complement the use of the user created content.

Even though in this case the information is stored locally, there's room for improvement by letting query this knowledge from a server and making this information better and broader, and if it's true that there are some applications that offer similar characteristics, AR can be a novel way to market them.

As applications like Google Glass move from the prototype phase to mass production and consumption, the fact that this pervasive technology is being made available to selected developers can give us a hint about a trend that will be even more popular as the time passes, and as with every technology, the hardware and software evolves, making us wonder what the future will bring to the AR.

Because of this is that, as a final thought, correct privacy and copyright measures must be taken in order to guarantee the safety of all the parties involved. Avoiding security breaches will be as important as the way the information is presented.

REFERENCES

[12] Amato, A., B. D. Martino, et al.; "Semantic Brokering of Multimedia Contents for Smart Delivery of Ubiquitous Services in Pervasive Environments"; International Jorunal of Interactive Multimedia and Artificial Intelligence (2012) pp. 16-25

[13] Azuma Ronald; "A Survey of Augmented Reality"; Presence: Teleoperators and Virtual Environments 6, 4 (Agosto 1997); pp. 355 – 385

[14] Benefon; "Benefon Esc! NT 2002"; http://www.benefon.de/products/esc/ (accesed on 2013/04/30)

[15] De Michelis Gio, De Faoli Flavio, Pluchinotta Constanza y otros; "Weakly Augmented Reality: observing and designing the work-place of creative designers"; Proceedings of DARE 2000 on Designing augmented reality environments (2000); pp. 81-91

[16] Dubois Emmanuel, Nigay Laurence; "Augmented Reality: Which Augmentation for Which Reality?"; Proceeding of DARE 2000, Design Augmented Reality Environments, ACM (2000); pp. 165-166

[17] Herbst Iris, Braun Anne-Kathrin, McCall Rod y otros; "Time Warp: Interactive Time Travel with a Mobile Mixed Reality Game"; MobileHCI (Septiembre 2,5 2008); pp. 234-244

[18] Hirokazu Kato, Mark Billinghurst, "Marker Tracking and HMD Calibration for a Video-Based Augmented Reality Conferencing System"; 2nd IEEE and ACM International Workshop on Augmented Reality 1999; pp.85

[19] S. Feiner, B. MacIntyre, T. Höllerer y otros; "A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment"; Proceedings of First IEEE International Symposium on Wearable Computers (ISWC '97); 1997; pp 74–81

[20] García, C. M., and G. M. Ortega; "Route planning algorithms: Planific@ Project"; International Journal of Artificial Intelligence and Interactive Multimedia (2009); pp. 57-66

[21] Impress Corporation; "Ketai Watch: J-SH04"; http://k-tai.impress.co.jp/cda/article/showcase_top/3913.html (accesed on 2013/04/30)

[22] Jong-Seung Park, Ramesh Jain; "Identification of scene locations from geotagged images"; ACM Transactions on Multimedia Computing, Communications, and Applications (TOMCCAP) TOMCCAP Homepage archive (Volume 9 Issue 1, February 2013); Article No. 5

[23] Junaio/Metaio; "Press Release: SZ Magazin and metaio develop Mobile AR Special"; 2010; http://www.metaio.com/press/press-release/2010/sueddeutsche-zeitung-sz-magazin/ (accesed on 2013/04/30)

[24] Layar; "What is Layar?; 2012; http://layar.com/what-is-layar/ (accesed on 2013/04/30)

[25] Lee Rainie, Susannah Fox. Just-in-time Information through Mobile Connections. Pew Internet & American Life Project, May 7, 2012, http://www.pewinternet.org/Reports/2012/Just-in-time/Main-Report/Findings.aspx (accessed on 2013/01/10)

[26] Magnusson Charlotte, Rassmus-Gröhn Kirsten, et al.; "Navigation by pointing to GPS locations"; Personal and Ubiquitous Computing archive, Volume 16 Issue 8 (December 2012); pp. 959-971

[27] Miyashita T, Meier P, Tachikawa T; "An Augmented Reality Museum Guide"; ISMAR '08 Proceedings of the 7th IEEE/ACM International Symposium on Mixed and Augmented Reality (2008); pp. 103-106

[28] Neustaedter Carman, Tang Anthony, et al., "Creating scalable location-based games: lessons from Geocaching"; Personal and Ubiquitous Computing archive, Volume 17 Issue 2 (February 2013); pp. 335-349

[29] NilssonSusanna, Arvola Mattias, et. al "Exploring place and direction: mobile augmented reality in the Astrid Lindgren landscape"; OzCHI '12 Proceedings of the 24th Australian Computer-Human Interaction Conference (2012); pp. 411-419

[30] Olsson Thomas, Lagerstam Else, et al., "Expected user experience of mobile augmented reality services: a user study in the context of shopping centres"; Personal and Ubiquitous Computing archive, Volume 17 Issue 2 (February 2013); pp. 287-304

[31] Ramirez, J. J.; "Collaborative Geographic Information Systems for Business Intelligence"; International Journal of Artificial Intelligence and Interactive Multimedia (2009); pp. 94-97

[32] Realinho Valentín, Teresa Romão, et al; "Building mobile context-aware applications for leisure and entertainment"; ACE '11 Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology (2011), Article No. 29

[33] Rekimoto Jun, Nagao Katashi; "The World Through the Computer: Computer Augmented Interaction with Real World Environments"; Proceedings of UIST '95 14-17 (Noviembre 1995) pp. 29-36 via [1]

[34] Rodríguez Sánchez, Martínez Romo, et al; "GAT: Platform for automatic context-aware mobile services for m-tourism"; Expert Systems with Applications: An International Journal archive. Volume 40 Issue 10, (August, 2013); pp. 4154-4163

[35] Rozhen Kamal Mohammed-Amin, Richard M. Levy, et al. "Mobile augmented reality for interpretation of archaeological sites"; PATCH '12 Proceedings of the second international ACM workshop on Personalized access to cultural heritage (2012); pp 11-14

[36] Sánchez Albert, Redondo Ernest, et al; "Developing an augmented reality application in the framework of architecture degree"; UXeLATE '12 Proceedings of the 2012 ACM workshop on User experience in e-learning and augmented technologies in education (2012); pp. 37-42

[37] Schmalstieg Dieter, Wagner Daniel; "Experiences with Handheld Augmented Reality"; Proceedings of the 2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality (2007); pp. 1 – 13

[38] Sutherland E. Ivan; "A head-mounted three dimensional display"; AFIPS '68 Proceedings of the December 9-11, 1968, fall joint computer conference part I (1968); pp. 757-764

[39] Urbanowicz Katarzyna, Nyka Lucyna; "Media architecture: participation through the senses"; MAB '12 Proceedings of the 4th Media Architecture Biennale Conference: Participation (2012), pp. 51-54

[40] Ventä-Olkkonen Leena, Koskenranta Olli, et al., "User expectations of mobile mixed reality service content"; MUM '12 Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia (2012); Article No. 52

[41] Wereable Computer Lab; "ARQuake: Interactive Outdoor Augmented Reality Collaboration System"; 2010; http://wearables.unisa.edu.au/projects/arquake/ (accesed on 2013/04/30)

[42] Yen-Ta Huang, Kuan-Ting Chen , et al; "Detecting the directions of viewing landmarks for recommendation by large-scale user-contributed photos"; MM '12 Proceedings of the 20th ACM international conference on Multimedia (2012); pp. 997-1000

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BPLOM: BPM Level-Oriented Methodology for Incremental Business Process Modeling and Code Generation on Mobile Platforms

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Abstract — **The requirements engineering phase is the departure point for the development process of any kind of computer application, it determines the functionality needed in the working scenario of the program. Although this is a crucial point in application development, as incorrect requirement definition leads to costly error appearance in later stages of the development process, application domain experts' implication remains minor. In order to correct this scenario, business process modeling notations were introduced to favor business expert implication in this phase, but notation complexity prevents this participation to reach its ideal state. Hence, we promote the definition of a level oriented business process methodology, which encourages the adaptation of the modeling notation to the modeling and technical knowledge shown by the expert. This approach reduces the complexity found by domain experts and enables them to model their processes completely with a level of technical detail directly proportional to their knowledge.**

Keywords — **Business Process Modeling, BPMN, process transformation, code generation.**

I. Introduction

Software development has seen some great changes in some of its methodologies and techniques, but some of its problems have remained unchanged since their appearance in the mid and late twentieth century. One of these lasting problems is related with requirements engineering, aspect of the software development process that has seen very little evolution. Sommerville and Kotonya stated in their study [1] that there are several problems related with this initial activity of the software development process. The first problem mentioned is that the requirements engineer is not an expert in the application domain being addressed. Another of the difficulties present in this phase of the software development cycle which is also mentioned by these two authors is the fact that natural language is ambiguous, which has also been confirmed by the work of Laue and Gadatsch [11].

The Business Process Management Initiative (BPMI) [24], a group inside the OMG [23], proposed a solution for this problematic situation: Business Process Modeling (BPM), a discipline promoting the implication of the domain experts in the requirements engineering process through the use of a modeling notation that lies between the domain experts' language and the computer experts' knowledge. In its proposal, the BPMI introduced Business Process Modeling Notation (BPMN) [25] as the standard notation for BPM. Although their intention was different, this standardization made the notation grow in size and complexity to the point where non-technical domain experts must undergo a training process in order to understand it and use it properly [5].

Due to this circumstance, some simplifications of BPMN have been conceived, with different success degrees; one of these simplifications is Simple BPMN (SBPMN) [6], defined during previous work at the University of Oviedo with the following objectives: reduce the number of symbols needed to model a process and raise the user's level of abstraction. SBPMN was used to generate applications in a similar scenario to the one presented in this paper [20], although in that case several adaptions of the model were necessary for the code to be generated. The results obtained by SBPMN in the tests carried out were satisfactory but we consider the number of symbols it offers to be too large for non-technical domain experts. In order to solve this situation our first objective is the definition of a BPM level oriented methodology, a system that enables the adaptation of a graphical modeling notation to the skill level presented by the business expert.

In order for our approach to be used in real scenarios we need to achieve two other objectives: encourage business experts to model their processes and enable quick generation of the applications supporting the models created by the experts. We intend to complete these two goals with the definition of two separate but closely related tools: BPLevel Modeler and BPLevel Generator. BPLevel Modeler is a business process modeling tool which supports the level oriented methodology and promotes the involvement of business experts in the requirements engineering process through a simple and intuitive user interface. On the other hand, BPLevel Generator is capable of analyzing the models created with BPLevel Modeler and generate a specific and custom application for each model; in this case the tool is

aimed at the computer experts in charge of developing the applications in each scenario.

A summary of the structure of our proposal is shown in Fig. 1, where the whole modeling and code generation process can be overviewed; as it is seen, business experts will be able to create their models through the use of our modeling software

and the models generated will be handed to the corresponding IT technicians who will generate the custom applications using our code generation tool. These computer experts will also be involved in the configuration of the XML file containing the graphical details of the custom application, which at this moment needs to be done manually.
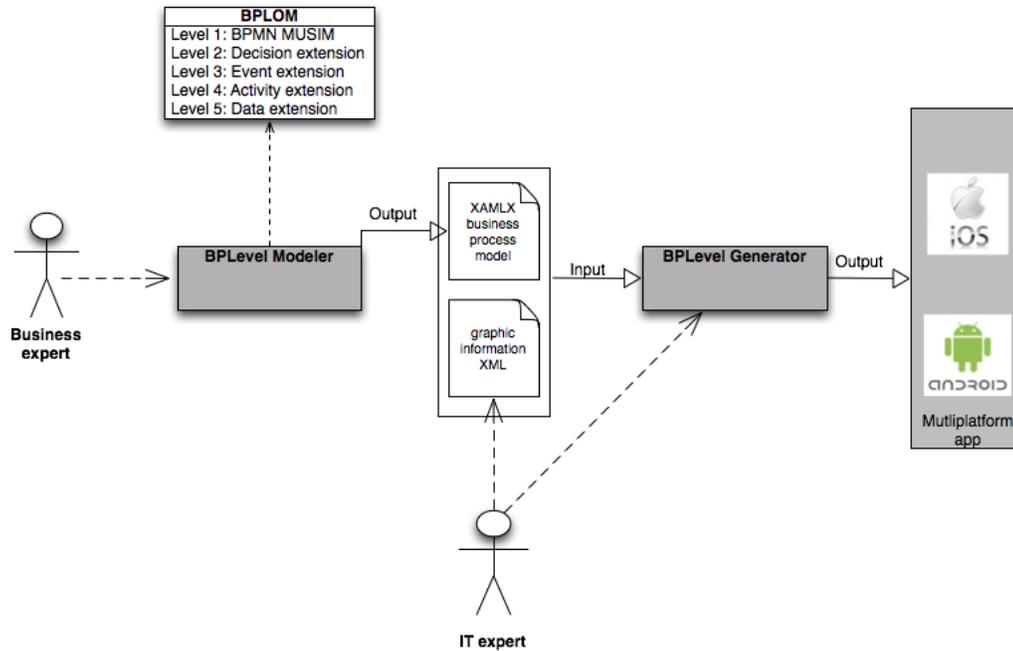
Fig. 1. Graphical overview of BPLOM use scenario

The rest of this paper will be structured as follows: section II will describe some of the existing BPM notations and establish the difficulties that non-technical domain experts undergo when using them. Section III will introduce our BPM level-oriented methodology and the results obtained by its initial level in a real scenario at a Spanish enterprise, where business experts used the initial level of our methodology for modeling their processes. In section IV we will present our tools, starting with BPLevel Modeler and continuing with BPLevel Generator and its intended use. Lastly, in section V, we will identify our conclusions and section VI will establish the future work we intend to carry out in order to improve not only our tools but also our methodology.

II. BPM AND BUSINESS PROCESS MODELING NOTATIONS

BPM is an initiative that encourages domain experts to define their business processes through modeling notations as a way of reducing the difficulties found in the requirements engineering process. This approach is based on the use of notations that are half way between the domain experts' language and the computer experts' knowledge.

There are, mainly, two types of business process modeling notations: graphical notations and textual notations. Bearing in mind our current application scenario, we have studied what we consider to be a representative set of notations that meet all of the following factors:

- High degree of diffusion, including in our revision those notations with higher diffusion degree.
- Wide range of complexity, from the most complex example (BPMN) to the simplest one (SBPMN).
- Domain expert implication, factor which rules out textual notations as a suitable modeling alternative. As stated by Lu and Sadiq [10], graphical notations allow users to represent business processes through simpler semantics and more abstract syntax, circumstance that lowers the complexity domain experts experience during the modeling and verification of the processes.

A. BPMN: the standard notation

BPMN is the standard notation for business process modeling. It was proposed by the BPMI in 2004 and since then it has undergone periodical revisions, being at the time in its 2.0 version. It is the most widely use notation of this type, with more than 70 implementations nowadays.

The two objectives that where stated as principal goals for BPMN in the introductory document written by Stephen White [2] where the following: provide domain experts an understandable and usable notation and reduce the number of existing notations and modeling tools.

1) BPMN's features

BPMN's root element is the Business Process Diagram (BPD), which is composed by a set of activities that represent the actions present in the business process and a group of flow

controls entities that establish the order in which these activities are done. The models built with BPMN can be enriched with other elements such as events, choreographies, messages, lanes and pools. BPMN's elements can be divided into the following categories: activities, gateways, conversations, choreographies, events, swimlanes and data.

The number of elements present in the BPMN specification is large, circumstance explained by the standard category of the notation. Version 1.1 of BPMN consisted of 52 different elements whilst the actual 2.0 version has seen an increase in this feature, as it can be seen in the BPMN 1.1 and 2.0 posters linked in the BPMN web page [25].

2) BPMN's disadvantages

The main issue regarding the use of BPMN when dealing with non-technical domain experts for process modeling is its complexity.

Wahl and Sindre have confirmed this fact in a study [5] where they state that a non-technical expert will need training in order to be able to use BPMN in a correct way. This complexity can also be seen in the investigation carried out by Recker in 2007 [7], where through the answers of 590 BPMN users he has been able to establish that there are several entities in BPMN that receive very little use. This fact can be seen in Fig. 2, a graphic classification of BPMN entities based on the use they receive obtained from the results presented in the referred work. The entities in BPMN are classified into three different categories: important, sometimes used and unused.
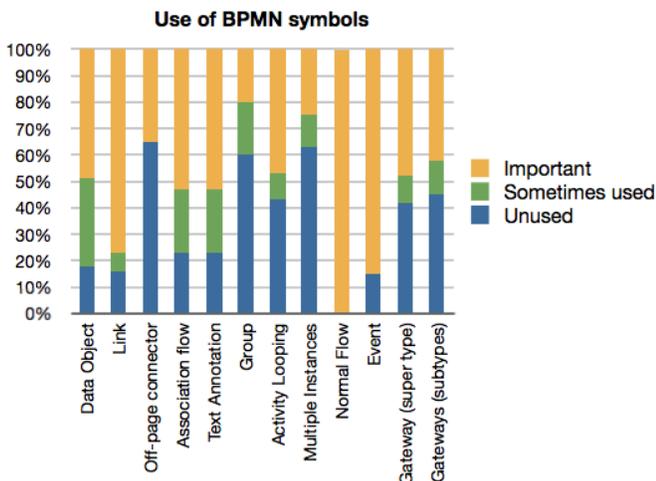
Fig. 2. Graphical representation of BPMN symbol importance obtained in Wahl's and Sindre's work

Stephen White and Miers also mention BPMN's complexity in their BPMN reference guide [8]. In one of the sections of the book they point out that it is not likely for a business analyst or end user, who can also be referred to as a application domain expert, to need all the symbols included in BPMN.

Another issue concerning the usage of BPMN by non-technical domain experts is the great number of BPMN supporting tools that exist actually. Although one of the objectives stated in the presentation of BPMN [2] was to reduce the number of tools with support for BPMN, the

situation has gone the other way; this circumstance can be confirmed by a study carried out in 2010 [13] where it is stated that the popularity of BPMN has encouraged the appearance of a greater number of modeling tools with support for the standard. The magnitude of this problem seems to increase when the differences between the tools are notable due to the interpretation of the standard made by the authors and the different approaches that lead to including BPMN entities to the tool or not.

B. UML Activity Diagrams

UML Activity Diagrams, which can also be referred to as UML AD, are one of the types of diagram included in the Universal Modeling Language (UML) [26] specification.

The Activity entity, which represents the different actions that have to be carried out during the execution of the process, is the base of this type of diagrams. The activity entity is accompanied in these diagrams by other artifacts like decisions and parallel activity execution syntax. Although UML AD include entities present in the other business process modeling notations, a study [4] referenced in our analysis establishes that UML AD are less expressive than BPMN.

Even though UML AD do not include such a great amount of entities as BPMN, fact which enables a reduction of the complexity found when modeling business processes, there are some issues regarding the graphical representation chosen for them. This circumstance is triggered by the fact that some of the entities included in the specification share the same graphical representation. For example, the decision entity is represented in the same way as the merge entity, situation that can lead to problems for the understanding of the model by the non-technical domain experts. This circumstance can be seen in Fig. 3, which shows a sample UML Activity Diagram process.
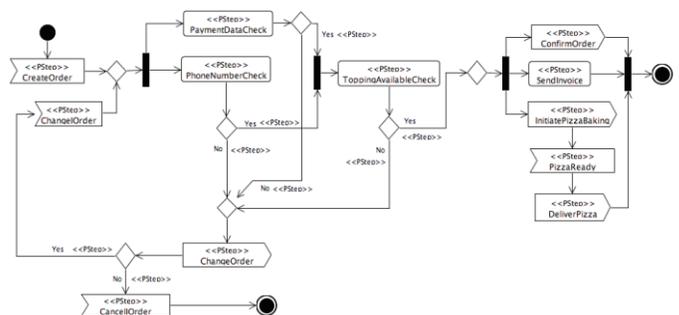
Fig. 3. UML AD sample process diagram

The other aspect that encourages us to avoid using UML AD as a valid notation for process modeling by non-technical domain experts is its abstraction level. As UML is a general-purpose language, UML AD offers the user a very low abstraction level. This aspect goes against one of the main goals in this investigation: usability experienced by non-technical domain experts.

C. jPDL, process modeling language in Java

jPDL, which stands for Java Process Definition Language, is a graphical language for business process definition included

in jBoss jBPM [27], a BPM suite written in Java for applying BPM under this platform.

This language appeared as a simplification of BPMN via two different approaches: reducing the number of entities available for the definition of the process and modifying some of the graphical representation of the entities through a color code. As a result of the appliance of these approaches, jPDL has managed to offer a lower complexity level than BPMN and has also achieved an increase in the user's level of abstraction. Fig. 4 shows a sample process diagram built using jPDL, where the color code can be appreciated as the main difference between this diagram and the one generated with UML AD.

An example where jBPM is used to increase the level of automation of the business processes can be found in the work done by Castaño [21]. Having correctly identified the suite's capability for adapting to nearly all business process, Castaño introduces a prototype using jBPM that enables further automation of business processes through the use of data mining. Via this solution, the dependency that some processes may have with human interaction can be reduced.
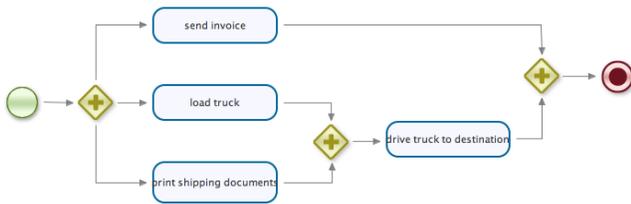
Fig. 4 jPDL sample process diagram

Although the inclusion of this color code favors the comprehension of the models built with jPDL and despite the fact that this language has managed to reduce the number of entities offered by BPMN, we consider that jPDL is not suitable for our investigation. Our main concern regarding jPDL is the user's level of abstraction, as there are two aspects related with the activity entity that make it low: on one hand, the fact that there are various types of activities which have high technical content (the script task, for example) and, on the other hand, the need to edit under some circumstances the XML code behind the graphical representation of the business process in order to configure some of its details.

D. Petri nets, another option for process modeling

Petri Nets [14], defined by Carl Adam Petri in the mid twentieth century, are another option to be considered when dealing with process modeling. There are several features that make Petri Nets suitable for this task, as stated by van der Aalst in his study [15]:

- Formal semantics, which enable the precise and clear definition of process models.
- Graphical nature, which promotes process definition through the use of nodes and transitions.
- Expressiveness, as they support all the primitives used when defining processes.
- The existence of many analysis techniques that can be applied to them. These techniques can be used to evaluate properties and also to calculate performance rates.

- Platform independency, as Petri Nets are not based on any proprietary software.

Despite these properties Petri Nets have and although they can be defined graphically, there is great concern when introducing them to non-technical domain experts: their complexity and low level of abstraction. These two inconveniences are against our usability and business expert focuses so we have decided to avoid using Petri Nets in our scenario, although we think they are suitable for completing modeling tasks under other use circumstances.

E. SBPMN: Simple BPMN

Simple BPMN, also referenced to as SBPMN [6][20], is a reduction of BPMN attempted as a previous investigation of components in our group at the University of Oviedo [28].

SBPMN arose as a possible solution to the problems found with the abstraction and complexity levels of the notations previously presented in this paper. One of the objectives of SBPMN was to reduce the technical knowledge level needed to complete the modeling of a business process by the domain expert. It also tries to avoid the arbitrary use domain experts give to some of the symbols present in BPMN.
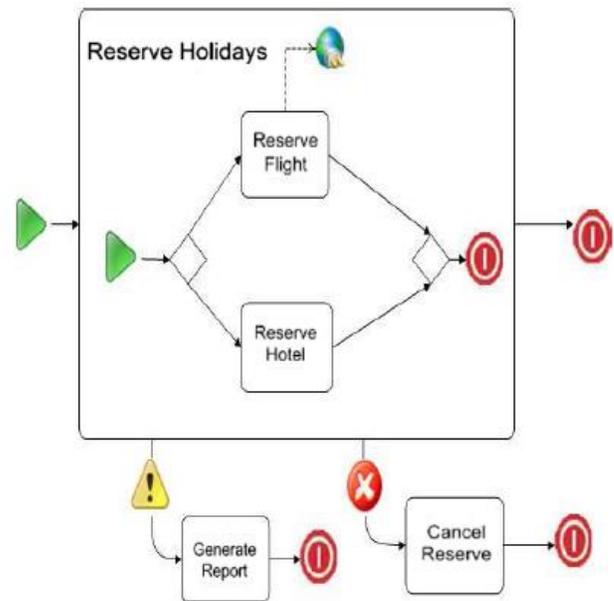
Fig. 5. SBPMN sample process diagram

Fig. 5 shows a sample SBPMN diagram representing the process used to make a trip reservation. As it can be seen, SBPMN offers different graphical representation of some of the entities it borrows from BPMN, which makes the process more intuitive for the user and simpler to understand.

The graph presented in Fig. 6 shows a graphical summary of the results obtained by SBPMN in the tests that were carried out after its definition. These results show that percentage of errors or failures made by domain experts when using SBPMN was less than when using BPMN, showing a reduction rate greater than 20%. This error reduction implies that the skill level shown by the users raised considerably when using SBPMN (more than 80% of skills shown) compared to BPMN (less than 50% of skills shown).
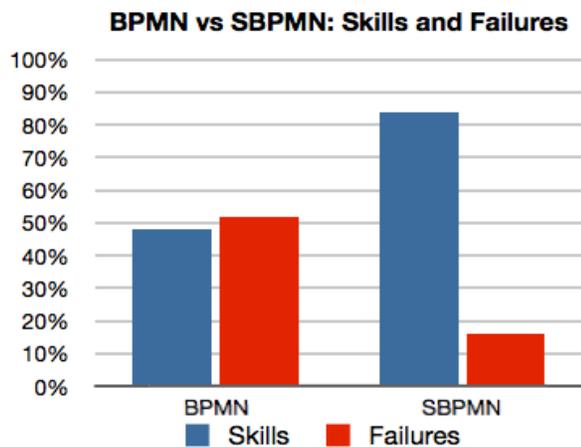
Fig. 6. Comparison of skills and failures between BPMN and SBPMN

The results shown establish that SBPMN is simpler than BPMN for non-technical domain experts when modeling their business processes. The problem concerning this simplification, despite the great effort shown in managing to simplify process modeling to non-technical domain experts, is the fact that the number of entities offered is still big and sometimes can be too complex for non-technical experts; for example, SBPMN proposes the use of various types of activities (human task, simple task and automatic task) and includes some entities with technical background like XML schema data object and data source object.

III. BPLOM: BPM LEVEL ORIENTED METHODOLOGY

Until this moment, we have focused on analyzing several notations based on their degree of diffusion and their complexity. All of the notations presented have managed to model processes correctly but there are several issues which make us discard them as suitable for non-technical domain experts: low abstraction level, big complexity in their use and difficulty in understanding the models at first sight.

A common feature of all of these notations is to present the user a set of entities to use, which cover the basic and the advanced features that can be present in a process model. This circumstance can bring problems to novice non-technical users, as they face the use of complicated and technical artifacts (like events, signals and data objects) that they may not understand fully. This situation can also lead to misuse of some of the entities in the language and, thus, to the specification of a wrong model.

In order to prevent this situation, why not present the user a set of entities that is capable of adapting to his modeling skills and knowledge? This is the basic approach of our proposal: a level-oriented methodology for the application of BPM to any type of business process, promoting the adaptation of the modeling entity set to the expert's knowledge level. This departure point differs from other business process modeling notations like the one introduced by Chinosi and Trombetta in the 2009 edition of the BPM Handbook [18]. The first stage of the referenced methodology is based on reading the documentation related to the process and creating a primary sketched version of the process derived from the interpretation a computer expert has of this documentation. Although this approach could be valid, the ambiguous nature of natural language [1][11] does not recommend it.

Our proposed methodology will be divided into 5 incremental levels. Level 0, also known as BPMN MUSIM [16], will be the initial level and it will offer the minimum number of entities needed for business process modeling. Throughout the following levels we will be introducing more artifacts like events or data objects to the methodology in order for it to gain in expressiveness, trying to reach an expressive power as similar as possible to that in BPMN. The levels will be incremental, so the user will be able to model his process using the entities contained in the current level in addition to those contained in the previous ones.

This gain in expressiveness achieved when going up through the levels is directly related to an increase in the complexity users fin when using the symbols included in the methodology, but as the higher levels are intended for more technical based experts this complexity increase is manageable.

A. Features of the Methodology

The methodology we propose has some key features we would like to point out. These are the following:

- Incremental nature of the levels, which allow the user to model his processes with the entities that adapt to his modeling skills and technical knowledge.
- All processes can be transformed to code and executed, no matter in what level they are in.
- Platform independency. Despite the fact that we have chosen .NET as the target platform in our study, this approach could be used to generate code for any other platform.
- BPM phase schema reduced. As the domain experts are in charge of modeling the processes and these will be used to generate code, there is no need to capture requirements in text form and translate this text into models. This enables the avoidance of common errors in the requirements engineering process [1] and reduces the 5-phase BPM application scenario described by Ryan K. L. Ko [9].

B. Drawbacks of the Methodology

The main disadvantage of our methodology in comparison to BPMN is its expressive power. Although our methodology includes the majority of the artifacts and entities included in the standard, some other components of it have been dismissed due to different reasons (see discarded BPMN entities section of this paper).

Despite this fact, we think the methodology is still capable of modeling any type of business process completely and with no need for any additional symbols, notwithstanding the possibility of further extensions of the entity set available in our approach.

C. Level Description

Once our proposal's main features and limitations have been introduced, the next step is to present each of the five levels that make up our methodology. This presentation will be done by introducing the symbols or entities present in each of the

levels with an explanation of their functionality and an overview of their graphical representation.

1) Level 0: BPMN MUSIM

The first level of our methodology is called BPMN MUSIM [16], which stands for very simple BPMN. As the basis of our methodology, this level is intended for novice, non-technical domain experts that want to model their processes through a simple and clear notation. It contains the minimum set of symbols needed for process modeling, 5 entities in total. BPMN MUSIM's main feature as an introductory modeling artifact for novice, non-technical domain experts is the quick and simple learning process domain experts undergo before they start modeling with it.

a) BPMN MUSIM entity selection

As it was stated before, BPMN MUSIM is conceived as the minimum set of symbols needed to define a business process completely. The selection of the entities it includes has been made following the results of several studies [3][7][9]. Particularly interesting are the results of the study carried out by Recker in 2008 [3], which show, through the analysis of several BPMN models, that there is a common subset of entities that are present in the majority of BPMN models produced by experts.

Fig. 7 shows a graphical recreation of the results obtained by Recker in this study in the form of a set diagram. Each of the boxes holds a group of entities of the BPMN symbol set and a number indicating the amount of times these entities appear together in the studied BPMN process models. For example, 116 models have tasks and sequence flow entities in common and 65 processes have these two entities and the start and end events in common; the greater the number inside the box, the greater the chance a business process model has of containing all of the entities inside the box. As the graph shows, the most commonly used symbols in BPMN are: tasks, sequence flow, start event, end event, pools and gateways. Based on this study and bearing in mind pools are mainly used as the representation of the ownership a user has of the business process, we believe 5 entities can compose the minimum set allowing complete modeling of business processes and thus we propose it to be the introductory level for our methodology.
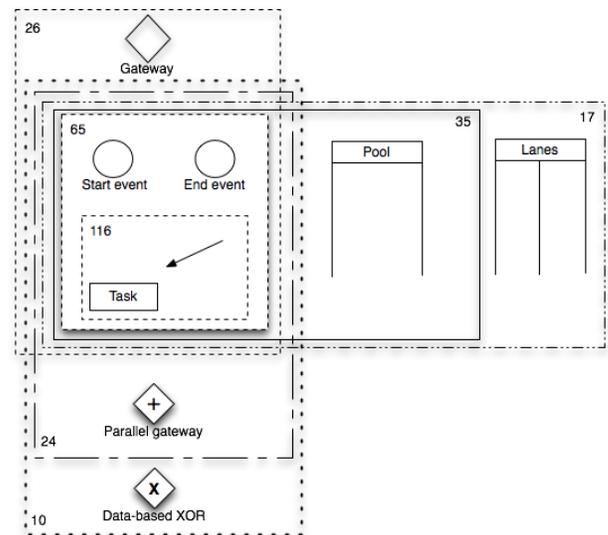
Fig. 7. Results extracted from Recker's 2008 study

b) Level 0 elements

The set of entities included in this level and their graphical representation is the following:

- **Starting point:** All processes modeled with BPMN MUSIM must have a single starting point that will be represented by a green circle.
- **Ending point:** A process defined with BPMN MUSIM can have one or more ending points, which represent the end of the process. The ending point in BPMN MUSIM will be a red circle.
- **Activity:** A rectangular shape with its name inside will represent an activity.
- **Transition:** A transition represents the flow between two elements of the model and will be represented with an arrow. The arrow's head will point the direction of the flow.
- **Decision:** Decisions enable alternative taking in business processes. A decision will be based in an expression to decide upon and two branches: true and false. A diamond shape will represent decisions.
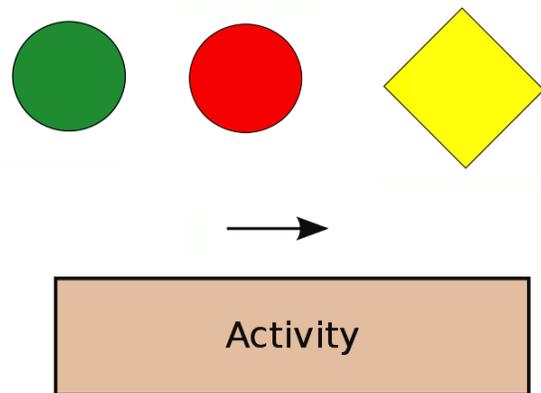
Fig. 8. Graphical representation of BPMN MUSIM entities

The graphical representation of the entities in this level, presented in Fig. X, was chosen due to the following reasons.

- The need to be close to the graphical representation chosen by the OMG for BPMN. As the standard notation, BPMN is widely used not only as it is but also as the basis for other notations and tools (like Microsoft Visio for example). For this reason, if we define a similar graphical representation for our initial level, user's migration to our approach can become a simpler task.
- We have defined first sight differentiable symbols for each of the entities offered in our methodology in order to avoid one of the problems found in UML AD, where two artifacts shared the same shape and this could lead to process experts misunderstanding the models.
- As the coloring approach offered by jPDL seemed to be generating more comprehensible models than those obtained with black and white entity representation, we decided to include color to our shapes. In this way, we continued with the green and red color code for representing starting and ending points and also added colors to the other symbols.
- Recker, Safrudin and Rosemann studied novice user modeling patterns in their work [12] and stated that this type of users understand better models including text and abstract symbols (circles, arrows and rectangles) than those containing concrete figures.

c) BPMN MUSIM's use in real life processes: examples and results

BPMN MUSIM has been used for modeling two real life processes in a Spanish enterprise, trying to demonstrate its suitability for business process modeling.

In order to establish its skills for the modeling of any kind of business process we decided to use BPMN MUSIM to model the following processes: informatics incidence management and recruitment, one of them close to computer science and the other concerning non-technical aspects. Details on the process models and other circumstances regarding the application of BPMN MUSIM to this use case can be found on the two articles [16][17] presented in 2011 at an Iberian congress.

The scenario designed for the application of BPMN MUSIM to these processes started with a brief meeting with the domain experts, where they were introduced to the notation: its entities, their meanings and the first modeling exercises. Once the experts understood the language and were capable of using it, an iterative meeting approach was taken: each of the experts was addressed to come to a meeting with the process models he had done and these would be reviewed with the project's team in order to spot the errors or difficulties; when the review was complete, the expert was set to correct the errors and another meeting was scheduled in the following days in order to undertake further review. This meeting schedule was repeated until the non-technical domain experts marked the process models as definitive.

As the following figures show, BPMN MUSIM has obtained good results in the aspects that were measured after its introduction to the domain experts. In first place, users have stated a better comprehension of the symbols in BPMN MUSIM, as seen in Fig. 9; this circumstance is due to the inclusion of the color code, which enables users to understand models better at first sight. Results also point out, like it is seen in Fig. 10, that the majority of the domain experts didn't spot the need for any additional symbols in BPMN MUSIM in order to be able to model their processes completely.

The interpretation of these results allows us to think that BPMN MUSIM symbols are easier to use than BPMN symbols and that the proposed symbol set is sufficient for non-technical experts to model their processes completely at a basic or early stage modeling level.
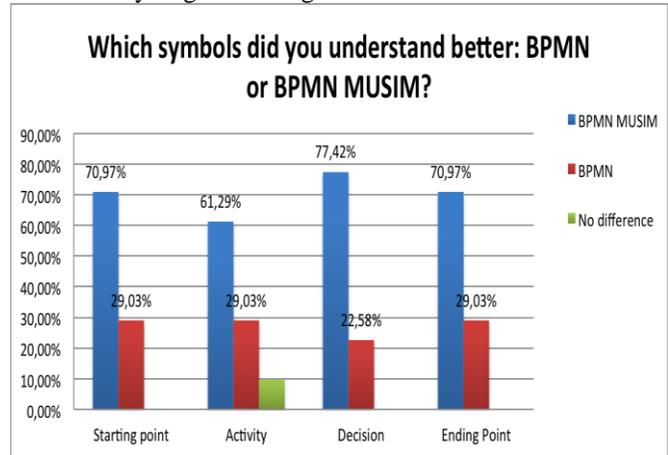
Fig. 9. BPMN MUSIM and BPMN symbol simplicity comparison
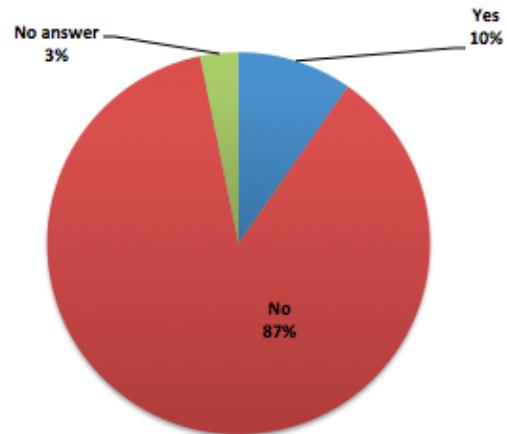
Fig. 10. Pie chart representing need for additional symbols in BPMN MUSIM

2) Level 1: Decision Extension

Once the basic symbols needed for process modeling have been introduced, its time for increasing the expressiveness of the methodology.

Fig. 7, which established the most widely used symbols in BPMN diagrams built by domain experts, showed that the main core of symbols are the ones included in BPMN MUSIM and that these are followed by the use of more complex decision entities. In order to follow the tendency pointed out in this investigation carried out by Muehlen and Recker [3], we have decided that the second level of our methodology is going to be the decision extension.

The symbol set proposed as a decision extension for the methodology is the following:

- **Parallel decision:** A parallel decision allows the expert to define the execution of two simultaneous paths inside the process. A yellow diamond shape with a cross inside will represent it.
- **Inclusive decision:** Inclusive decisions enable the activation of at least one of their branches, depending on the incoming condition. A yellow diamond with a circle inside will represent an inclusive decision.
- **Join:** The inclusion of these new decision types forces the inclusion of the join entity, the point where the process waits for the completion of the process' paths before moving forward to the next activity. A horizontal line with two incoming transitions and one outgoing transition will represent joins.
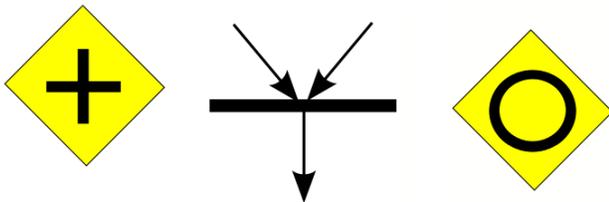
Fig. 11. Graphical representation of Level 1 entities

3) Level 2: Event Extension

Once the elements pointed out by Muehlen and Recker as the most used in BPMN have been included in the methodology, it is time to extend our proposal with other type of artifacts provided by BPMN and which are intended for more technical and experienced users.

BPMN gives a lot of importance to the events, entities that reflect the appearance or occurrence of certain actions that alter the normal process flow. The entities of this kind offered by BPMN cover from messages to signals, without forgetting others like time events and errors. With a closer look at the BPMN 2.0 entity set, clearly represented in the BPMN 2.0 poster offered by the OMG [23], there is a main issue regarding the event use in this version of the standard: each of the events proposed in BPMN 2.0 has several graphical representations depending on the place where they appear in the model (beginning, intermediate and end) and if they activate a subprocess or not.

In order to simplify the event model proposed by BPMN for the non-technical domain experts and, at the same time, avoid the appearance of different entities with similar graphical representation, we propose another approach for event modeling under level 2 of our methodology. We call this level the event extension.

a) Level 2 elements

The entities included in the event extension of the proposed business process modeling methodology are the following:

- **Message event:** This type of event allows the user to include message receiving and sending inside a process, enabling communication between different processes and/or users. Messages will have two graphical representations in this methodology: an outgoing message will be represented by an envelope with an arrow pointing up and incoming messages will be represented by an envelope and an arrow pointing down.
- **Time event:** A time event allows the definition of time conditions inside a process, like the fact that a process must wait for a certain activity to end before continuing or also a time lapse. A clock will represent time events.
- **Error event:** Error events define the place where a process stops due to the appearance of an error, ending the process' execution immediately. Error events will be represented by a prohibition signal with the word "Error" inside.
- **Cancelation event:** Cancelation events represent the moment where a process' execution is cancelled. A red colored cross will represent these events.
- **Signal event:** This event allows the user to send a signal to another process in order for it to continue its execution. It is directly related with the time events presented before. A danger signal will represent signal events in this methodology.
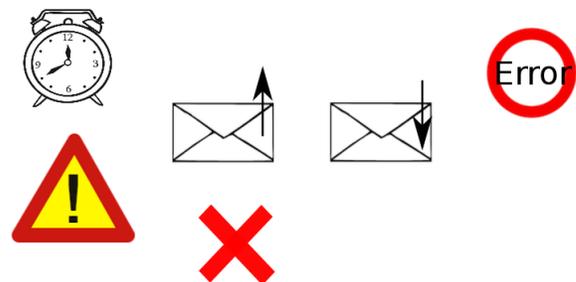
Fig. 12. Graphical representation of event extension entities

b) Using Events in the Models

Once the events have been introduced, there is the need to explain how they can be used for process modeling. All events, except cancelation and error events that need to appear just before an ending point, can appear in any point of the process.

Events are artifacts that make the process stop until their occurrence in order to continue normally. Thus, an event must always appear after the activity that generates it and before the entity whose execution it has to impact.

For example, if we need to model a process where an activity causes the sending of a message and after the delivery takes a decision we would have to place the activity first, then the outgoing message entity and finally the decision. Making the model like this will ensure the process will send the message once the preceding activity has been completed and also it will wait until the message is sent before going on to taking the decision.

4) Level 3: Activity Extension

The fourth level of the proposed methodology is defined as an activity extension for the proposal. Until this moment the methodology only provided the user one type of activity, which represented an automatic or user task.

However, as domain experts move along the levels of the methodology they have more experience with the use of the notation and also their processes need of more rich constructions in order to be modeled precisely. Under these circumstances, the activity extension of the methodology introduces subprocesses and function calling to its artifacts.

a) Level 3 elements

The elements included in the activity extension of the proposed methodology are the following:

- **Call activity:** A call activity references a global task that is repeated throughout several processes. This entity allows the user to call certain a certain task without having to redefine it in each of the processes it appears in; a common call activity could be user identification or login. Call activities are represented by the same entity as the normal activities but including a world globe icon that identifies it as a call activity.
- **Subprocess:** A subprocess is a set of activities that need to be done without any interruption. If any of the activities inside one subprocess produces an error, the process will be terminated. A subprocess is represented by a dashed rectangle that includes all of the activities of the subprocess.
- **Event subprocess:** Event subprocesses are a special type of subprocess, which is triggered after the appearance of an event; it will behave identically as the normal subprocess in case an error takes place. Its representation is the same as the normal subprocess one but the first entity of an event subprocess must be an event (in the following image the event is an incoming message event). The events available for an event subprocess are: incoming and outgoing message events, time events and signal events.
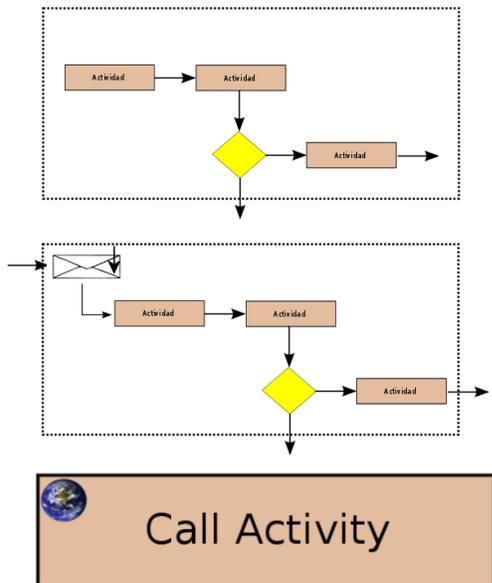
Fig. 13. Graphical representation of the activity extension elements

5) Level 4: Data Extension

The last level of this BPM methodology is defined as a data extension. Until this level, the introduction of technical detail in the models has been kept as small as possible in order to preserve the expert from tying the model to any technical aspect.

However, at this top level of the methodology the experts are considered both experienced modelers and technically prepared, so this status requires the introduction of data elements that enable the definition of information structure and flow through the processes. This detail is directly related with technical application implementation details that are too complex for the novice modelers using the lower levels of the methodology.

a) Level 4 elements

The elements included in the data extension level of the methodology are:

- **Data object:** A data object represents information that flows through the process in different ways (documents, data introduced in a form, etc.). A paper sheet that represents information stored in a computer defines a data object.
- **Object collection:** An object collection represents a set of data objects that flows through the process, like a list of documents for example. A stack of documents, which establish that an object collection is made up of multiple data objects, represents it.
- **Warehouse:** A warehouse represents the moment where a process reads or writes data in a database. This implies that data generated in a process and passed to a warehouse survives the process' instance. The classical hard drive representation with the word "Warehouse" inside will represent this entity.
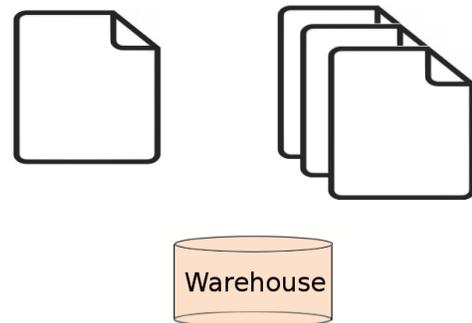
Fig. 14. Graphical representation of Level 4 entities

6) Discarded BPMN Entities

As it has been seen in the presentation of the levels that make up our methodology, there are several artifacts included in BPMN that are not present in our proposal. As the results of the referenced studies show [3][19] several of the modeling entities offered by the standard business process modeling notation experience little use.
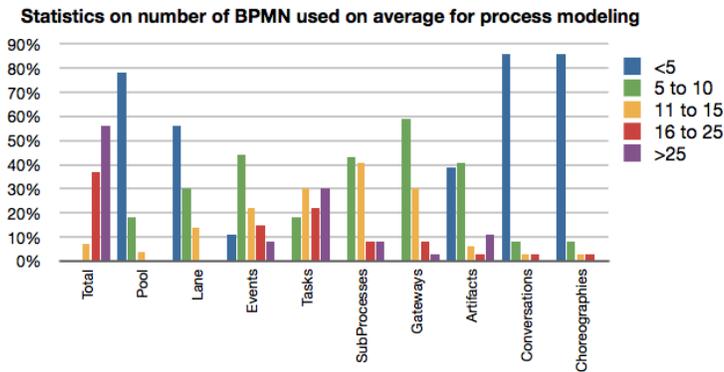
Fig. 15. Results obtained by Chinosi and Trombetta in their work

Fig. 15, a representation of the results from Chinosi's and Trombetta's study published in 2012 [19], shows a bar graph with a measurement for the number of times each of the represented BPMN constructs appear in the models included in the study. As it can be seen, BPMN elements like conversations, choreographies and pools, for example, experience low use by modeling experts. Thus, we have decided to exclude these symbols from this first version of our proposed methodology. Although the results extracted from this study differ in some of its figures from those obtained by Recker [3], the similar low symbol usage trends allow us to rule out some of the least used features found in BPMN.

At this moment we must establish that the exclusion of these symbols is not a definitive decision. As it will be explained in the future work section of this paper, we intend to make our level oriented methodology undergo a thorough testing procedure. One of the main goals of these tests would be to determine the suitability of the selected symbol set for the modeling of all types of business processes. With the results obtained from the tests we will be able to determine the need to include additional symbols to the methodology or discard the inclusion of any other entity to our methodology.

7) Applying BPLOM to a business process

The initial level of BPLOM has been used to model real life business processes at a Spanish enterprise called Isastur. The business processes that were modeled represented to areas of the enterprise with different characteristics: one was the informatics incidence management process and the other was the recruitment process.

This difference in characteristics allowed BPMN MUSIM to be considered suitable for modeling different kinds of processes and at this point we are going to use BPLOM to represent a model from a completely different nature. In this case we are going to use our level oriented approach to illustrate a product catalog application, including the possibility of buying the goods at the en of the process. The different figures in this section will represent the aspect of the process model as it passes through three of the levels in BPLOM: level 0, level 2 and level 4. These levels have been chosen because they correspond to the initial, middle and last stages of the methodology.
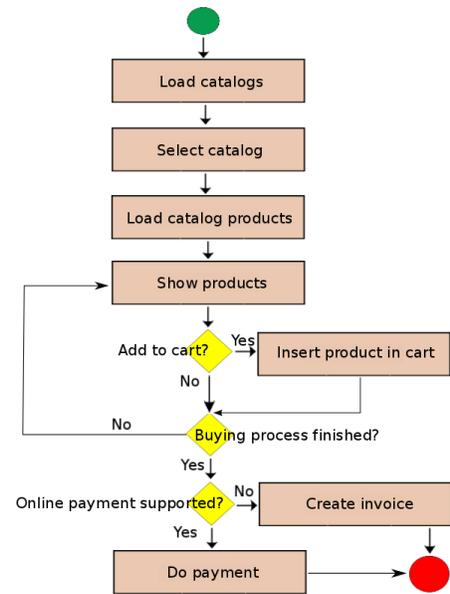
Fig. 16. Level 0 catalog application process model
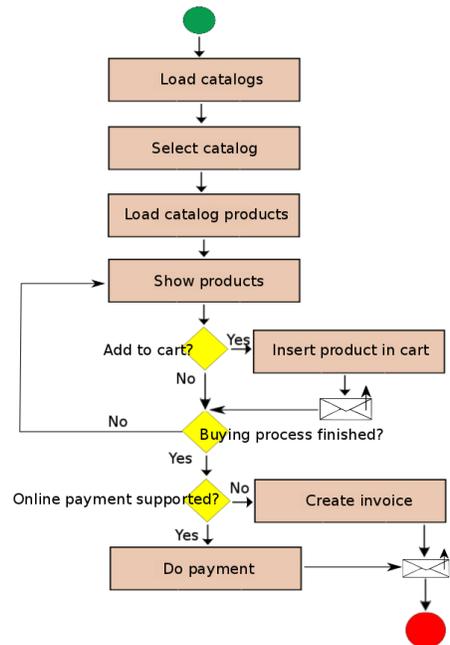
Fig. 17. Level 2 catalog application process model
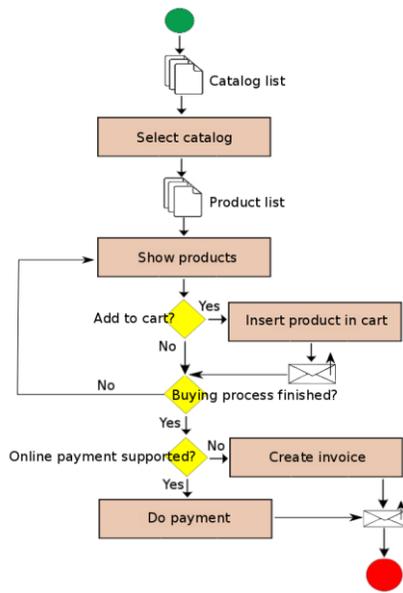
Fig. 18. Level 4 catalog application process model

Looking at the three precedent figures the evolution a process undergoes when passing through the levels of our methodology can be clearly seen. A BPMN MUSIM version of the process is shown in Fig. 16. As it can be seen this process contains no technical detail at all, as this level of our methodology is targeted towards non-technical application domain experts. Once the domain expert has gained some experience with the initial level of the methodology, he would start going up through the following levels, and thus an increase in the number of entities available for modeling and of the notation expressiveness would take place.

A non-technical expert with medium modeling skills would have access to level 2 of the methodology and therefore would design the process seen in Fig. 17. In this case, the inclusion of the outgoing messaging events gives the process additional functionality and shows the richer expressiveness of the notation at this level.

The last process, shown in Fig. 18, represents the use a business process modeling expert with some technical knowledge would give to the methodology. For this particular process the difference between the process models built with level 2 and 4 of the methodology is the inclusion of the object collection entities. This circumstance shows that the business expert that modeled the process has some technical knowledge as he manages to understand the concept of an object collection.

IV. BPLOM TOOLS: BPLEVEL MODELER AND BPLEVEL GENERATOR

As it was mentioned in the features section, BPLOM enables the definition and execution of the processes modeled with the proposed entity set. In order to achieve this functionality, BPLOM requires the development of a couple of prototypes that enable the digital definition and transformation of the models. These prototypes have been called BPLevel Modeler and BPLevel Generator.

Despite the platform independent nature of the proposed methodology both prototypes have been built using Windows Workflow Foundation. This is due to the degree of customization that this platform offers for creating a modeling tool like the one that will be introduced. The fact of using this platform for creating our modeling tool has no effect on the platform independency feature shown by the methodology, as it will be explained later in this section.

A. BPLevel Modeler: Graphical Definition of BPLOM Models

BPLevel Modeler is a business process-modeling tool that supports the BPM level methodology proposed in this paper. This tool has been developed under the .NET platform, as Windows Workflow Foundation [22] offers an attractive scenario for developing highly configurable business process modeling tools.
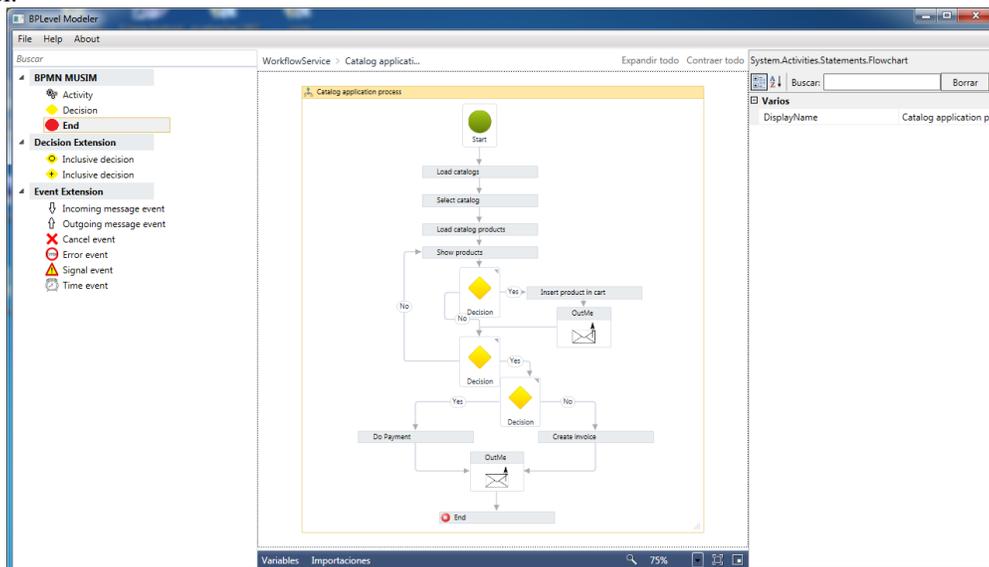
Fig. 19. BPLevel Modeler graphical user interface

The graphical user interface of BPLevel Modeler is shown in Fig. 19. As it can be seen, BPLevel Modeler has been kept as simple as possible in order to adapt to the computer skills shown by non-technical business experts. This tool has only one screen, which was divided into three different areas:

- The entity section, on the left of the screen, contains the different entities that can be used during process modeling. This section has been divided into five different categories, which represent the five levels of the methodology.
- The modeling section takes the center of the interface and is intended for the definition of the business process. It is closely related to the entity section, as the components in it can be dragged into the modeling section to define the desired business process.
- The property section, situated at the right hand side of the tool's screen, contains the property view of the BPLOM elements. The contents of this section depend on the element selected in the modeling section.

As BPLOM is designed as a skill level adaptive methodology, BPLevel Modeler must also adapt to the skill level presented by the user. In order to do so, when the tool is executed it will ask the user his knowledge level and based on the expert's choice the entity section will be adapted to show only the corresponding elements. Fig. 19 shows an entity section corresponding to a Level 3 expert and the business process model for the catalog application for that level.

Although BPLevel Modeler has been developed with Windows Workflow Foundation, which is included inside the .NET platform, the models it generates are considered platform independent. Windows Workflow Foundation stores models in a XML enriched format named XAML, a normal XML file with additional information regarding the position of the elements in the graphical representation of the process. Thus, BPLevel Modeler archives could be transformed using platform independent artifacts (like XSLT stylesheets, for example) and therefore used to generate code for any desired platform. As a matter of fact, in the use case described in this paper BPLevel Modeler files will be transformed using BPLevel Generator to generate mobile device applications for the Android and iOS platforms.

B. BPLevel Generator: Creating custom apps for BPLOM Models

BPLevel Generator is our code generation application. It analyses business process files built with BPLevel Modeler and generates multiplatform applications with specific characteristics for the given BPLOM model. Despite the fact that it is intended for computer experts this code generating tool has also been kept as simple as possible.
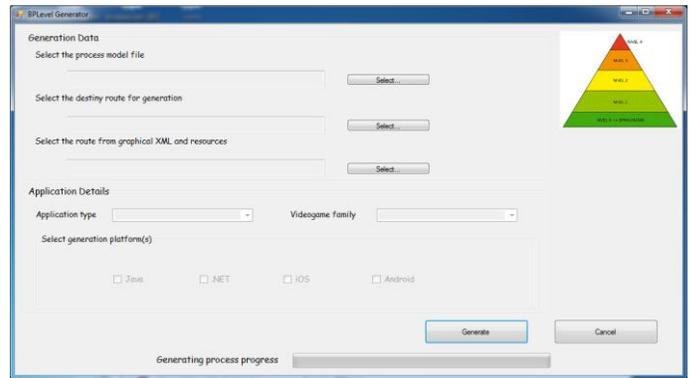
Fig. 20. BPLevel Generator graphical user interface

Fig. 20 shows a screen capture of the BPLevel Generator interface. As it can be seen, this tool requires the user to introduce several pieces of information:

1. The BPLevel Modeler file that represents the process that is going to be used as the basis for the code generation.
2. The path where the application(s) resulting from the generation process will be stored.
3. The path where the XML file with the graphical information of the application and the media resources are stored.
4. The platform(s) that the software is going to be generated for.

It must be pointed out that at this moment not all the generating features of BPLevel Generator are functional, but it is prepared for the inclusion of this functionality as a result of the planned future work.

Once the user introduces this data and starts the generation process, BPLevel Generator begins the analysis of the business model provided by the user and transforms this into the application represented by the details provided by the user. The generation process is divided into the following steps:

- **Preparing the creation structure.** Based on the path provided by the user as destiny for the generation process, BPLevel Modeler prepares the route for receiving the generated app.
- **Creating the custom app.** Code templates of the application(s) for the desired platform(s) are placed inside the path provided as the destiny of the generation process.
- **Configuring the GUI of the application.** BPLevel Generator analyses the XML file containing the graphical details of the application and substitutes the values of these details in the corresponding code class inside the application. BPLevel Generator also copies all of the resources the application needs into the appropriate folder inside the application.
- **Configuring functionality of the application.** Through an analysis of the business process model created with BPLevel Modeler our code generating tool substitutes the needed lines of code inside the application.

```
<main_screen_image>
    <main_screen_image_source>main_background.png</main_screen_image_source>
    <main_screen_image_width>320</main_screen_image_width>
    <main_screen_image_height>480</main_screen_image_height>
    <main_screen_image_x_position>0</main_screen_image_x_position>
    <main_screen_image_y_position>0</main_screen_image_y_position>
</main_screen_image>
```

Substitution

```
#define imageMenu @"main_background"
#define imageMenuHeight 480
#define imageMenuWidth 320
#define imageMenuPosX 0
#define imageMenuPosY 0
```

Creation

```
background = [[UIImageView alloc] initWithImage:[UIImage imageNamed:[NSString
    stringWithFormat:@"%@/%@", inst.imagesDir, imageMenu]]];
[background setFrame:CGRectMake(imageMenuPosX, imageMenuPosY, imageMenuWidth, imageMenuHeight)];
```

Fig. 21. Overview of the phases in the generating process and its result in the application's code for the background image of the main screen

Fig. 21 shows an example of how BPLevel Generator manages to substitute the graphical configuration information inside the application that is being generated. As it can be seen, the XML file contains three types of details for each of the controls or elements inside a given screen of the application: position (x and y coordinates), size (width and height values) and image. For each of the elements these values are stored in a specific class inside the application and then the instances of the elements in each screen are created using these values. The figure shows as an example the graphical configuration of the background image used in the main screen of the iOS application, as the rest of the elements are configured in a very similar way.

V. CONCLUSIONS

Requirements engineering is a critical task in the software development process, as it is the first phase done during the construction of any IT application and it establishes the needs and characteristics of the software. Despite this importance, requirements engineering has seen little changes in the last years and difficulties stated by Sommerville and Kotonya in their 1996 work [1] remain valid: the ambiguous character of natural language, also stated by Laue and Gadatsch [11], and the fact that the requirements engineer is not an expert of the application's domain. With these difficulties, another approach for the requirements engineering process arose: business process modeling. This discipline promotes the implication of application domain experts through the use of notations half way between computer knowledge and business domains.

Several business process modeling notations have appeared since BPMN was defined, in some cases trying to reduce the complexity level demonstrated by BPMN. This is the case of SBPMN [6][20], a simple business process modeling notation previously defined at the University of Oviedo. The mentioned complexity rate makes some of the notations difficult to use and understand by application domain experts with little or none modeling and technical knowledge. In addition to the complexity for modeling processes with these notations,

several studies on the usage rates of the symbols in BPMN [3][7][19] have demonstrated the low use of some of the symbols included in these notations.

Bearing in mind the figures of these symbol usage studies and the difficulties found by business experts due to the complexity of these notations, we have tried to define a business process modeling methodology with two main goals: adapt the notation's complexity to the modeling and technical knowledge of the business experts and reduce the symbol set available in accordance with the mentioned usage rates. In order to adapt the notation to the expert's conditions, our methodology promotes the definition of five incremental levels, which add symbols to the notation gradually. When using the last level in our methodology, the expert is capable of using 20 symbols for modeling its processes; with this number of symbols, we manage to minimize the loss in expressiveness in comparison to BPMN and, at the same time, make our methodology capable of modeling any type of business process.

Once we defined this level oriented business process methodology, we decided to create two tools to take advantage of the methodology's features: platform independency and adaptive complexity. In first placed we built BPLevel Modeler, our business process modeling tool with support for our incremental level approach. Depending on the level selected by the business expert at the startup of BPLevel Modeler, the tool will automatically adapt its entity section to hold only the symbols available in the selected level; for example, if the user indicates its knowledge level is Level 2, BPLevel Modeler will show in its entity section all the symbols in levels 0, 1 and 2.

The other tool we have created is named BPLevel Generator, a code generating tool intended for IT experts. As business process models created with BPLevel Modeler are stored in an extended XML format and our methodology is platform independent, with BPLevel Generator we are capable of generating custom applications for each business process model constructed. For this generation to take place, BPLevel Generator needs the following information: the business process model file, the XML file with the graphical definition of the user interfaces the application has and the resource files used, the route for the code to be stored in and the deployment platform (Android or iOS). With these pieces of information,

BPLevel Generator is capable of analyzing the business process created with BPLevel Modeler in order to create a custom application with support for that specific process model in the desired platform, taking advantage of the platform independency characteristic of our level oriented methodology.

With this approach we manage to achieve the goals presented at the beginning of this paper. The first objective was to create a modeling notation capable of adapting its complexity to the skill level shown by the user, goal achieved through the definition of the level oriented methodology that fosters the adaptation of the modeling notation to the skills and knowledge the business expert has. We were also keen on involving business experts in the requirements engineering phase; this objective was accomplished with the creation of BPLevel Modeler, a simple, graphical business process modeling tool with support for the level oriented basis of our methodology. Lastly, we intended to use the generated models to generate the code of the custom applications that would give support to this models; with BPLevel Generator we can analyze the models created by the business experts and generate the mobile applications that represent them.

VI. FUTURE WORK

This paper includes some usability results that were carried out in order to establish the simplicity of BPLOM Level 0 and the completeness of its symbol set. In order to test the entire methodology we need to carry out some further testing with the rest of the proposed levels, the first point in our future work list. These usability tests will be focused in measuring the following aspects: the entities' graphical representation in comparison with BPMN, as this methodology intends to increase the experts' usability and abstraction levels; and the suitability of each of the levels regarding the entities they include and the order they are presented in, intending to minimize the time needed for the expert to advance through the levels. In this extended testing procedure we will also be able to determine the need to include more symbols present in BPMN to our notation, as it was already said in part six of the third section of this paper.

Another important point in our future work schedule is to change the way in which the XML file with the app's graphical information is created. At this time, the IT expert needs to manually introduce the details included in this document; these details include image files for the backgrounds, positioning of the elements inside the screen and size of these elements. Our main goal is to design and program a graphical user interface that enables the business expert to define the appearance of the different screens that make up the app easily. We are considering a drag and drop approach where the business expert can include backgrounds, buttons and other controls inside a canvas and adapt their look and feel to the style he prefers.

As it could be seen in Fig. 1, the proposed business process methodology is used to generate multiplatform mobile apps. In the use case documented in this paper, the generated software is a catalog app that allows users to scan through product catalogs, add them to their basket and buy them. At this moment the apps are generated for the most widely used platforms for this type of devices: Android and iOS. Although these platforms allow us to reach to the majority of mobile device users, we are interested in offering support not only for other mobile device platforms like Windows Phone but also for desktop and web applications through other platforms like Java and .NET. Moreover, we are also attracted by the possibility of creating other types of applications for the currently supported mobile platforms; for example, BPLOM could be used to model the process behind multimedia mobile apps like interactive books or even videogames, allowing the corresponding business experts to design and generate their own applications.

REFERENCES

[1] Kotonya, G. and Sommerville, I. "Requirements engineering with viewpoints". 1996. *BCS/IEE. Software Eng. J.* , 11(1): 5-18

[2] Stephen A. White, "Introduction to BPMN". Business Process Management Iniciative (year 2004).

[3] Michael zur Muehlen, Jan Recker. "How Much Language is Enough? Theoretical and Practical Use of the Business Process Modeling Notation". 20th International Conference on Advanced Information Systems Engineering (CAiSE 2008).

[4] Lauri Eloranta, Eero Kallio y Ilkka Terho. "A Notation Evaluation of BPMN and UML Activity Diagrams" (year 2006).

[5] T.Wahl and G. Sindre. "An Analytical Evaluation of BPMN Using a Semiotic Quality Framework". CAiSE'05 Workshops. Volume 1, pages 533–544. FEUP, Porto, Portugal (year 2005).

[6] Fernández, H. F., et al. "SBPMN – An easier business process modeling notation for business users". Computer Standards & Interfaces 32 (1-2):18–28.

[7] Jan C. Recker. "BPMN Modeling – Who, Where, How and Why". BPTrends (year 2008).

[8] Stephen A. White y Derek Miers. "BPMN Modeling and Reference Guide: Understanding and Using BPMN". Future Strategies Inc. (year 2008).

[9] Ryan K. L. Ko. "A computer scientist's introductory guide to business process management (BPM)". Crossroads v.15 n.4, p.11-18 (year 2009).

[10] R. Lu y S. Sadiq. "A Survey on Comparative Modelling Approaches". Proc. BIS'07 (year 2007).

[11] Ralf Laue y Andreas Gadatsch. "Measuring the Understandability of Business Process Models - Are We Asking the Right Questions?". Business Process Management Workshops - BPM 2010 International Workshops and Education Track (year 2010).

[12] Jan Recker, Niz Safrudin y Michael Rosemann. "How Novices Model Business Processes". Business Process Management – 8th International Conference (year 2010).

[13] Zhiqiang Yan, Hajo A. Reijers y Remco M. Dijkman. "An evaluation of BPMN Modeling Tools". Business Process Modeling Notation - Second International Workshop (year 2010).

[14] C.A. Petri. "Kommunikation mit Automaten". PhD thesis, Institut fiir instrumentelle Mathematik, Bonn. (year 1962).

[15] W.M.P van der Aalst et al. "The Application of Petri Nets to Workflow Management". The Journal of Circuits, Systems and Computers, 8(1):21–66. (year 1998).

[16] Jaime Solís Martínez, Vicente García Díaz, Begoña Cristina Pelayo García-Bustelo y Juan Manuel Cueva Lovelle. "BPMN MUSIM: Notación BPMN muy simplificada". 6ª Conferencia Ibérica de Sistemas y Tecnologías de Información (CISTI 2011).

[17] Jaime Solís Martínez, Vicente García Díaz, Begoña Cristina Pelayo García-Bustelo y Juan Manuel Cueva Lovelle. "Isastur Modeler: A tool for BPMN MUSIM". 6ª Conferencia Ibérica de Sistemas y Tecnologías de Información (CISTI 2011).

[18] Michele Chinosi and Alberto Trombetta. "A design methodology for BPMN". Chapter in the 2009 BPM and Workflow Handbook. (year 2009).

[19] Michele Chinosi, and Alberto Trombetta. "BPMN: An introduction to the standard." *Computer Standards & Interfaces* 34.1 (year 2012).

[20] H. Fernandez-Fernandez, E. Palacios-González, V. García-Díaz, B. Cristina Pelayo G-Bustelo, Oscar Sanjuán Martínez and Juan Manuel Cueva Lovelle. "Developing a Business Application with BPM and MDE". International Journal of Artificial Intelligence and Interactive Multimedia (IJIMAI). (year 2009).

[21] A.P. Castaño. "Prototype of assignment intelligent adaptive of service providers inside of ESB with data mining". International Journal of Artificial Intelligence and Interactive Multimedia (IJIMAI). (year 2009).

[22] Windows Workflow Foundation. Last visit on May 5th 2013. http://msdn.microsoft.com/es-es/netframework/aa663328

[23] OMG. Last visit on May 6th 2013. http://www.omg.org/

[24] BPMI. Last visit on May 7th 2013. http://www.omg.org/bpmi

[25] BPMN. Last visit on May 5th 2013. Last update on April 29th 2013. http://www.omg.org/bpmn/

[26] UML. Last visit on May 4th 2013. Last update on April 15th 2013. http://www.uml.org/

[27] jBoss jBPM. Last visit on May 4th 2013. http://www.jboss.org/jbpm

[28] MDE Research Group in the Department of Computer Science, University of Oviedo. Last visit on May 7th 2013. Last update on December 2012. https://sites.google.com/site/mdeootlab/Home

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Kuruma: The Vehicle Automatic Data Capture for Urban Computing Collaborative Systems

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Abstract — **Smartphones can provide coverage in large areas all around the world and with the availability of powerful operating systems they can become solid sensing infrastructures. In fact, static sensors are hard to deploy and maintain while modern mobile devices include many sensors that can be used to sense and benefit from collaborative communities. This project tries to improve urban computing by developing a framework able to create monitoring applications for mobile devices, focusing on obtaining the highest degree of interoperability between sensors. A prototype application has been developed to demonstrate the feasibility of creating multidisciplinary applications with several different approaches. The application developed consists of a Road Roughness Information System that measures smoothness and detects irregularities on the roads.**

Keywords — **OBD, Internet of Things, Urban computing, Vehicle**

I. INTRODUCTION

Nowadays passenger vehicles are filled with technology; some modern cars have numerous different sensors that are continuously sensing. This converts vehicles into a great platform for urban sensing networks. All the amount of information that can be obtained from vehicles can be very valuable if it is shared and compared with other readings. This data can be used for numerous practical applications. Our intention is to collect as much information as possible and upload it to the cloud. We expect this information to be useful for many applications.

The motivation is originated with the generalization of the use of mobile phones that combined with the use of a cheap OBD (On Board Diagnosis) connector can be a very powerful tool, providing almost complete engine control as well as monitoring parts of the chassis, body and accessory devices, including the diagnostic control network of the carrier. Since these sensors are connected to vehicles that continuously move, we can achieve a much larger sensing areas than with a static sensor network. Static sensors can be deployed in main roads but it would be very expensive to install them in the road network. Covering wide areas of roads is part of the Nericell [1] project that consists on monitoring road and traffic conditions by using the sensors in the users smartphones.

Using the built-in accelerometers, microphone and GPS they are able to detect potholes, bumps, breaking and honking, the use of the Smartphone sensors in other mobile areas [2-3].

The idea of using a vehicle as distributed mobile sensors is not new. CarTel [4] has established a system that can be installed into vehicles. Each vehicle, when installed with an embedded computer, is considered a node that gathers and processes sensor readings locally. Data is sent to a central portal, where it is analyzed and visualized.

There are other researches that have shown the possible benefits of studying data collected by sensors in cars. Traffic can be efficiently monitored as proved by several researches [5,6] by recording the speed of several vehicles and comparing the information.

Even commercial products like TomTom HD Traffic record the speed of their users to make traffic estimations. TomTom claims that if 10% of vehicles in the road would drive with their system they would have a real time accurate description of the traffic conditions.

Not only traffic can be monitored. Some researches such as ParkNet [7] and Fueoogle [8] have already demonstrated that sensing different parameters in vehicles can have many utilities. They established that by collecting data from sensors they can create the optimum routes for fuel efficiency or locate street parking spaces in an accurate way.

In addition, complex simulations on distributed systems, for instance, SignalGuru [9] consists on generating traffic light patterns that provide the optimum speed for vehicles to reduce fuel consumption and reduce the environmental impact.

All these collaborative systems aim for different objectives, but they all have a common base, they all sense from devices mounted in moving vehicles. We aim to create a common platform that can gather all kinds of different localized data that can be compared with data from other users to obtain some kind of common benefit.

The contributions of this work are the following:

1. The creation of a framework capable to help in the implementation and maintenance of sensor based applications. The framework is called NIKKO.
2. The creation of a user focused application that can sense and upload data by the use of Smartphones connected to the vehicles OBD port. This application is called Kuruma.

3. The discussion of four possible uses that can be based on the Kuruma application, including black box applications, road hazard detections systems, automatic suspension setting recommendations and a study of the relationship between road roughness and fuel consumption.

The remainder of this paper is structured as follows: first, in Section 2 we present an overview of the NIKKO framework. In Section 3 we describe the main concepts related to the Kuruma application. In Section 4 we show a practical use of Kuruma through a road roughness information system. Section 5 underlines other possible applications for Kuruma. Finally, in Section 6 we indicate our conclusions and future work to be done.

II. THE NIKKO FRAMEWORK

In order to satisfy the objectives of the project, we designed and created a new framework that helps us to generate a system in which sensors can be easily managed to create many kinds of applications that use different types of sensors (Fig. 1).
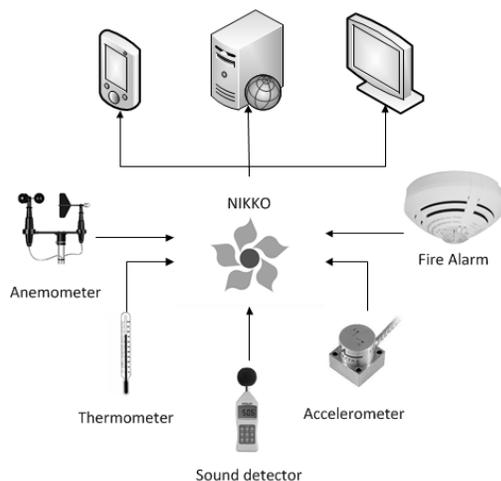
Fig. 1. NIKKO Overview

The framework was designed to obtain as much flexibility as possible with sensors. In order to enable a quick and efficient way to change the destination of the sensor notifications, a configuration file has been kept separated from the source code so that it can be easily modified without the need of recompiling. NIKKO has the ability of adding, deleting and interchanging sensor notifications with a simple file that can change the complete behavior of the applications. That way, the applications that use the framework can be very flexible and valuable tools that are easily maintainable.

The core function is to monitor the events that the sensors generate and to create the specific response actions included in the configuration file (Fig. 2).
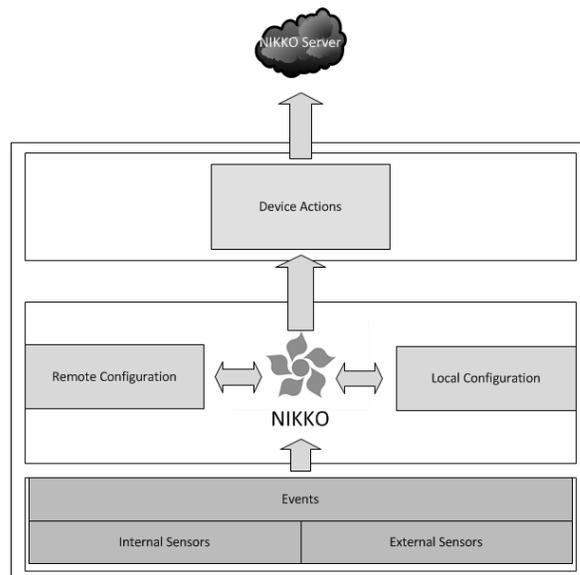
Fig. 2. NIKKO Modules

When the module receives a new event, it checks if the received event is one of the events that it has to handle. If it is included on the list, it calls the method of the actions it has assigned.

NIKKO is conFig.d by an XML file. The file provides the relationships between the sensors events and the actions they have to trigger. The configuration file can be obtained from a local file in the device or a remote location in a web server.

Internal and external sensors are encapsulated in events that are triggered when sensors reading reach a specific measure.

The Device Actions module is used to send the actions when an event is triggered. This module can be highly conFig.d and can create all sorts of actions, including uploading to servers or notifications in applications.

III. KURUMA

The Kuruma application senses the information from vehicle surroundings. The application is based on the NIKKO framework developed for Android devices. It uses an OBD Bluetooth port to connect to the sensors of the vehicle that is monitored.

Taking in consideration all the sensors that can be connected to a phone with the OBD port, it points out the need to collect data and upload it to share it with other users. There could be hundreds of possible applications.

Our intention is to create the base for an application that gathers localized data from vehicles to show the feasibility of these kinds of systems.

The developed application can monitor any standard parameter such as speed or engine load (called PIDs) from an OBD port of a vehicle. Likewise, any nonstandard PIDs could be easily added and monitored (Fig. 3).

Fig. 3. Kuruma Application

Fig. 4. Road Roughness Information System
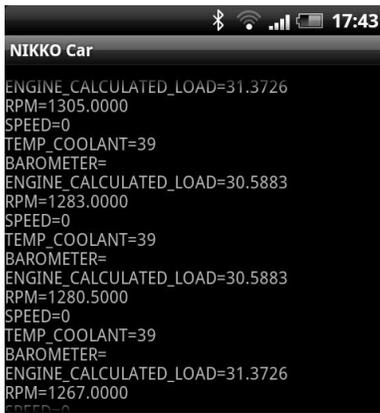
Once the application is started it will begin searching for paired Bluetooth devices. If it finds an ELM327 Compatible Bluetooth OBD adapter it will start sending requests to obtain the sensors indicated in the configuration file. Then, the application will show in the device screen the values obtained from the vehicle's OBD port.

The application uses the NIKKO framework to manage the different sensors. With NIKKO, the actions that the application has to perform when there is a specific event are easily configurable. By changing the XML configuration file the application can show in the application screen or upload to a server the monitored sensors.

IV. PRACTICAL APPLICATION

To demonstrate the Kuruma's potential we have developed a naïve system that could lead to future research lines of investigation.

A. Road Roughness Information System

The application consists on developing a cheap system to create and maintain information of the roughness in roads. Pothole Patrole [10] focuses on detecting potholes and bumps, but does not measure the state of the roads. In a deteriorated road there could be no potholes at all, so this system would not find any irregularities. Potholes appear in weakened roads, so the ideal system would help detecting irregular roads and potholes. Our objective is to not only focus in detecting potholes but also adding the ability to track the state and smoothness of the roads.

To achieve these objectives the system uses Smartphones with built-in accelerometers and GPS receivers. The mobile phone users will record with the accelerometers the alterations of the roads and will report them to a centralized server. This information is useful to generate a detailed map of cracking, rutting, patching and potholes without the need of special expensive vehicles that measure roughness of the roads.

The motivation is to create a system that monitors in real time the smoothness of the roads by the help of phone accelerometers. Fig. 4 shows an example.
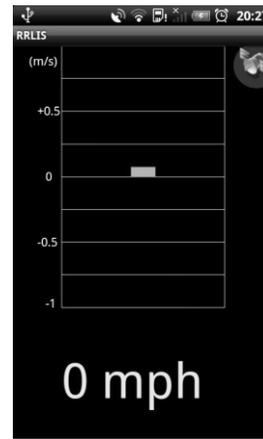
Phone users obtain data that will be able to generate a more detailed and realistic map of the actual state of the roads. Thus, by increasing the accuracy of the information on the roads, maintenance can be done in a much more efficient way, selecting only the roads that really need a service. In addition, after the conservation works the road evolution can also be monitored.

B. Implementation

To implement the system we have used an application that runs in an Android phone that will collect data from the accelerometers using our special algorithm and emit it to the system data server.

The data is sent to the server and must be collected while driving a vehicle. The Android application will be in standby mode without transmitting data; only when the accelerometer sensors detect a perturbation, the data will be sent. The data that the application sends will be the intensity of the acceleration, the speed of the vehicle in the acceleration moment and the location provided by the GPS.

Fig. 5. Road Roughness Information System Output

Providing the speed is crucial because the same bump at different speeds can cause different accelerations. For example, a big bump at a very low speed could be inappreciable for the accelerometer sensors. That is why speed data is necessary to ensure that the data is valid. The user can forget to stop the application and while he is walking, the

application will be aware of this and discard this data without sending it. After the data is classified it is shown in a map available through an Internet browser.

To test the application, a small deployment of the system with one vehicle was done. The preliminary results obtained are shown in the Fig. 5. They were obtained on the University of South Florida campus and show the bumps and smoothness of some roads

V. OTHER POSSIBLE APPLICATIONS OF KURUMA

A. Relation between Consumption and Road Roughness

Working with Kuruma application, research could be developed to determine how irregular roads affect the consumption of vehicles. To generate this study, vehicle consumption in addition to the irregularities of roads should be monitored at all times.

To determine a correct relationship between the data many additional factors have to be considered. Not all drivers will drive with a manner of the same efficiency. Also different cars have different consumptions and their suspension differ in order to record the bumps. Hills have to be reflected, in terms of consumption is different to go uphill than to go downhill. Also external factors like weather conditions or traffic state have to be measured to ensure the correctness of the data.

B. Black Box

The idea is create a Black Box similar to those used in aircraft or railways locomotives. Its function is to capture all the possible information from vehicles and record it in case of an accident. Depending on the intensity of the crash the system will contact automatically with the emergency services providing relevant existing information that can collect from the accident. Also all the other data will be captured for it to be examined with more detail.

Depending on the vehicle it can record different parameters from the vehicle and its surroundings like video, audio, speed, accelerations, vehicle position, throttle position, DTC's (Trouble Codes) and other parameters obtained from the OBD port.

We have already done a first prototype that detects crashes and reports them by calling the emergency services. Fig. 6 shows the augmented reality application based on the Wikitude API that is used to find the crashed vehicles.

Fig. 6. AR Vehicle Crash Detector Application

C. Road Hazard Detector

This system is destined to detect risks in the road like for example, slippery roads. To detect risky conditions of the road the system must be installed in modern vehicles that are equipped with some kind of Electronic Control System (ESP). The ESP improves the safety of a vehicle's stability by detecting and minimizing skids.

The idea to monitor the activity of the ESP and when it starts working determine the situation that made it trigger. Thanks to other parameters like speed, throttle position and the kind of road the vehicle is going though, it could be determined if it was an inadequate speed of the driver or if there was actually a danger in the road. This information would be sent to a server. So if other drivers report the same situation in the same place of the road, a notification would automatically be sent to alert other drivers around the areas. This information could be also very useful and effective for authorities not only to respond to a specific alert, but to determine in which parts of the roads it would be more likely to generate an accident.

D. Automatic Suspension Setting

Based on the information of the accelerometers provided by users a model of the irregularities of the road can be obtained. This is useful for vehicles that can set up their suspension settings changing its firm. If the road is very bumpy you would like to change your settings to a softer suspension, and if the road is very smooth you can change the setting for a stiffen suspension that increases safety.

VI. CONCLUSIONS AND FUTURE WORK

In this paper, we have presented a framework for urban computing monitoring that is aimed to develop collaborative user focused applications. The framework settles the base for future applications which creates a series of benefits such as standardization, integration, flexibility and maintainability.

Through a unified architecture we have been able to develop a base application and full working prototype that classifies the state of the firm of the roads. Road Roughness Information System is a naïve application that was created just as an example. Despite that, it could have great future potentials for different kinds of applications.

The framework is still in development, but with the developed applications and the examples provided we have demonstrated the feasibility of the framework and discovered new directions and features that need to be implemented for future versions. Additionally, because of the collaborative user focused nature of the framework, issues involving trust, privacy and security still have to be resolved in a near future.

In addition, we have observed that all sensors and events are treated equally. In real-world applications, not all the information has the same importance. Some events could be mere statistic Fig.s while other could be vital emergency information that has to be immediately sent. The obvious solution would be to make all the information important and

send it as soon as possible; however this has terrible consequences in real-world applications viability. For these reasons we have designed, but not yet implemented, an improved version of NIKKO with priorities (Fig. 7).
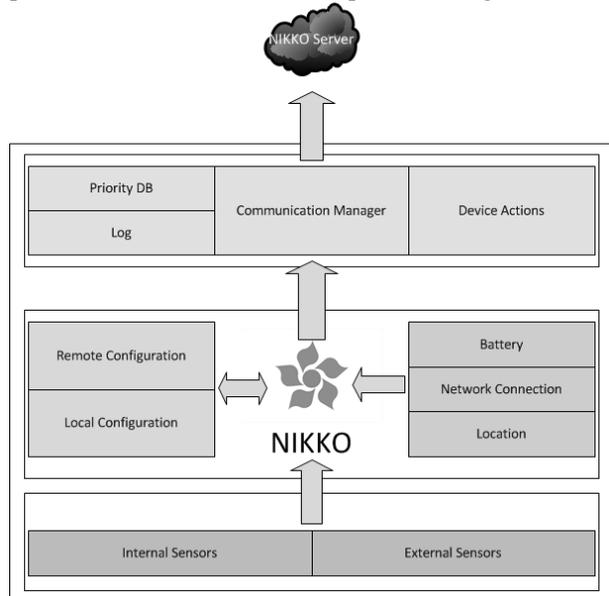
Fig. 7. NIKKO Diagram with Priorities

There are important because real users of mobile devices have data restriction limitations. Added to this problem is the issue of power consumption, that it could be mitigated when the Smartphone is plugged in a vehicle but still could be an interest to take into consideration for person centered applications.

The principal idea of flexibility is maintained, having the same basic scheme. The same three modules are preserved, but new components needs to be added to them.

The center module is still in charge of monitoring the events that the sensors generate and to create the specific respond actions included in the configuration file. Likewise, the configuration file or files are still managed by it and can be imported from the local device or from a remote location.

The main change is that the configuration file will include extra information concerning priorities. NIKKO will obtain information from the device such as, data connection availability, battery status and location information that will help decide the action that has to perform.

A Communication Manager and a new database will be added to store the obtained data. The communications manager would be in charge of making the connections with the NIKKO server. Depending on a 5 level priority scale it will upload the information when the requirements are met. Gathered information could be discarded, logged, saved, uploaded or urgently uploaded.

REFERENCES

[1] P. Mohan, V. N. Padmanabhan, R. Ramjee, "Nericell: Rich Monitoring of Road and Traffic Conditions using Mobile Smartphones", *ACM Sensys*, Nov. 2008.

[2] J.P. Espada, "Service Orchestration on the Internet of Things", International Journal of Interactive Multimedia and Artificial Intelligence, vol. 1(7), pp. 76-77, 2012.

[3] A.G. García, M.A. Álvarez, J.P. Espada, O.S Martínez, J.M.C. Lovelle, C.P. G-Bustelo, "Introduction to devices orchestration in Internet of things using SBPMN", International Journal of Interactive Multimedia and Artificial Intelligence, vol. 1(4), pp. 16-18, 2011.

[4] B. Hull, V. Bychkovsky, Y., Kevin Chen, M. Goraczko, A. Miu, E. Shih, H. Balakrishna, S. Madden, "CarTel: A Distributed Mobile Sensor Computing System", *ACM Sensys*, Nov. 2006.

[5] J. Yoon, B. N. Mingyan, Liu. "Surface Street Traffic Estimation", *ACM MobiSys*, Jun. 2007.

[6] A. Thiagarajan, L. Ravindranath, K. LaCurts, S. M. H. Balakrishnan, S. Toledo, J. Eriksson. "VTrack: accurate energy-aware road traffic delay estimation using mobile phones", *ACM Sensys*, Nov. 2009.

[7] S. Mathur, T. Jin, N. Kasturirangan, J. Chandrashekharan,W. Xue, M. Gruteser, W. Trappe. "ParkNet: Drive-by Sensing of Road-Side Parking Statistics", *ACM MobiSys*, Jun. 2010.

[8] N. Pham, R. Ganti, S. Nangia, T. Pongthawornkamol, S. Ahmed, T. Abdelzaher, J. Heo, M. Khan, and H. Ahmadi. "Fueoogle: A Participatory Sensing Fuel-Efficient Maps Application", *Computer Science Research and Tech Reports*. Oct. 2009.

[9] E. Koukoumidis, L. Peh, M. Martonosi. "SignalGuru: Leveraging Mobile Phones for CollaborativeTraffic Signal Schedule Advisory", *ACM MobiSys*, Jun. 2011.

[10] J. Eriksson, L. Girod, B. Hull, R. Newton, S. Madden, H. Balakrishnan. "The Pothole Patrol: Using a Mobile Sensor Network for Road Surface Monitoring", *ACM MobiSys*, Jun. 2008.

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Gade4all: Developing Multi-platform Videogames based on Domain Specific Languages and Model Driven Engineering

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Abstract — **The development of applications for mobile devices is a constantly growing market which and more and more enterprises support the development of applications for this kind of devices. In that sense, videogames for mobile devices have become very popular worldwide and are now part of highly profitable and competitive industry. Due to the diversity of platforms and mobile devices and the complexity of this kind of applications, the development time and the number of errors within that development process have increased. The productivity of the developers has also decreased due to the necessity of using many programming languages in the development process. One of the most popular strategies is to employ specialized people to perform the development tasks more efficiently, but this involves an increase of the costs, which makes some applications economically unviable. In this article we present the Gade4all Project, consisting in a new platform that aims to facilitate the development of videogames and entertainment software through the use of Domain Specific Languages and Model Driven Engineering. This tool makes possible for users without previous knowledge in the field of software development to create 2D videogames for multiplatform mobile devices in a simple and innovative way.**

Keywords — **DSL, Gade4all , MDE, VideoGame**

I. INTRODUCTION

The use of new technologies (like smartphones, tablets, computers and the Web) as tools for the use of videogames and entertainment applications is quite extended nowadays. This expansion has lead to the appearance of a great diversity of platforms and mobile devices that allow to execute a wide range of applications.

The existance of different types of platforms and mobile operative systems and the constant evolution and appearance of new devices has brought with it an increase of the development time and the appearance of errors during that process. Also, the productivity of the developers of mobile applications has decreased, generally due to the necessity of developing the same application using many programming languages in order to publish it in other platforms and reach a higher number of users in the market.

Also, the development of games is generally aimed to people with extensive knowledge in the development of this kind of applications. Normally, an important part of these applications are developed for mobile devices and the Web [1].

All this suggests that the development of videogames can be much more profitable and optimized if we can abstract the main characteristics of many videogame typologies. This abstraction serves a base for the reuse of code and the generation of multiplatform videogames in an automatic way.

With the objective of minimize the aforementioned inconveniences, improve the efficiency and solve the typical problems of software development [2][3], this project proposes the use of Model Driven Engineering (MDE) [4] to develop a tool that allows to create multiplatform videogames in a quick and simple way. This tool can be used by anyone, even if that person lacks programming knowledge.

By using typologies templates and the most advanced technology for automated generation of code based on Domain Specific Languages and Model Driven Engineering, this tool allows the development of 2D multiplatform games. These applications are automatically generated in native code for platforms like Windows Phone, Android, iOs and HTML5, managing to optimize the development time, raise the efficiency and reduce the number of errors.

The reminder of this paper is structured as follows: in Section 2 we present a summary of the current problems that affect the development of videogames. Section 3 presents the background of the videogames, some videogame development tools and the general concepts of Model Driven Engineering and Domain Specific Language. Section 4 shows the gade4all case of study, Section 5 contains the conclusion and future research directions of this work and Section 6 shows the Acknowledgement.

II. PROBLEMS

In their beginning, videogames were developed by very small groups of people and they could only be executed by a small amount of devices, some of which had a very high price. As the videogame industry evolved, so did the size of the development teams and the variety of devices able to execute

those videogames. This is because the growing popularity of mobile phones has encouraged software development enterprises to produce a greater number of videogame applications.

Roughly speakning, we could conclude that the development process of multiplatform videogames is facing the following problems:

A. Complexity within videogame development

Due to the existing multiple mobile platforms for the development and deployment of videogames, the development of this kind of applications has become harder. This is because it's necessary of developers to have an extensive knowledge of the videogame's domain, as well as experience in the development of multi-device software.

In that sense, the development of videogames requires not only experience in the development of software, but also a great knowledge of the different programming languages that are used to create multiplatform videogames. This increases the complexity of videogame development and also the necessity of having a highly qualified person that can handle the problem.

B. Huge variety of platforms and technologies

Due to the existence of a high diversity of languages and platforms like Java, Objetive C, Microsoft .NET, HTML5 and others that allow to develop applications for their deployment on devices based on Android, iOS, Window or the different web browsers. This often causes the development of applications for specific technologies to be poorly feasible. This is because each technology fills a different market niche, which reduces the number of potential user for the developed product. Fort the enterprises focused in videogame development, this implies having development teams for each platform. This way, they can make sure that their products will be well positioned in the different market niches and make them more feasable.

C. Increase of development time and implementation costs

This is a problema that arises from the complexity of the development of multiplatform and multi-device software. Due to the great diversity of platforms and devices, it's often necessary to develop the same application for different devices and operative systems. This causes a reduction of the speed and effectivity of the software development process, specially when developing multiplatform products. Currently, if we want to generate native applications for the different existing platforms, we have to develop the same application with different programming languages and in different environments, which considerably raises the amount of time and money necessary for the development of the application.

III. BACKGROUND

Videogames are applications developed for personal entertainment that are based on the interaction of one or more persons with the electronic device in which its being executed. In most cases, videogames represent virtual environments in which the player can control one or more characters with the objective of fulfilling objectives according to the rules of the game.

Since the 70s, videogames have become popular worldwide and are now a highly profitable and competitive industry. The "trend" of videogames has been kept afloat thanks to the great diversity they offer, as well as the evolution of their technology and creativity. Originally, videogames were created and designed to be executed in computational systems, but in the middle 70s the first home video game consoles appeared and became quite popular in a short time, hitting 13 millions of units only in the United States [5].

The devices and the way of playing have also experienced a big evolution, from the buttons and sticks of the old games to the motions sensors and tactile interfaces of today. This is possible thanks to the technological advances and the inventiveness of the creators of the games, which take advantage of the available resources to expand the possibilities. The revolution of the Web and the mobile devices represents a new era for videogames, as there are millions of them in the Web prepared to be executed in a web browser and many mobile devices and platforms, like Android, iOS, Windows Phone and others.

To facilitate the creation of videogames for all these platforms and devices, several graphic tools have been developed to help videogame creators and users in general to generate videogames in an easy way. This section describes some of the videogame editors that help to perform this task. Also, it shows the general concepts about Model Driven Engineering and Domain Specific Language as software development approaches, which served as a base for the development of the Gade4all platform.

A. Videogame Editors

Nowadays there are many videogame editors that make easier to develop this kind of applications. Some of these tools allow to export videogames to different platforms like Windows, iOS, Android, Flash and HTML5. The main differences between these tools are the supported platforms, the typologies of games that can be generated, the degree of customization of the characteristics and behaviours of the elements present in the games and, most importantly, their simplicity and accessibility. Below are some examples of videogame editors that can be found in the market:

1) GameSalad

It's a tool that allows to develop videogames and export them for its distribution in different devices and platforms: Macs, PCs, iOS smart devices, Android, and HTML5 [6]. The development of games with GameSalad Creator is performed through scenes and actors, whose attributes can be defined to stablish a behavior, physical appearance, sounds and rules. However, while it has many advantages that make easy to develop them, the videogames created with GameSalad can

only be edited from this tool, which doesn't make possible for other developers to expand them using the native development environments.

2) GameMaker Studio

GameMaker Studio is a tool for the creation of videogames, aimed both to novice users and experimented professionals of videogame development. It's quite intuitive, because it was originally designed for inexperienced users to learn the basic concepts of programming, understand game's architecture and create games in a simple way [7]. In [8] it's shown how some children designed educative videogames that demonstrated their understanding of the GameMaker software. This tool is based in its own interpreted language called GML (Game Maker Language), which is based in scripts aimed to expert users. The program is regulated by the Drag and Drop philoshopy, so supposedly is not necessary to write a single line of code. It allows the generation of videogames for HTML5 and the platforms iOS, Android, Windows.

3) Stencyl

It's a tool for the creation of videogames developed by StencylWorks [9]. This product offers videogame designers a graphical editor that allows them to create games and export them to iOS, Mac, Windows and Flash formats. Since version 3.0 (version beta) Stencyl allows to export applications to Android and HTML5. The creation of games in Stencyl is based in the definition of scenes and actors. Each scene corresponds to a level in the game, and the different actors are added to those scenes. An actor is any element that is shown in the level, from the graphical elements without added logic or functionality to the characters of the game, with their own rules and behaviors. The development environment of Stencyl is intuitive enough for people with experience in design program, and though it has several default templates, it demands programming and algorithmic logic knowledge, as many of the game's modifications require the creation of algorithm flowcharts.

B. Model Driven Engineering

MDE, or "Model Driven Engineering" is an approach that suggests the use of models as the main axis of the lifecycle of a software and saves time and effort in the development process [10]. Those models are abstractions that are focused in the development of specific applications of a problem.

The implementation of Model Driven Engineering allows the raise of productivity through the reutilization of standardized models, thus simplifying the development process through recurring templates of an specific domain, and, at the same time, creating an standardization of the terminology and the best practices used in the application of the domain.

Model Driven Engineering possesses a wide spotlight architecture and automation with high levels of abstraction in software development. This abstraction promotes the design of simple models with a wide perspective for the resolution of specific problems, which combined with the adequate semantic, raise the total rate of possible automation.   The OMG (Object Management Group) has developed a set of standards referred to as MDA (Model Driven Architecture).

According to [10] a model is the description of one or more elements of the domain or real world. There is also the concept of metamodel, which presents the tools that allow the creation a model through its description. Metamodels also describe themselves, generating an extremely high abstraction in which all the models match each other.

The use of Model Driven Engineering is key for the development of this project, as the concepts about the definition of models with high levels of abstraction efficiently adjusts to the developed tool. By applying the principles of this engineering we manage to abstract the main characteristics of the supported videogames, making easier to create a Domain Specific Language that allows the generation of multiplatform games in a simple and easy way.

C. Domain Specific Language

DSL, or "Domain Specific Language" is a usually declarative language that focus on the resolution of problems of particular domain. In many cases, these solutions can be translated to library calls or common subroutines, in which the DSL can be seen as a way of occulting the details of that library [11]

As [12] describe, models can be clearly expressed by using a DSL whose language is specifically designed to meet the specific needs of the application's domain. In that sense, the DSL contains specific concepts of the domain that allow a better understanding of it and ignoring elements that moves away from the reality of the domain.

As **Fig.8** shows, one of the main characteristics of the DSL is that it allows the implementation of a definition that is independent from the platform and, once finished, will go through a transformation process, offering the construction of a proyect in a specific platform as a final result. The DSL defined for the Gade4all project makes easier to generate complete applications for the iPhone, Android, Windows Mobile and HTML5 platforms.

Fig.8. Transformation of platform independent models

DSL is crucial for Model Driven Engineering and so for the project. The DSL used for the definition of the videogames contains a high level of abstraction that allows to define all the elements that are necessary for the generation of a videogame, as well as the stablishment of the required values to assign a behavior to the actors. That task is performed through a videogame editor, so the final user doesn't need to know its details.

IV. CASE STUDY

In the last years several operative systems for mobile devices have appeared, among which we can mention: iOS, developed by Apple, Windows Phone, developed by Microsoft and Android, developed by Google. The birth of the Smartphone has unleashed a war in the development of applications for mobile devices based on the aforementioned operative systems.

The necessity of developing applications that can be executed in different platforms has brought with it the appearance of problems that were described in Section II. In order to solve those problems, it's necessary to create a tool that allows to develop applications for different platforms in an agile, efficient and easy way.

In the context of videogames, a tool that allows to reduce the complexity of the developing of multiplatform videogames will also allow to minimize the costs and development time, as well as reducing the appearance of errors in this kind of application.

In this case study we show the Gade4all videogame platform, which has been developed with the purpose of making possible for a wide range of inexperienced users to create multiplatform videogames in an easy way. Because many videogames share a series of characteristics and behavior patterns, Gade4all has defined a high level language that allows the creation of a great variety of videogames in an easy and effortless way, all through the abstraction of the most relevant characteristics of the main videogame typologies.

A. Gade4all

Gade4all is an innovative project that aims to simplify the development of multiplatform videogames for mobile devices and the Web. Through the use of a graphical tool, it allows inexperienced users to develop software and create innovative videogames in a quick and simple way. The Gade4all tool, which has been developed using Model Driven Engineering as a base, facilitates the development of videogames in a dynamic way by using a Domain Specific Language (DSL). This platform allows the definition of the elements, characteristics and rules of videogames in an easy way. The use of this editor as a tool for the development of videogames makes easier to get in touch with the most demanded technologies and devices nowadays, like: Android, iPhone, Windows Phone and HTML5.

This tool allows an agile development of 2D videogames that are automatically generated in native code for multiple platforms, allowing the improvement of the development time, the reduction of the number of errors and the raising of productivity.

The generation of applications in native code offers different advantages, among which we can highlight the real use of the functionalities of each platform and the possible incorporation of improvements by developers with knowledge of the environment. In that sense, the generated games can be used as prototypes for more complex applications.

Besides, the platform is oriented to create videogames and entertainment software of any kind, quickly enough to create them as support applications to advertise recent events, reducing costs and development time.

On its first stage of development, this platform supports a series of videogame typologies like: touch, trivial, strategy, puzzle and platform. These make easier to create videogames for devices like Android, iPhone, Windows Phone y web navigators that support HTML5.

B. Gade4all platform Archytecture

As shown in Figure 2, through the use of a graphical editor, the Gade4all platform allows the creation of videogames easily and intuitively. This allows us to create all the elements, actors and rules of the game and offers all the necessary mechanisms for the configuration and use of the DSL that describes the model of videogames automatically and dynamically. Once the application has been designed with the editor, an integrated transformation engine uses the DSL and the default templates to generate a complete application in native code, which will be ready to be executed in the selected platform. Below we describe the different elements that the Gade4all platform's architecture is composed of:
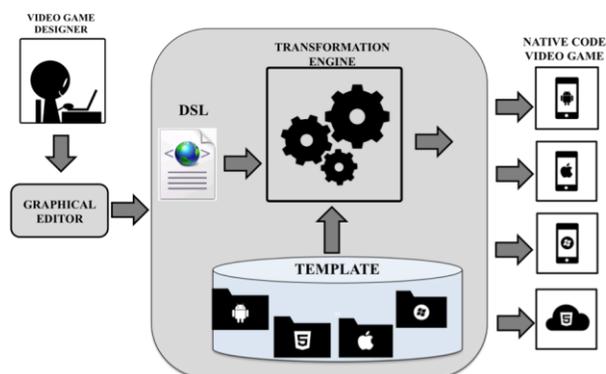
Fig. 9. Gade4all Platform Arquitecture

1) Graphical editor

Many videogames share several patterns of behavior and we intend to take some of the most representative to allow the definition of videogames in a quick and simple way, just by modifying some of the properties of those behaviors.

In order to do this, it's necessary to define the variable elements that make a videogame (graphic aspects, sounds, characters…) and specially their behavior of those elements, so we can stablish the rules of the game.

The graphical editor allows both videogame designers and inexperienced users to define the characteristics and rules of the game through a graphical interface that makes the development of videogames more intuitive.

If a user wants to define a videogame using this tool, he will only have to follow some interactive steps, through user-friendly screens that make the process easier and quicker. This sequence starts with the selection of a typology and ends with the selection of the platform in which we want to deploy the videogame. **Fig. 10** and figure**Fig. 11** show the graphical

interfaces of the videogame typology selection screen and the deployment platform selection screen, respectively.

Fig. 10. Interface for the selection of the videogame typology

Fig. 11. Interface for the selection of the deployment platform

The steps to follow can differ from one another, as some of the characteristics and behaviors of the games are different. For instance, a trivial game has different characteristics than a platform game.

Fig. 12 shows the steps that a user must follow to define a platform game, each of one its composed by user-friendly screens that make easier to define the characteristics and behaviors of the videogame even if the user does not possess technical knowledge at all.

Some of these screens represent the pre-configured main elements, which can be used with their default values or can be modified by the use according to the characteristics he wants to include in its videogame.
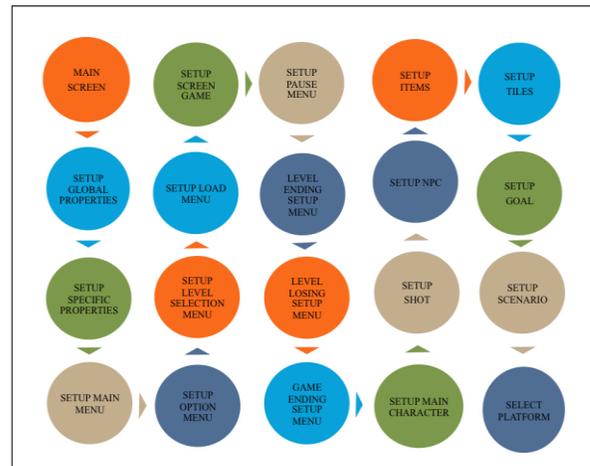
Fig. 12. Screen structure for the creation of a platform game

Fig. 13 shows a graphical interface that allows the user to create a library of characters in a platform videogame. Here is where the main characteristics of the characters are defined: size of the character, number of lives, sounds, animations, etc. The characters defined in this screen are the ones that will be used in the defined scenes defined for the levels of the videogame.

The rest of the screens defined in the editor allow the user to configure the different components that will appear in the videogame: menus (main menu, options menu, pause menu, game, etc), elements (main character, NPCs, obstacles, items, tiles,etc) and scenes (the levels of the videogame). These screens have been defined following the same structure, so the users can interact with them intuitively.
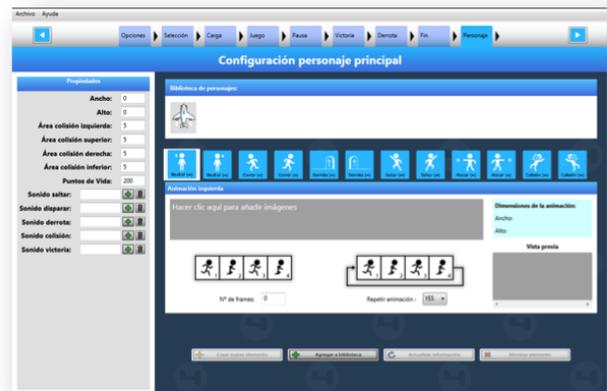
Fig. 13. Interface for the creation of the main character in a platform game

2) Domain Specific Language

On of the main pillars of this platform is the domain specific language that defines the main characteristics of the different videogame typologies supported by the platform. Thanks to the graphical editor, this high level language defined in XML allows videogame designers to define the rules of the game they are developing in a simple way. This language makes easier for inexperienced users to develop videogames in a very intuitive way.

Fig. 14 shows a fragment of DSL corresponding to the "Properties" section of the screen shown in Figure 6. These values are modified by the user from the graphical editor. Generally, the creation process will result in the obtention of a XML file containing all the defined elements corresponding to the DSL of the developed videogame.

```
<character>
    ...
    <character_width>90</character_width>
    <character_height>90</character_height>
    <character_collision_area_left>5</character_collision_area_left>
    <character_collision_area_top>5</character_collision_area_top>
    <character_collision_area_right>5</character_collision_area_right>
    <character_collision_area_down>5</character_collision_area_down>
    <character_health>200</character_health>
    <character_sound_on_jump_source>sound1.mp3</character_sound_on_jump_source>
    <character_sound_on_fire_source>sound2.mp3</character_sound_on_fire_source>
    <character_sound_die_source>sound3.mp3</character_sound_die_source>
    <character_sound_collision_bad_item_source>sound4.mp3</character_sound_collision_bad_item_source>
    <character_sound_collision_good_item_source>sound5.mp3</character_sound_collision_good_item_source>
    ...
    ...
</character>
```
Fig. 14. Fragment of DSL from a platform game

3) Template

To generate native code, we employ a series of templates that abstract a set of common characteristics that can be used as a generic model. This templates are developed as a base for the different platforms that Gade4all supports: iPhone, Android, Windows Phone and HTML5. These projects (Template) abstract a set of attributes and generic methods that make easier to convert and import the characteristics tha result from the implementation of a request from the DSL. **Fig. 15** shows a section of the template where the "Start" button of a videogame is configured. The values of the variables wil be replaced by the transformation engine when the game is generated for the selected platform. This mechanism for the replacement of variables is commonly used on those elements that don't change their behavior too much from game to game, like option menus, stage select menus, etc.

Fig. 16 shows a section of the template where the generation and load processes of the levels of the videogame are performed. This is done with the transformation engine, using SAX (Simple API for XML) technology and Reflection.

This dynamic loading mechanism is used when the behavior of the videogame's elements changes considerably depending on the levels and the typologies. For instance, the positioning and behaviors of the characters within the scene).

Also, because the scene does not know how many elements or characters will appear in every level, we need a a mechanism like this, which offers flexibility to load the elements required for the definition and configuration of a videogame.

```
public int imageButtonStart = %main_screen_start_button_image_source%;
public int heightImageButtonStart = %main_screen_start_button_image_height%;
public int widthtImageButtonStart = %main_screen_start_button_image_width%;
public int posXButtonStartMenu = %main_screen_start_button_x_position%;
public int posYButtonStartMenu = %main_screen_start_button_y_position%;
```
Fig. 15. Template design for the creation of a button

```
tiles[levelLoaded.character_x_position / Tile.Width][ levelLoaded.character_y_position / Tile.Height] =
    LoadStartTile
    (
        levelLoaded.character_width,
        levelLoaded.character_height,
        levelLoaded.character_collision_area_left,
        levelLoaded.character_collision_area_top,
        levelLoaded.character_collision_area_right,
        levelLoaded.character_collision_area_down,
        levelLoaded.character_health,
        levelLoaded.character_sound_on_jump_source,
        levelLoaded.character_sound_on_fire_source,
        levelLoaded.character_sound_die_source,
        levelLoaded.character_sound_collision_bad_item_source,
        levelLoaded.character_sound_collision_good_item_source
        ...
        ...
    );
```
Fig. 16. Template that enables the automatic loading of levels

4) Transformation Engine

The videogames' specifications performed with the DSL are processed by a transformation engine. This engine automatically generates applications in native code, which can be executed in the platforms selected by the videogame designer during the development process. The transformation engine applies a set of algorithms on the specification of the game to convert this "abstract" code into specific code (Java, C#, Objective C, HTML5) that can be executed in a mobile platform or the Web.

This transformation engine allows us to perform the following tasks in the videogame's generation process:

- Copy image and sound resources used in the editor.
- Copy of the files of each level, obtained from the editor, in order to simplify the transformation process.
- Replacement of the values of the DSL's request in the selected templates.
- Automatic loading of the different XML levels configured in the developed videogame.

Fig. 17 shows the process of automatic replacement of values in the variables defined in the template where the main characteristics of a button are abstracted.

```
public int imageButtonStart = %main_screen_start_button_image_source%;
public int heightImageButtonStart = %main_screen_start_button_image_height%;
public int widthtImageButtonStart = %main_screen_start_button_image_width%;
public int posXButtonStartMenu = %main_screen_start_button_x_position%;
public int posYButtonStartMenu = %main_screen_start_button_y_position%;

public int imageButtonStart = R.drawable.u1;
public int heightImageButtonStart = 216;
public int widthtImageButtonStart = 39;
public int posXButtonStartMenu = 118;
public int posYButtonStartMenu = 120;
```
Fig. 17. Transformation process of a button's characteristics

Finally, once the transformation engine has performed all the processes for the generation of native code, the resulting projects can be imported, modified and compiled in the development environment of the selected platform: Eclipse, Xcode, Visual Studio .Net, etc.

Fig. 18 shows an example of the transformation and compilation process of a videogame developed for the

Android platform, which will generate an application that can be executed in any device that supports this type of application.
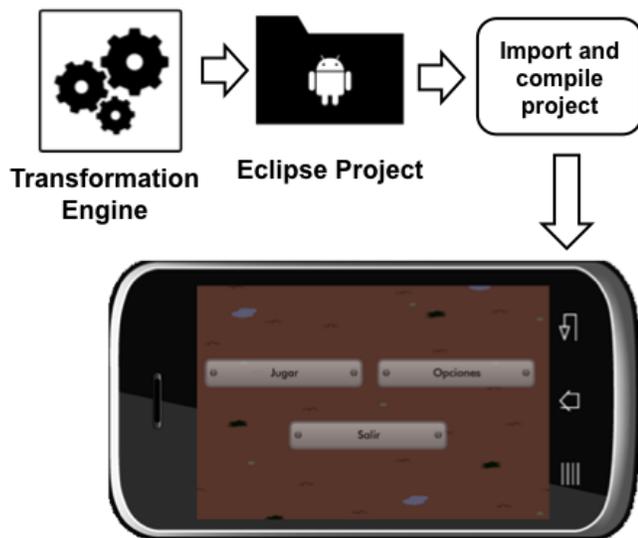
Fig. 18. Transformation and compilation process in Android

C. Supported typologies

Gade4all makes easier to develop videogames for different typologies in a flexible, user-friendly way. These typologies allow users to develop any kind of 2D videogame that matches the supported typologies. To simplify the development process and group the different types of games within a specific classification, the tool allows the development of videogames belonging to the following typologies:

a) Touch ability games

In this kind of typology we move the main character by touching the surface of the mobile phone's screen. As it can be seen in Figure 12 the mechanic of the typology allows users to create videogames based in dodging enemies and gathering items. The objectives of the level can be different: advance a certain amount of distance without crashing into enemies or obstacles, gather a special item, obtain a certain amount of points, etc.

Fig. 19. Ability Touch game developed with the Gade4all tool

b) Trivial Typology

With this typology users can create many types of videogames based on questions that can contain different types of resources: texts, images, sounds, videos, etc. Each question can have one or more valid answers and even a order for the correct answers can be stablished. This typology offers lots of possibilities regarding the kind of questions: memory questions, logic questions, trivial-like questions, questions based on observation, etc.

With the support of this typology, we can generate multiplatform educative videogames to help and motivate students and teachers to take advantage of the new technologies in order to improve the process of learning.

Fig. 20 shows some examples of the type of questions that can be created with this typology. These can contribute to interest teachers in this tool and help them creatings educative videogames as a learning resource.

These resources can include tutorials, math exercises, trivials or mental agility tests to help the students to improve their learning through videogames and entertainment applications.

Fig. 20. Trivial game developed with the Gade4all tool

c) Puzzle Typology

As shown in Figure 14, with this typology we can design games in which we can connect pieces or throwing them to others. The mechanics of this typology allow users to create games in which they control the pieces that appear on the screen in order to make them collide with others. There are many possible winning conditions for each level: eliminate all the pieces of the same color, destroy all the pieces of the same color, hit a certain piece, etc.

Gade4all offers a flexibility that makes possible to develop any type of videogames based on this typology, which allows the creation of a wide range of puzzle videogames, in a simple and effortless way.

Fig. 21. Puzzle videogame developed with the Gade4all tool

d) Plataform Typology

In this typology we move the main character by using the controls that appear on the screen: horizontal movement, jump and shoot. As Figure 15 shows, the main character advances through a stage composed of blocks of different types, defeating enemies and dodging their shoots. The character can gather items in order to obtain points and the objective o each level is to reach a certain point of the stage or collecting one special item.

Fig. 22. Platform videogame developed with the Gade4all tool

e) Strategy Videogame

This typology allows user to design classic turn-based strategy videogames. As it can be seen in **Fig. 23**, in this type of videogame we define the aspect of the troops from two armies: the player's army and the computer's. The game can be composed by several levels, with different thematic, terrains and obstacles. The gameplay is turn-based, alternating between the movements of the player and the computer's. There are many possible winning conditions: defeating the leader of the other army, eliminating the whole enemy's army, capturing a flag, etc.
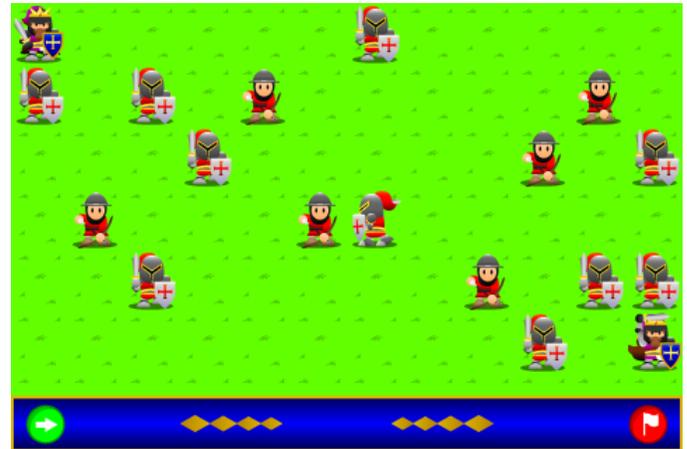
Fig. 23. Strategy videogame developed with the Gade4all tool

D. Comparison of Videogame Editors

In this section we analyze some of the characteristics of the different videogame creation tools that were previously described in this proposal. **¡Error! No se encuentra el origen de la referencia.** shows a general vision of the main similarities and differences between Gade4all and the rest of tools.

It should be noted that, as it can be seen in Table 1, the Gade4all platform offers some significant advantages in comparison to the other tools that were analyzed, among which we can highlight the fact that only Gade4all offers the possibility of developing videogames without requiring knowledge on software development. This makes possible for the tool to be used almost by more people. Also, it is the only tool that allows the complete generation of a videogame in native code for the different platforms, which makes possible for developers to modify or expand previously generated projects and create more complex applications.

1) Main similarities between Gade4all and the rest of videogame editors

After analyzing a set of tools and performing a comparison of these with the Gade4all platform, we can highlight some of the similarities that have been found:

- Possibility of creating actors and characters.
- Definition of sounds for events.
- Graphical editor for the creation and edition of levels.
- Generation of games for different platforms.
- Storage of the characteristics of a videogame for its later modification.

TABLE 1: COMPARISON OF THE MAIN TOOLS OF THE MAIN VIDEOGAME EDITOR

	GameSalad	GameMaker Studio	App Inventor	Stencyl	Gade4all
Previous knowledge on software development	Yes	Yes	Yes	Yes	No
Graphical editor of menus	No	No	Yes	No	Yes
Graphical editor of characters and levels	Yes	Yes	Yes	Yes	Yes
Definition of sounds for events	Yes	Yes	Yes	Yes	Yes
Generation of the complete game in native code, aside from the executable file	No	No	No	No	Yes
Possibility of saving the state of the game	Yes	Yes	Yes	Yes	Yes
Possibility of loading an existing game	Yes	Yes	Yes	Yes	Yes
Editing solutions outside the tool	No	No	No	No	Yes
Modifying levels outside the tool	No	No	No	No	Yes
Checking functioning of a generated level	Yes	Yes	Yes	Yes	Coming soon

2) Main differences between Gade4all and the rest of videogame editors.

As it has been specified in previous sections, even though the existing videogame editors share some similarities with the Gade4all tool, there are some important differences that should be mentioned:

- With Gade4all, we can configure the different menus of the game, while with the others (except App Inventor) we can only configure the game screen and its elements.
- The final result of a game created with any of the mentioned editors can only be edited with the same tool and there is no way of using the development's native environments. Gade4all, on the other hand, offers the source code of the games, making possible for them to be modified directlty from the original development environment.
- Aside from having a graphical editor, Gade4all allows the access to the XML file that describes the complete request of the DSL.
- Games developed with Gade4all have a level-loading software module based on XML, which makes possible to add and edit levels without the editor.
- Gade4all doesn't require to type a single line of code, all the behaviors and rules of the game are already defined, which means that anyone can create games without problems, even people with no knowledge on software development. If the code of a level has to be modified, we can go directly to the generated project, but this will require knowledge on the development environment. However, other tools not only require previous programming knowledge, but it's also necessary to learn its own language. For instance, GML to develop with GameMaker.

E. Statistics of videogames developed with Gade4all

With the alpha version of this platform we have developed some videogames that have been deployed in different platforms like Google Play for Android and App Store for iOS applications. Table 1 shows the statistics of the games developed for the different platforms and in different languages. These are just some samples of the videogames that the "University of Oviedo" has published as an associate of the Gade4all project. The other associates of this project have also published their own games, with their own statistics.

TABLE 1: STATISTICS OF VIDEOGAMES DEVELOPED USING THE GADE4ALL TOOL

Product	Download	Platform
Tiro Skeet	2,113	Apple
Tiro Skeet	999	Android
Ace Athlete	1,475	Apple
Ace Athlete	6756	Android
Tennis Adventure	874	Android
Touch Tank Game	220	Android
Platforms Game	94	Android
Strategy game	68	Android
Trivia about Spain	8	Android
Pepins Adventures	9	Android
Puzzle Game	3	Android
Warzone	52	Android

V. CONCLUSIONS AND FUTURE WORK

With the use of the platform presented in this proposal we are trying to fill an important gap in the design and creation of videogames, seeking to simplify the development of this kind of applications for every user, even the ones without programming knowledge.

By following the approach of Model Driven Engineering, we have managed to implement a generic Domain Specific Language which has helped to abstract the main characteristics of the main videogame typologies. This DSL has served to automate all the process of creating videogames for multiple

platforms. This automation is reached through the graphical editor, allowing users to develop different types of 2D videogames in a simple and effortless way.

The Gade4all platform helps to increase the competitiveness levels in the development of videogames for mobile devices and the Web, as it makes easier to develop videogames for platforms like Windows Phone, Android, iOs and HTML5 without having to write a single line of code. With automatic generation of code, Gade4all improves the efficiency in the videogame development processes, reducing the development time and the number of errors and increasing productivity.

Currently, this tool can only generate videogames for the typologies shown in this proposal, but the development team is working to implement new ones, as well as improvements of some existing characteristcs, like the inclusion of a videogame library with some pre-designed videogames to make the development process even easier.

On its first stage of development, Gade4all only allows users to generate 2D videogames, but one of its objectives for the future is to support the creation of videogames in 3D.

VI. ACKNOWLEDGMENT

REFERENCES

[1] M. D. Walker, M. Nilsson, T. Jebb, and R. Turnbull, "Mobile video-streaming," BT Technology Journal, vol. 21, no. 3, pp. 192–202, 2003.

[2] B. Selic, "MDA manifestations," The European Journal for the Informatics Professional. June, 2008.

[3] E. González, H. Fernández, and V. Díaz, "General purpose MDE tools," IJIMAI, vol. 1, 2008.

[4] S. Kent, "Model Driven Engineering," COMPUTER-IEEE COMPUTER SOCIETY-, vol. 2335, no. 2, pp. 286–298, 2002.

[5] T. Donovan and R. Garriott, Replay: The history of video games. Yellow Ant, 2010.

[6] M. Duggan, Making a GameSalad for Teens. Course Technology Ptr, 2013.

[7] J. Elliott, HTML5 Game Development with GameMaker. Packt Publishing, Limited, 2013.

[8] A. Baytak and S. M. Land, "A case study of educational game design by kids and for kids," Procedia - Social and Behavioral Sciences, vol. 2, no. 2, pp. 5242–5246, Jan. 2010.

[9] L. Stencyl, "Stencyl: Design Once, Play Anywhere," 2013. [Online]. Available: http://www.stencyl.com/.

[10] C. E. MONTENEGRO MARÍN, P. A. GARCÍA, J. M. CUEVA LOVELLE, and O. S. MARTÍNEZ, "Aplicación de ingeniería dirigida por modelos (MDA), para la construcción de una herramienta de modelado de dominio específico (DSM) y la creación de módulos en sistemas de gestión de aprendizaje (LMS) independientes de la plataforma.," DYNA, vol. 78, no. 169, pp. 45–52, 2011.

[11] A. van Deursen, "Domain-Specific Languages versus Object-Oriented Frameworks: A Financial Engineering Case Study," in Proceedings of Smalltalk and Java in Industry and Academia (STJA'97), 1997, pp. 35–39.

[12] E. Miotto and T. Vardanega, "On the integration of domain-specific and scientific bodies of knowledge in model driven engineering," Procs. of STANDRTS, vol. 9, 2009.

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Smart Indoor Positioning/Location and Navigation: A Lightweight Approach

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Abstract — **In this paper a new location indoor system is presented, which shows the position and orientation of the user in closed environments, as well as the optimal route to his destination through location tags. This system is called Labelee, and it makes easier the interaction between users and devices through QR code scanning or by NFC tag reading, because this technology is increasingly common in the latest smartphones. With this system, users could locate themselves into an enclosure with less interaction.**

Keywords — **Indoor location system, NFC technology, QR codes.**

I. Introduction

INDOOR Positioning shall be defined as any system which attempts to provide an accurate positioning inside of a covered structure; it is used to locate people or required objects in large buildings and in closed areas/spaces. At present, there are several types of location-sensing systems, each having their own strengths as well as limitations. [1]Indoor location sensing systems have become very popular in recent years, because many applications need to know the physical location of objects. These systems provide a new layer of automation called automatic object location detection[2] and use wireless concepts, optical tracking or ultrasonic techniques.[3]

The relevance of context-awareness for mobile users has been demonstrated in several applications which have been summarized in applications of context-aware computing, and have included fieldwork, museums, route planning, libraries and tourism.[4] There are three technologies commonly used for indoor location systems –ultrasonic, infrared and radio frequency. These can be supplemented by inertial systems which are generally used for prediction. [5]

One of the most well-known location-based systems is the Global Positioning System (GPS), which is widely used to track moving objects located outdoors and determines the position (altitude, longitude and latitude) of an object in any point of the planet by triangulation [6]. However, GPS, as it is satellite dependent, has an inherent problem of accuracy, when determining the location of objects inside buildings. Active

Bat and Cricket, are cited as [7] use ultrasonic pulse TDOA to enable high precision and dimensional positioning in indoor environments. Although, ultrasonic positioning system requires additional hardware to send and receive ultrasonic pulse, it can determine 3D position of indoor objects with an accuracy of a few mm to a few cm. [1]

Indoor location technologies may be also classified according to the location positioning algorithm, the physical layer or location sensor infrastructure. Locations sensing approaches can be classified as follows: location fingerprinting (scene analysis), triangulation, trilateration, hyperbolic lateration, proximity, and dead reckoning.[8]

In this paper/article, Indoor positioning systems are classified according to the technology on which they are based. There are systems which use Wireless networks, Satellite-based techniques, infrared systems, ultrasonic systems, Ultra Wide Band (UWB), RSS, hybrid systems, GPS indoor, Bluetooth…

Technical deployment of indoor positioning systems involves significant investment. Also these systems have a lot of problems like multipath effects, they need a specific infrastructure, require a Line Of Sight[1] (LOS) etc. also they consume battery of mobile devices when obtaining the information of indoor location.

We present an indoor positioning and orientation system, which optimize the user mobility in closed spaces. This technology employs a location codes system. It is a simple and inexpensive solution to obtain the indoor location and orientation.

This paper is organized as follows. Section 2 presents relevant overview of existing indoor location systems, section 3 explains the most common problems of indoor location systems, section 4 describes the indoor position system based in QR codes. Finally, section 5 ends the paper with a discussion about future work and conclusions.

II. Overview of Existing Indoor Location Systems

Physical location class can be broken down into three subcategories: describe locations, spatial locations and network locations:

- Location related to geographic objects such as mountains, lakes, cities, roads, countries or other structures that have a description such as name, identifier, or number is known as a descriptive location.

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[1]Line of sight is a type of propagation that can transmit and receive data only where transmit and receive stations are visible each other without any sort of an obstacle between them.

- Spatial location is used more in professional applications where a descriptive location does not provide enough details.
- Network location refers to a location based on the topology of a communications network. A user´s device position in a network is achieved based on its Internet Protocol (IP) address. However in mobile networks a network location is achieved from the base stations used by the mobile terminal. [8]

The techniques used to estimate location in a cellular network have been successfully used in wireless Local Area Networks (WLANs), Bluetooth, Ultra-wideband (UWB), Ultrasound, Radio Frequency Identification (RFID), Hybrid technologies, and QR scanning method.

- *Systems based on WLANs:*

In the last few years, WLAN radio-signal-based positioning systems, supported by underlying Radio Frequency (RF) and Infra-Red (IR) transmission technologies has experimented an enormous expansion and is expected to continue this trend due to the fact that it is an economical solution providing convenient connectivity and high speed links, and can be implemented with relative ease in software.

Wi-Fi RTLS (Real Time Location Systems) enables position sensing by using existing wireless LAN routers [9]. Additionally, WLAN covers a large area and is not restricted by line of sight issues. A WLAN can support a large number of nodes and vast physical areas by adding access points to extend coverage. Therefore, WLAN allows users to be truly mobile as long as the mobile terminal is under the network coverage area. [4]

WLAN is appealing because it allows enhanced connectivity and is particularly useful when mobile access to data is necessary. Additionally, user flexibility and probability can easily be reconfigured while requiring no cable infrastructure.[4]

The Wave LAN system triangulates 2D position of an object within a building by using either empirical data or a mathematical model of indoor radio propagation. Advantages of this system are such that it requires few base stations and it uses the same general wireless networking in the buildings. [3]

A special case of this technology is a systems based on fingerprinting. Location fingerprinting refers to techniques that match the fingerprint of some characteristic of the signal that is location dependent. The fingerprints of different locations are stored in a database and matched to measured fingerprints of different locations are stored in a database and matched to measured fingerprints at the current location of an MS (Mobile Station). [10]

The fingerprinting technique is relatively simple to deploy compared to the other technique such as angle-of-arrival (AOA) and time-of-arrival (TOA). Moreover, there is no specialized hardware required at the mobile station (MS). Any existing wireless LAN infrastructure can be reused for this positioning system. The most common algorithm to estimate the location computes the Euclidean distance between the measured RSS vector and each fingerprint and database. The coordinates associated with the fingerprint that provides the smallest Euclidean distance is returned as the estimate of the position. [11]

- *Systems based on Bluetooth:*

The Bluetooth wireless technology is a technology originally designed as a short-range connectivity solution for personal, portable, and handheld electronic devices.

Bluetooth is lighter standard than WLAN, highly ubiquitous (embedded in most phones, personal digital assistants (PDAs), etc.) and supports several other networking services in addition to IP. Bluetooth tags are small size transceivers. As any other Bluetooth device, each tag has a unique ID. This ID can be used for locating the Bluetooth tag. [2]

The position estimation occurs in the mobile terminal without the need of changes in the already fixed installed network topology. The developed system is based on the known and already published triangulation methods using the received signal power strength of the surrounding Bluetooth access points. These points must exist previously. For precise position estimation, the dependence between the distance and the received signal strength has to be determined. [12]

- *Systems based on UWB:*

Ultra Wide band (UWB) impulse radio signals are employed for location and tracking. This system platform was constructed using standard electronics components, therefore, it allows fast performance evaluation and to estimate the time of arrival (TOA) of received pulse signals. Systems based on UWB use receivers deployed in a building to track users carrying small tags which emit ultra-wideband signals. Finally, these signals are transferred to a server where the location of the transmitter is calculated [12].

The main advantage of the UWB signals is to have high temporal resolution and to provide accurate TOA measurements in multi path environments. The transmitted signal has a sequence of short pulses. These are propagated in the media and received by at least four receivers placed in known positions [3].

- *Systems based on Ultrasounds:*

Indoor ultrasonic location sensing systems frequently use a number of ceiling-mounted transmitters to measure the position of a user in a room, and they process data from time of flight between transmitters and this user. Usually, these systems are composed by a hardware, consisting of transmitters or beacons which emit signals; software-based algorithms of location and at least one receiver that the user must carry. These receivers can take several forms depending on the system used.

For example, the Cricket system has an accuracy of 1 m to 3 m and supports multiple target discoveries. The user´s position is not shared unless the user accepts advertising that

information. Thus there are no privacy issues due to the location being estimated on the mobile device.

Cricket´s limitations are the absence of a centralised management and monitoring functions. The computational requests are also quite high, which means high power consumption in order to synchronise the ultrasound pulse an RF data.

Another system based on Ultrasounds is called Bat system. This system consist that users wear small badges which emit an ultrasonic pulse when are radio-triggered by a central controller. The system determines the time of flight of the pulses from the badges to a network of receivers on the ceiling, and calculates the 3D positions of the badges using a multilateration algorithm. [13]

- *Systems based on RFID:*

Radio Frequency Identification (RFID) is a rapidly developing technology for automatic identification of objects [12]. The RFID position estimation is based on electromagnetic communication between RFID readers and tags, so RFID readers can read data emitted from RFID tags. Also, it is becoming more common that mobile devices have Near Field Communication (NFC) reader based on RFID technology, which allows reading these tags [13].

NFC technology is a bidirectional short range, wireless communication technology. Therefore, the communication occurs between two nearby devices: on one hand, a mobile phone acting as a NFC reader, and on the other hand, RFID tags, which are processed by the device. Systems based on NFC technology orient the user by gathering his destination point; this way the mobile device collects the current position from NFC tags, so the system computes the optimal route. Finally, another factor to keep in mind is that this technology can operate in card emulation, reader / writer, and peer-to-peer (P2P) modes [14].

RFID tags are categorized as either passive or active. Active tag contains embedded batteries in order to provide a much broader scanning range. The major disadvantage of using active RFID tag based solutions is the high cost of the active tags. [14]. In contrast, passive tags operate without a battery and are mainly used to replace the traditional barcode technology. They are much lighter and less expensive than active tags, offering a virtually unlimited operation lifetime. However, their read ranges are limited, offering a less range than active tags [7]. The employed signal technologies include RF (radio frequency) such as ultrasound, infrared, vision-based systems and magnetic fields[15].

The main advantages of this technology, is that non-contact is required and not need direct vision (N-LOS) [3]. Therefore, RFID systems have been widely adopted as an attractive technology for many significant applications such as asset tracking and industrial automation [13].

- *Systems based on hybrid technologies:*

Hybrid systems combine two or more technologies in order to improve the accuracy and precision of the location estimation. Depending on used technologies by these systems, they will have certain advantages or disadvantages. These technologies have been described in a bellow section.

An example of hybrid systems is the system called indoor GPS. In this system, user position tracking is mainly defined by at least four (or more) transmitters and a receiver. A battery operated transmitter uses laser and infrared light to transmit one-way position information and elevation from the transmitter to the receiver. The receiver has photodiodes inside its module and senses the transmitted laser and infrared light signals. The signal is transferred through a wireless network connection providing mobility to users. The 3D position of the optical receiver is then calculated by the process of triangulation. Triangulation is used if the angles to known (α and β) are given. With two known locations, the absolute position in 2D can be determinate. The two angles are used to determinate the line-of-sights (LOS) for each of the known locations. Indoor GPS, unlike UWB, depends on a clear line of sight and some calibration points are required. However, both technologies offer centimetre level positioning accuracy with Indoor GPS positioning offering significantly higher precision.[4]

- *Systems based on QR scanning method:*

QR-Codes are a type of visual tag, like a 2D barcodes, since they are more efficient than traditional tags and have a much higher information capacity. Due to the open QR-Codes specification, these codes can be employed without restriction and for all applications. Many mobile services rely on them; indeed it has been proposed that they should be embedded in images, such as those used on printed paper tickets. [16]

QR-Maps, is a solution to obtain indoor user locations using QR-Codes (Quick Response Codes) and Google Maps API. Since a smartphone is available, a QR-Code with a short text can be decoded. This text is sent to a location server, which returns an URL showing the map centred in the specific location[16]. Thus, no special hardware is required, simply a smartphone with a camera capture QR-Codes and Internet connection to access the map.[17]

There is another system which combines all previously mentioned features (QR scanning, do not required any specific API installed; do not need any transmitters and receiver, etc.). This system is called Labelee and it based on scanning QR codes, which allows the location and position in indoor environments.

The main improvement regarding the system described above is that Labelee allows showing the position at indoor environments, therefore users knows their position and it will be much easier to know where they would like to go.

Indoor position systems could be classified in active or passive systems. Passive location represents the estimation of a person´s position without require of a physical device, for example, a tag or sensor. However, most of location techniques are part of the active systems class, due the need of people who want to locate themselves into an enclosure to carry an electronic device or another object which allows

estimating their position.[8] Table 1, summarizes the main characteristics of the technologies described above:

| | WiFi | Bluetooth | UWB | Hybrid S./I. GPS | Labelee | |
					RFID/ NFC	Scanning/QR
Outdoor location	✘	✘	✘	✘	✔	✔
Indoor location	✔	✔	✔	✔	✔	✔
Location and Orientation in Indoors	✘	✘	✘	✔	✔	✔
Guided indoors	✔	✔	✔	✔	✔	✔
Accuracy	3 m	2 m	10 cm	1/5 m	0 m	0 m
Range	Room Scale	10 m	15 m	Gobal	Scale according enclosure	Scale according enclosure
Signal	RF	RF	RF	RF	RF	___
Necessary Infrastructure	WLAN router	Specific Trans.	Specific Trans.	Specific Trans.	NFC Tag	QR Tag
Battery consumption/Energy Spending	Medium	Medium	Medium	High	Low	Low
Specific Application	✔	✘	✘	✔	✘	✘
Cost	High	High	High	High	Low	Low

III.   REVIEW OF THE MOST COMMON PROBLEMS

Since GPS is not available indoor location, many approaches have been proposed to facilitate indoor location based on wireless technologies such as RFID (radio frequency identification), Bluetooth or IEEE 802.11. All these solutions require the deployment of a wireless infrastructure and, in some cases, specific technologies seldom found in smartphones.[16]

The GPS signal [7] is not usually available in indoor environments. [18] Satellite-based navigation systems require an unblocked line of sight between the satellite and the receiver to function properly. If this prerequisite is not met, satellite navigation is degraded; different methods and technologies are needed.

One way for locating a mobile device in two dimensions requires the measurement of the Line Of Sight (LOS) distance between the mobile phone and at least three participating BSs (Base Stations). Each distance measurement generates an area which is focused at the measuring base station and has a radius equal to the mobile-to-base distance. So, the three regions unambiguously determine the location of the device.

However this may become a problem if the LOS is not continuous. The usage of signals that can penetrate building materials may overcome this problem in the near future[15]. A mobile phone positioning system is accurate to around 100 m. at indoor, short-range (approximately 10 m radius) wireless cell may be used to determine positions based on cell identification, but requires many stations. [18]

When the range measurements are corrupted by noise, then the location of the mobile station can be determined by finding the solution that is most consistent with the measurements. However, in dense urban environments, there may be no direct path from the mobile to the BS. Due to reflection and diffraction, the propagating wave may actually travel excess path lengths on the order of hundreds of meters and the direct path is blocked. In order to mitigate the effect of the measurement BS, it is necessary to develop location algorithms that are robust to the NLOS (Non Line Of Sight) error.[19]

Another factor that affects the indoor positioning systems is called multipath. This is the propagation phenomenon that results in radio signals reaching the receiving antenna by two or more paths. The multipath transmission (multi path fading) includes large scale fading and small scale fading. Large scale fading corresponds to average signal power attenuation, small scale fading is due to dramatic alterations in amplitude and phase. Almost all indoor position systems have these effects of multipath systems that include constructive and destructive interference, and phase shifting of the signal. Destructive interference cases fading[20]. It is important to note that, RSS measurements are affected by multipath effects or attenuation when passing through walls, distorting them from the expected free space values. [21]

A solution to compensate the multipath effects on received signal, is equalized these effects by using Equal Gain Combining Algorithm further correlating the received signal with reference signal so that we can eliminate other unwanted signals. The problem is that obtained signal has more noise power, so signal may not sufficient to locate Indoor positioning in centimetre level or millimetre level.[20]

Moreover, the cost of a positioning system may depend on many factors. These factors include money, time, space, weight, and energy. The time factor is due to installation and maintenance, also, mobile units may be having tight space and weight constraints. Sometimes, installation of indoor positioning systems may not have to result in additional costs, since previously there could exists hardware being used for another purposes. Energy is another important cost factor. For example, some mobile units like RFID tags are completely energy passive since they only respond to external fields and, thus, could have an unlimited lifetime, unlike most devices with rechargeable battery, which have a lifetime of several hours without recharging [2].

Another factor to consider is complexity of a positioning system. This can be attributed to hardware, software and operation factors. Most of the mobile units lack strong processing power and long battery life; so, positioning algorithms with lower complexity would be preferred. Usually, it is difficult to derive the analytic complexity formula of different positioning techniques; thus, the computing time is considered. Another factor to keep in mind is location rate, which is an important indicator for complexity. The dual of location rate is location lag, which is the delay between a mobile target moving to a new location and reporting the new location of that target by the system.[2]

Apart from the general problems mentioned above, each indoor positioning system, according to the technology on which they are based, has its specific problems, which will be analysed below.

- *Inconvenient of WiFi based systems:*

In order to enable the user to locate himself in enclosures, it is necessary that the mobile phone and the network are synchronized; therefore, the device should calculate its distance from the access point (AP).

The only available information is the signal strength received from each AP. Indeed, the received signal strength is measured. Such information is available because the APs send signals periodically. Mobile devices use those signals to handle the roaming inside the network. Given this consideration, it is possible to get a list of the received power coming from all the APs covering the area where the mobile phone is moving.

The easiest approach for locating a mobile device in a WLAN environment is to approximate its position by the position of the access point received at that position with the strongest signal strength. However the main drawback is its large estimation error. The accuracy is proportional to the density of access points; which is in the range of the 25 to 50 meters for indoor environments. [22]

In order to configure a wireless navigation system in an indoor environment it is required individually encoded transmitters and the setup of a sufficient number of receivers to provide at least room-level resolution. Also, for the navigation environment a map is required, which holds the RSSI at strategic points in that area, usually in form of a grid. The process, during which the RSSI is recorded at each grid point, is called fingerprinting and it is a very time consuming one. It is usually only valid for a particular antenna/access point pair and is very sensitive even to the slightest change in the surroundings (e.g. the removal of a particular item of furniture). Some problems of fingerprinting are that such techniques require specialized hardware in every base station, or access point to correlate the multipath characteristics. In WLANs, an easily available signal characteristic is the received signal strength (RSS) and this has been used for fingerprinting. The RSS is a highly variable parameter and issues related to positioning systems based on RSS fingerprinting are not understood very well. This may not very costly for small areas, but it becomes an increasingly important component as the area to be covered and the number of users becomes large. [10]

We must also take into account a problem with the multi floor environments, because two or more very different locations could potentially have the same RSS location-fingerprint. Instead of storing average RSS values, the joint or marginal distributions of the RSS are used in fingerprinting locations. The experiments are once again conduced in hallways and the accuracy rages between 5 and 20 feet in most cases.

- *Inconvenient of Bluetooth based systems:*

This system was not designed taking into account privacy and security topics, due to the installation of Bluetooth beacons that will send advertisements to mobile devices which are within its scope. Also, device address data sent from a Bluetooth Sensor to the Ad Server is not encrypted. [1]

Another disadvantage is the Bluetooth range which depends on the Bluetooth Class. The maximum range is approximately 100m for Bluetooth Class 1. The range can be extended with directional antennas and signal amplifiers but this increases the cost to deploy a Bluetooth-based localisation system [7].

Furthermore, the position accuracy is dependent on the amount of cells used [14]

- *Inconvenient of UWB based systems:*

Indoor location systems are based on UWB, and have some disadvantages produced by the effects of metallic and liquid materials, these effects can be reduced with a good placement of the UWB readers. UWB technology is suitable for 2D and 3D location estimation. Most common methods used in a UWB localisation system are Uplink-Time Difference of Arrival (TDOA) and Angle of Arrival (AOA). A combination of TDOA an AOA can reduce the number of sensor required for a system using just TDOA.[8]

The problems of using this ultrasonic technique are the requirement of large number of receivers across the ceilings and their placements across the ceiling which needed quite sensitive alignments. [3]These systems are loss of signal due to obstruction; false signals due to reflections; and interference from high frequency sounds.[5]

- *Inconvenient of Ultrasound based systems:*

The main issue of using ultrasonic techniques is the requirement of a large number of receivers across the ceiling. Their placement needs some calibration [3]. Other disadvantages is that need a single-user access, if multiple collocated transmitters send at the same time, their signals can interference with one another, and make it difficult for the receiver to distinguish between them. Also, these systems presents a poor performance in the presence on in band noise, this means that, people create ultrasonic noise trough their everyday actions, although they are rarely aware of it because ultrasound is inaudible. [23]

- *Inconvenient of RFID based systems:*

A drawback to consider in systems based on RFID technology is the type of label used. Active tags are more accurate, hence their cost is much higher, however, passive tags are more economical, and yet have a lower precision. Also, It must be taken into account the greater the number of labels installed, a larger area will be covered and therefore, the cost will be higher.

- *Inconvenient of Hybrid based systems:*

All previously described inconvenient are mixed on hybrid based systems, so it uses these technologies.

- *Inconvenient of scanning QR Codes:*

The main disadvantage of methods based on QR codes scanning, is that the determined position is always the position of the marker. So the used navigation device must be placed closed to the marker. The range depends on the resolution of the used camera; the accuracy depends on the accuracy of the measured marker position. [18]

QR-Codes have been specifically designed for fast information transfer. QR-code data retrieval depends on factors such as camera quality, picture angle or luminosity, as well as on the area of the code. Thus area depends on the size of the data. In our case data size is minimal, just a short text identifying the map and the location, which corresponds to a small QR-Code that can be placed on any wall or displayed on any screen with negligible aesthetic impact.[16]

IV. NEW APROACH TO CREATE A CHEAP, PLATFORM INDEPENDENT AND LIGTH WEIGHT INDOOR POSITIONING SYSTEM

A recent investigation of Baltimore University shows that our position in known environments is represented in a short of interior map located in cerebral hippocampus, formed by neuronal groups called "places-cells". When we make a walk that we had make before, places cells are activated sequentially in our interior map, showing the right way.[24] Working in a similar way, Labelee employ location tags which contains a QR code, which are distributed at indoor environments, acting as a places-cells, so users only needs to scan the QR code using their devices to find the way to go. These location tags act the same form as location cells, because they encode their position and orientation to allow guidance and navigation.

Labelee is an indoor positioning and orientation system, which optimizes the client/user mobility inside the building. Labelee employs the LC (location codes) system, which includes a QR (quick response) code and a NFC chips that acts as an information point for the user: it stores its geographic position and leads him to its target.

The user only has to take a picture of one of those QR labels or read the NFC chips with his "smartphone", and then the system will place him and lead him in the map, without the need of downloading or installing any app in the mobile phone. Figure 1 shows how Labelee works. Since a user arrives at a closed environment, and wishes to know where he. Users can locate other points of interest in the map.
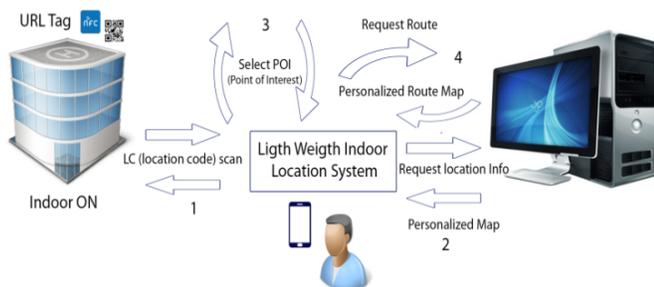
Figure 1:How Labelee works

To know these points, users need to scan the nearest location tag. Once a point of interest is selected, Labelee indicates the current position and the selected point of interest. If the selected point of interest is located on a different floor,

Labelee shows the closer available stairs or elevator and returns a map displaying the shortest way to change floors.

To navigate on indoor environments with Labelee, it is necessary to have all the indoor space information previously processed, in order to calculate all possible routes. Depending on the extent of the environment, or the complexity of these, there will be more or less location tags that correspond to the placement of the labels. Those location labels will be strategically distributed all over the place, when the user scans any location tag, Labelee will indicate his current position and will guide him step by step to his destination. This system works with any smartphone or tablet, even if the smartphone have any camera, just entering the URL which appears besides the QR code. In the figure 2 shows this process.
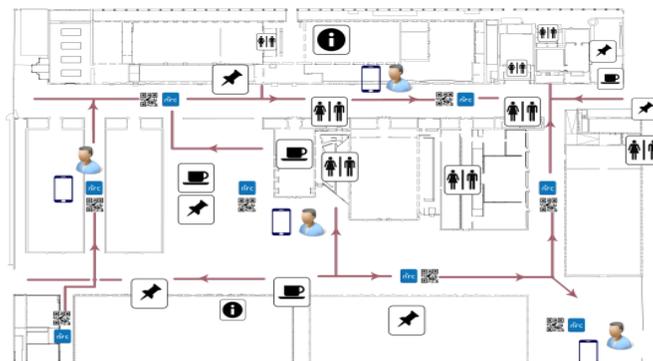
Figure 2: Routes to arrive the destination

Therefore, applications of Labelee are varied and can be installed in any type of area where it needs to have reference plans. This system is very useful, for environments due to the functions they perform, attract different people daily.

In outdoor spaces, Labelee is an alternative in urban historical centres or any place where, due to the morphology or the density of habitants, the GPS signal is not optimal despite the fact is an open space. Also, this solution enables visitors the location, orientation and guidance in public parks, city centres, amusement parks and tourist attractions, apart from showing other routes of various kinds.

Moreover, Labelee is very helpful choice, because it does not rely on any wireless network antennas or transmitters; hence, the required installation is minimal, so it is suitable for shopping centres, parking, airports, museums, hospitals, data processing centres, buildings and office centres, special events (fairs, festival, congresses, conferences, etc.), stadiums, holiday resorts, cruises, etc.

V.CONCLUSIONS AND FUTURE WORK

This paper has presented an indoor location system based on QR codes and recently RFID technology, through NFC readers, more common in the latest smartphones; users could locate themselves into the environment with less interaction. Moreover, it would be interesting to try to regulate the transmission of location according to the bandwidth, in order to get a greater energy savings and a less data consumption.

As future work, we intend to use smartphone compasses to show the user how to go the desired destination. With the of help of accelerometers, it will be also possible to estimate walking distances as additional information. Also the management module could be improved to get information from the public which uses different browsers to find the target audience

Some improvements will be shown, for example plant aerial view of buildings, different levels of detail within the map, zoom in the area where the user is situated-so you could get a clearer idea of where is located.

A cartographic base with vector maps is being created at this moment, which will be useful, for example, to remember the position where our car is parked, offer custom routes and maps, different levels of detail inside the map, show distance and time to our destination using 3D maps.

Another important topic is regarding optimize the file sizes, in order to get a better transfer. Also is being done. Also it is being created a test procedure for different mobile platforms, which will serve as the basis for the development of an easy-to-use application which will have continuous integration, so eventual mistakes will be corrected very quickly. Incidents resolution and detection will be faster, because events, queries and errors are being defined and stored in a specific database.
Location could be also shared, using instant messaging applications, social networks, or just share with tourist information webpages, entertainment, etc. A new web portal with maps will be developed, which will have maps classified by categories from all areas where the system is installed. Therefore users could interact, share or point their places of interest.

Overall, a direct relationship exists between the accuracy and the cost in positioning systems. However, the system described in this article, is considered a fine-grained system, which means that its accuracy can be estimated with a high degree of resolution, with a low cost.

REFERENCES

[1]   [1] L. Escobés, "Summary of the State of the Art in indoor location systems," no. December, pp. 1–3, 2009.

[2]   [2] H. Liu, S. Member, H. Darabi, P. Banerjee, and J. Liu, "Survey of Wireless Indoor Positioning Techniques and Systems," vol. 37, no. 6, pp. 1067–1080, 2007.

[3]   [3] H. Koyuncu and S. H. Yang, "A Survey of Indoor Positioning and Object Locating Systems," vol. 10, no. 5, pp. 121–128, 2010.

[4]   [4] H. M. Khoury and V. R. Kamat, "Evaluation of position tracking technologies for user localization in indoor construction environments," Automation in Construction, vol. 18, no. 4, pp. 444–457, Jul. 2009.

[5]   [5] C. Randell, "Low Cost Indoor Positioning System ⋆ ," no. 15986.

[6]   [6] R. G. Crespo, G. G. Fernandez, and O. S. Martínez, "In Premises Positioning – Fuzzy Logic," pp. 284–291, 2009.

[7]   [7] Y. Fukuju, M. Minami, H. Morikawa, T. Aoyama, I. Science, and F. Sciences, "DOLPHIN : An Autonomous Indoor Positioning System in Ubiquitous Computing Environment Yasuhiro FUKUJU *, Masateru MINAMI *, Hiroyuki MORIKAWA **, and Tomonori AOYAMA * * Graduate School of Information Science and Technology , The University of Tokyo ** Gr."

[8]   [8] G. Deak, K. Curran, and J. Condell, "A survey of active and passive indoor localisation systems," Computer Communications, vol. 35, no. 16, pp. 1939–1954, Sep. 2012.

[9]   [9] U. Rueppel and K. Stuebbe, "BIM-Based Indoor-Emergency-Navigation-System for Complex Buildings," Tsinghua Science & Technology, vol. 13, no. October, pp. 362–367, Oct. 2008.

[10]   [10] P. Prasithsangaree, P. Krishnamurthy, P. K. Chrysanthis, T. Program, and I. Section, "ON INDOOR POSITION LOCATION WITH WIRELESS LANS," pp. 720–724, 2002.

[11]   [11] K. Kaemarungsi and P. Krishnamurthy, "Modeling of indoor positioning systems based on location fingerprinting," Ieee Infocom 2004, vol. 2, pp. 1012–1022.

[12]   [12] S. Feldmann, K. Kyamakya, A. Zapater, and Z. Lue, "An indoor Bluetooth-based positioning system : concept , Implementation and experimental evaluation."

[13]   [13] M. Hazas and a. Hopper, "Broadband ultrasonic location systems for improved indoor positioning," IEEE Transactions on Mobile Computing, vol. 5, no. 5, pp. 536–547, May 2006.

[14]   [14] B. Ozdenizci, K. Ok, V. Coskun, and M. N. Aydin, "Development of an Indoor Navigation System Using NFC Technology," no. April, pp. 25–27, 2011.

[15]   [15] R. Mautz, "Overview of current indoor positioning systems," Geodesy and Cartography, vol. 35, no. 1, pp. 18–22, Jan. 2009.

[16]   [16] E. Costa-montenegro, F. J. González-castaño, D. Conde-lagoa, A. B. Barragáns-martínez, P. S. Rodríguez-hernández, and F. Gil-castiñeira, "QR-Maps : an Efficient Tool for Indoor User Location Based on QR-Codes and Google Maps," pp. 928–932, 2011.

[17]   [17] Y. Xue, G. Tian, R. Li, and H. Jiang, "artificial object mark in complex indoor environment," pp. 6648–6653, 2010.

[18]   [18] C. Lukianto and H. Sternberg, "Overview of Current Indoor Navigation Techniques and Implementation Studies Overview of Current Indoor Navigation Techniques and Implementation Studies," no. May 2011, pp. 18–22.

[19]   [19] M. P. Wylie and J. Holtzman, "The non-line of sight problem in mobile location estimation," Proceedings of ICUPC - 5th International Conference on Universal Personal Communications, vol. 2, no. 3, pp. 827–831.

[20]   [20] P. Veeranath, D. N. Rao, S. Vathsal, and N. Bhasker, "Reducing Multipath Effects in Indoor Channel for Analysis of GPS / Pseudolite Signal Acquisition," vol. 3, no. 2, pp. 1–6, 2013.

[21]   [21] Y. Á. López, M. E. D. C. Gómez, J. L. Álvarez, and F. L.-H. Andrés, "Evaluation of an RSS-based indoor location system," Sensors and Actuators A: Physical, vol. 167, no. 1, pp. 110–116, May 2011.

[22]   [22] F. Evennou and F. Marx, "Advanced Integration of WiFi and Inertial Navigation Systems for Indoor Mobile Positioning," EURASIP Journal on Advances in Signal Processing, vol. 2006, pp. 1–12, 2006.

[23]   [23] M. Hazas and A. Ward, "A Novel Broadband Ultrasonic Location System," pp. 264–280, 2002.

[24]   [24] J. Sampedro, "SOCIEDAD Un GPS en el cerebro," pp. 4–5, 2013.

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Open Data as a key factor for developing expert systems: a perspective from Spain

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Abstract — **The open data movement is relatively new but very significant, and potentially powerful. The overall intention is to make local, regional and national data available in a form that allows for direct manipulation. This paper is based on analyzing the current context of the Open Data initiative in Spain, from its origins and concepts, the legal framework, current initiatives and challenges that must be addressed for effective reuse of public sector information.**

Keywords — **Open Data, Interoperability, linked data, e-government.**

I. INTRODUCTION

THE new technologies of information and communication technologies (ICT) have dramatically changed the ways of access to public sector information facilitating information processing and its dissemination. The main producer of information are the governments, which, in the exercise of their functions, create, collect, treat, store, distribute and disseminate large amounts of information of various fields.

The e-government, the reuse of public sector information, with open data initiative has led to the spread of numerous campaigns opening public sector data and administrative transparency. Spain has not been unresponsive to these initiatives. However, despite the good position in the world ranking for the development of Open Data initiatives, the efforts made so far are still insufficient.

Artificial intelligence contributes to the advancement of government management models, where issues relating to electronic government and open, ensure transparency of data online and public accountability, and citizen participation.

This paper shows the current situation of open data initiative from a Spanish perspective, its importance, challenges and opportunities.

II. BACKGROUND

In recent years has begun a revolution called "Open Data" caused by the wide array of government data that are significant not only because of the quantity and centrality but also because most government data are public by law [1] and that entails access and reuse of public information [2].

The Open Data initiative is related to the e-government and the web presence administration and is about to publish the Public Sector Information in standard formats, open and interoperable, facilitating their access and enabling reuse.

Many central governments are making government information more easily available on the Web to the public and in formats that citizens can reuse. This occurs in response to the needs of society for transparency, participation, collaboration, innovation, accountability, economic development, job growth, cost reduction, interoperability, among other [3].

The open data value chain including the source which can be public or private, infomediaries which are responsible for data processing and end users who may be enterprises or citizens (Fig. 1).
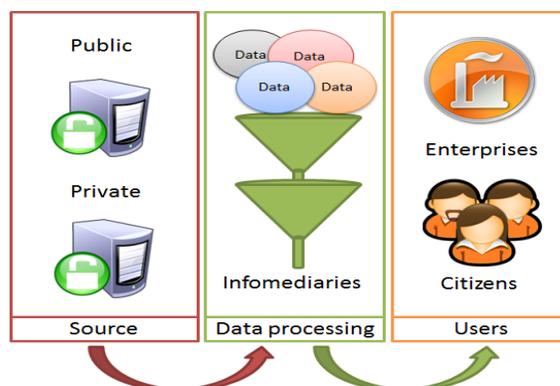
Fig. 1. Open Data value chain

Technical semantic and organizational interoperability difficulties are evident throughout the value chain of open data. From the lack of a clear legal framework and political leadership[4–6] until socio-technical impediments from the perspective of the open data user [7].

Reuse of Public Sector Information (RPSI) is the main objective of Open Data initiatives. RPSI means making public information generated by the public sector available to individuals and business. Although its great economic potential is not yet possible to quantify the benefits of this initiative.

A study, of use of open government data (OGD) from data.gov.uk [8] puts forward five processes of OGD use (fig. 2): Data to fact, information, interface, data or service.

For improving the open data process research should be about the impediments in users groups with the objective to propose strategies allowing for the accomplishment of the desired impact.
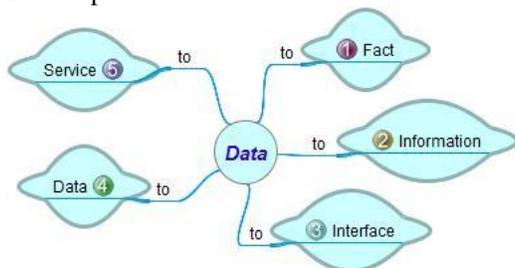
Fig. 2. Five processes of OGD

Moreover, linking information from different sources is a key for further innovation. The ultimate goal of Linked Data is to enable the use of the Web like a single global database [9] with easy accessible information obtained from different sources [10]. If data can be placed in a new context, more and more valuable applications will be generated [11]. It is clear that interoperability and standards are a key to fully benefit from OGD. Therefore, Linked Data is essential to generate an information management through standards to ensure interoperability. This needs to be considered at three levels [12]:

Organizational level: coordinated processes in which different organizations achieve a previously agreed and mutually beneficial goal.

Semantic level: precise meaning of exchanged information which is preserved and understood by all parties, enables organizations to process information from external sources in a meaningful manner.

Technical level: planning of technical issues involved in linking computer systems and services, It includes aspects such as interface specifications, interconnection services, data integration services, data presentation and exchange, etc.

Not only users, but also other stakeholders, may have greater freedom to make choices when the level of interoperability increases, there are other benefits to make interoperable government systems, for example, better data quality, the greatest opportunity in the delivery of information and finally non-tangible benefits such as gaining greater citizen trust[13]. Furthermore using the right architectural model to deploy interoperable e-government services results in a direct, positive impact on Gross domestic product (GDP) [14].

III. OPEN DATA IN WORLD

Open data is closely related to the maturity models as the e-government. The World Bank described e-government as the use of information technologies by government agencies that have the ability to transform relations with citizens, businesses, and other arms of government [15].

Governments around the world are at various stages of e-Government readiness and implementation, European countries generally taking the top spots [16]. According to the 2012 United Nations E-government Survey rankings, the Republic of Korea is the world leader (0.9283) followed by the Netherlands (0.9125), the United Kingdom (0.8960) and Denmark (0.8889), with the United States, Canada, France, Norway, Singapore and Sweden close behind [17].

Data.gov is an initiative to put hundreds of thousands of public datasets in an easily usable and retrievable form in one location. It means democratizing access to data, it is one of the first initiatives, which since 1999, is driving the U.S. government.

The United Kingdom repository data.gov.uk is a large repository of public information that the British government launched to provide transparency to the management, data and financial issues on the UK government are an example of transparency.

The European Union (EU) recently released the beta version of its open data portal. This web page contains all public information generated by EU institutions. A study conducted ten portals, edited by public bodies member countries of the European Union in 2012 showed that most have less than two years and are in a phase of organization and implementation, so that consistency and data coverage is very uneven [18].

In Latin America, in Chile, there are three open data initiatives: an open data portal which publishes, on a single website, public information sets in more than one format, Chile Library of Congress the first Latin American state institution validated with five stars Open Data by CTIC Foundation and Open Data catalogue by the Chile's Transparency Board. In Brazil, there are open data portal and Federal Senate Legislative Open Data as national initiatives and other regional such as "Minas em Numbers" data, statistics and indicators of mines.

Several countries in Latin America are studying and making experiments with Open Data, the same is happening, on a much smaller scale, in a few parts of Asia and Africa. Kenya is the first developing country to have an open government data portal, the first in sub-Saharan Africa and second on the continent after Morocco[19].

IV. OPEN DATA IN SPAIN

A. legal framework

In 1998, the European Commission launched the "Green Paper on Public Sector Information in the Information Society" highlighting the need to improve synergies between the public and private sectors in the information market. In this Green Paper lies the foundation for the regulation of access to public information, transparency, reuse and trading it. The Green Paper proposals inspired the Directive 2003/98 of The European Parliament and of The Council of 17 November 2003 on the re-use of public sector information.

Meanwhile in Spain the law 37/2007 was passed for the regulation of the legal regime applicable to the reuse of documents produced or held by the Administrations and public

sector bodies and the law 11/2007 which recognizes the right of citizens to interact with the public administrations by electronic means and regulates basic aspects of using information technologies. The Royal Decree 1495/2011 and the Royal Decree 1671, respectively, partially implemented such laws (fig. 3).

Recently, the EU Council approved the amendment of Directive 2003/98/EC which regulates the reuse of Public Sector Information. Among the innovations introduced is expanding its scope, the obligation to publish a standard format, open and processable by automatic means. On the other hand, member states will be held accountable for the implementation of the Directive every 36 months and the Commission should develop guidelines for licensing unique rates and publication preferred datasets.

Spain is working on transparency law and executing projects and initiatives in order to fulfill The European eGovernment Action Plan 2011-2015.
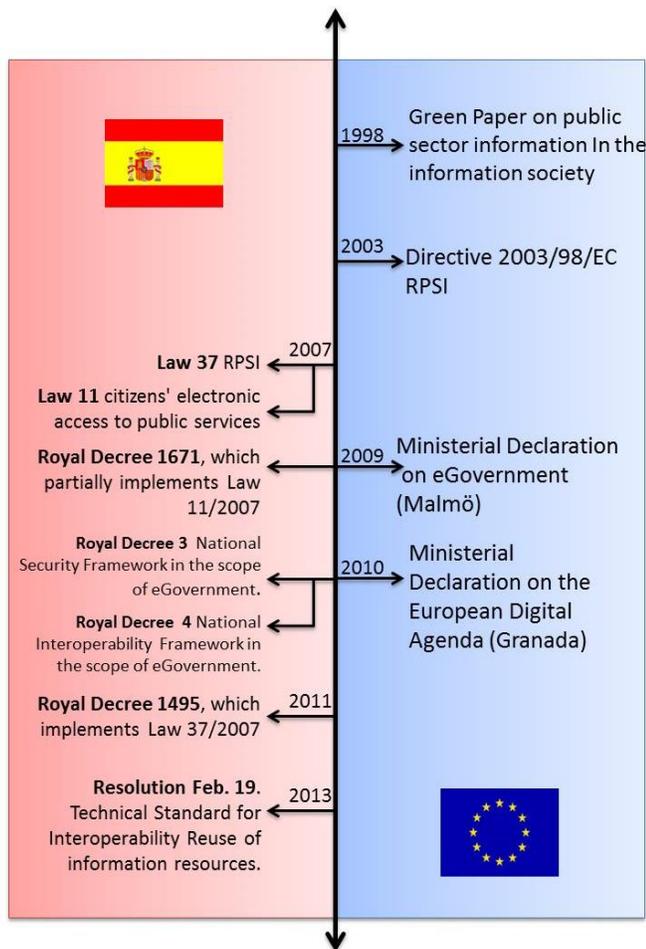
Fig. 3. Legal framework 1998-2013.

B. National and Regional initiatives

In 2005 Spain's government approved through the Avanza Plan, the first national action line dedicated specifically to promote the opening of public sector information. In 2009 it created the project Aporta, fruit Avanza2 Plan. Two of his main achievements were the launch of www.aporta.es and the

publication of the Aporta Guide. The Guide offers a series of recommendations and best practices in open public sector information and is a good starting point for any work related to Open Data. Through the Aporta Program, what has been working to boost the provision of public information by the different administrations, with several initiatives for effective implementation of the culture of reuse of information within the administration.

In March 2010 (fig. 4), the Public Information catalogue was launched, the first single access to available data sources in Spain's public sector. In June 2011, the "Characterization infomediary sector 2011" was published a study, which showed the situation of open data in Spain. In that same year, the initiative datos.gob.es was launched, taking over from project "Contribute" and assumed its commitment to open public sector information. Its main objective is to promote the publication, improve access and encourage reuse of public information corresponding to the General State Administration.
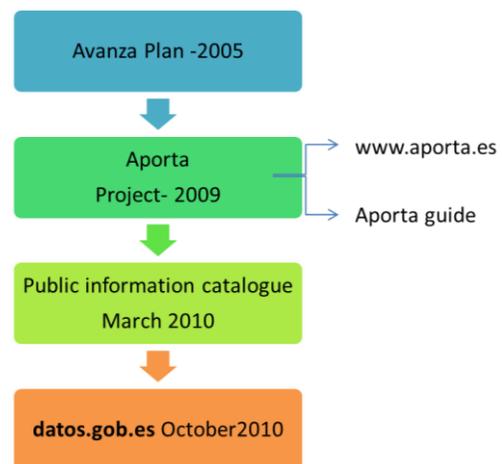
Fig. 4. Initiatives open data in Spain

Other examples of policies reuse of information is opening data from the General Directorate for Cadastre and National Geographic Institute.

The CTIC Foundation (Center for the Development of Information and Communication Technologies in Asturias) is a organization, constituted by a group of firms from the Information and Communication Technologies field, and the Government of the Principality of Asturias. The datos.fundacionctic.org is the CTIC website dedicated to Open Data. Its goal is to help government and public bodies in the publication of your information in accordance with current regulations.

There are also some regional projects that have been developed by several Public administrations to share their data, together with CTIC Foundation. Table I shows the main initiatives undertaken in provinces of Spain.

Although the government is working on the reuse of data and important steps have been taken in recent years, there is still much to be done in the field of open data.

Open data Euskadi was born in 2010 as the first open data

portal in Spain. It has been awarded the "Project Transparency Referent in central, regional or Local Government" in 2013 and shows a genuine opening of public data for reuse. In Asturias on the other hand, despite linked data, the number of published datasets is very low and not updated frequently. Gencat data catalogue uses different formats according to the data type, this variety makes it hard access. Most of the data sets published in the Open Data Junta de Castilla y León are in proprietary formats o Comma Separated Values (CSV). It particularly emphasized the launch of Open data Córdoba in 2011, with an investment of 382,000 [21] euros, which is not currently operating and for which the reasons are unknown.

TABLE I
OPEN DATA REGIONAL INITIATIVES IN SPAIN

Region	Open data initiatives	Catalogue status [20]
Andalucía	Andalucia Open Data Catalog	Open formats
	Open Data Universidad Pablo de Olavide - Sevilla	Open formats
	Open Data Córdoba	Extinct
Asturias	Asturias Public Data	Linked Data
	Gijón Public Data Catalogue	RDF Data
País Vasco	Open Data Euskadi	RDF Data
Navarra	Open Data Navarra	Open formats
	Pamplona Open Data	Open formats
Aragón	Aragon Open Data	RDF Data
	Zaragoza Public Data Catalogue	Linked Data
Galicia	Abert@s (Galicia Open Data)	RDF Data
Castilla La Mancha	Portal de Datos Abiertos de JCCM	RDF Data
Cataluña	Lleida Open Data	Open formats
	Gencat data catalogue	RDF Data
	Open Data Terrassa	RDF Data
	OpenData Sabadell	Open formats
	Badalona Open Data	Open formats
	OpenData Barcelona	RDF Data
	Observatori de la Ciutat Open Data Sant Boi	Open formats
Islas Baleares	Balearic Islands Open Data	RDF Data
Castilla y León	Open Data Junta de Castilla y León	RDF Data

Only 60% of open data catalogs of the initiatives mentioned above announced the update frequency and none makes visible downloaded datasets registration number. Also it is difficult to know the true value of such data. Furthermore Lleida and Sant Boi portals are only available in Catalan.

V. CHALLENGES AND OPPORTUNITIES

The impact of open data initiatives is emerging, while it is true, Spain has consolidated initiatives, a legislative framework to promote the reuse of public information, steady growth in electronic government there are many challenges still to face (fig. 5).

Technically speaking it is necessary to establish common parameters for all the autonomous communities regarding the information published, quality, format, licensing, processing and loading at each site. Regarding the semantic the challenge is to standardize formats and establish a standard reference vocabulary that various administrations can use to facilitate the linking of data and broaden the scope to nationwide solutions.

Finally, from an organizational perspective strong leadership from General State Administration is required in order to identify what are the data that generate added value, define indicators to measure and evaluate initiatives and recognize the importance of open data as an engine for the generation of economic benefit, transparency and improving vertical and horizontal interoperability in public administrations.
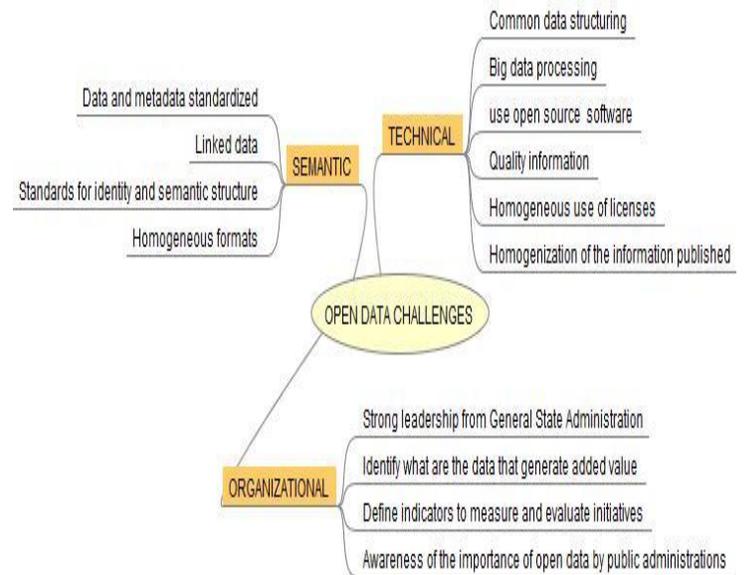
Fig. 5.Challenges open data

The actual citizen participation is essential, the frustration and lack of trust in institutions in many countries are high, so it's no surprise when people express skepticism that opening government data won't help much in fixing things.

VI. CONCLUSIONS

Despite the significant advances in the reuse of public sector information, in Spain there are still things to be done. The progress has been slow if we consider that for over 15 years, the European Commission has been working in this scope.

Probably the most difficult problems to overcome are not technical or semantic, but rather those relating to the understanding that the information belongs to everyone and that the empowerment of the public administrations is essential in order to share its information with others, and to raise awareness of the potential of opening data for reuse.

In this sense, research on new expert systems applied to the generation of an assistant to the search, extraction and understanding of information in large volumes of data is completely innovative, and allows for a tremendous value to projects that leverage the potential of Open Data.

REFERENCES

[1] Open Knowledge Foundation, "Manual de los Datos Abiertos," *Portal de Datos Abiertos del Gobierno de Misiones*, 2012. [Online]. Available: http://www.datos.misiones.gov.ar/directorio/documentos/Manual_de_Datos_Abiertos.pdf.

[2] A. Naser and G. Concha, "Datos abiertos: Un nuevo desafío para los gobiernos de la región," *Naciones Unidas*, 2012. [Online]. Available: http://www.eclac.org/publicaciones/xml/7/46167/DatosAbiertos_17_04_2012.pdf.

[3] Proyecto Aporta, "Guía Aporta sobre Reutilización de la Información del sector Público," 2011.

[4] N. Huijboom and T. Van Den Broek, "Open data: an international comparison of strategies," *European Journal of ePractice*, pp. 1–13, 2011.

[5] M. Fioretti, "Open Data : Emerging trends , issues and best practices administration," 2011. [Online]. Available: http://www.lem.sssup.it/WPLem/odos/odos_report_2.pdf.

[6] E. D. Rico and R. M. Calenti, "Open Data y RISP: generando valor social y económico. Transparencia e innovación en la eAdministración," *Santiago de Compostela: Colexio Profesional de Enxeñaría en Informática de Galicia*, 2011.

[7] A. Zuiderwijk, M. Janssen, and S. Choenni, "Socio-technical Impediments of Open Data," *Electronic Journal of eGovernment*, vol. 10, no. 2, pp. 156–172, 2013.

[8] T. Davies, "Open data, democracy and public sector reform. A look at open government data use from data.gov.uk," University of Oxford, 2010.

[9] C. Bizer, T. Heath, and T. Berners-Lee, "Linked data - The story so far," *International Journal on Semantic Web & Information Systems*, vol. 5, pp. 1–22, 2009.

[10] J. L. Redondo-García, V. Botón-Fernández, and A. Lozano-Tello, "Linked Data Methodologies for Managing Information about Television Content," *International Journal of Interactive Multimedia and Artificial Intelligence*, vol. 1, no. 6, p. 36, 2012.

[11] F. Bauer and M. Kaltenböck, "Linked Open Data: The Essentials," 2011.

[12] F. B. Vernadat, "Technical, semantic and organizational issues of enterprise interoperability and networking," *Annual Reviews in Control*, vol. 34, no. 1, pp. 139–144, 2010.

[13] G. Concha and A. Naser, "El desafío hacia el gobierno abierto en la hora de la igualdad," 2012.

[14] L. Madrid, "The Economic Impact of Interoperability Connected Government," *Microsoft Corporation*, 2012.

[15] The World Bank, "e-Government," 2011. [Online]. Available: http://go.worldbank.org/M1JHE0Z280. [Accessed: 15-Feb-2013].

[16] W. Olatokun and B. Adebayo, "Assessing E-Government Implementation in Ekiti State, Nigeria," *Journal of Emerging Trends in Computing and ...*, vol. 3, no. 4, pp. 497–505, 2012.

[17] United Nations Department of Economic and Social Affairs, "E-Government Survey 2012," 2012.

[18] F. Ramos, R. Arquero, I. Botezán, S. Cobo, A. Sala, R. Sánchez, and F. del V. Gastaminza, "De la reutilización de información del sector público a los portales de datos abiertos en Europa," *BiD: textos universitaris de biblioteconomia i documentació*, vol. 29, 2012.

[19] "Kenya openData," 2013. [Online]. Available: https://www.opendata.go.ke/.

[20] Fundación CTIC, "Public Dataset Catalogs Faceted Browser," 2013. [Online]. Available: http://datos.fundacionctic.org/sandbox/catalog/faceted/.

[21] Diario Córdoba, "Nace la plataforma ´Open data Córdoba´ para buscar empleo o crear empresas," 2011. [Online]. Available: http://www.diariocordoba.com/noticias/cordobalocal/nace-plataforma-open-data-cordoba-para-buscar-empleo-o-crear-empresas_625578.html.

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Using rules to adapt applications for business models with high evolutionary rates

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Abstract — **Nowadays, business models are in permanent evolution since the requirements belongs to a rapidly evolving world. In a context where communications all around the world travel so fast the business models need to be adapted permanently to the information the managers receive. In such world, traditional software development, needed for adapting software to changes, do not work properly since business changes need to be in exploitation in shorter times. In that situation, it is needed to go quicker from the business idea to the exploitation environment. This issue can be solved accelerating the development speed: from the expert to the customer, with no –or few, technical intervention. This paper proposes an approach to empower domain experts in developing adaptability solutions by using automated sets of production rules in a friendly way. Furthermore, a use case that implements this kind of development was used in a real problem prototype.**

Keywords — **business rules, domain experts, software adaptability, software architecture**

I. Introduction

Business environments and business needs are changing rapidly, thus a progressive change and adaptation of the systems development is unavoidable in order to maintain the customer satisfaction. Even though, it is an expensive and difficult task for software engineers and developers to align the changing business requirements with actual software systems to keep them working properly [1]. Software adaptability must therefore be taken into account throughout the full software life cycle. Systems adaptation may be undertaken using two different levels in most of the cases: simple adaptations usually performed by using configuration files and complex adaptations where solutions are commonly structural ones. This paper focuses on the latter type of system adaptation, the complex or logical systems. These systems can be modified by using rules that solves first order logical issues over the predicates in order to assist decision making process [2].

The difficulty in ensuring systems adaptability is highly related with the software development lifecycle. Usually, human knowledge is transformed into software systems by the mediation of requirements documents and design models. These documents and models provide a high level view of the system and guide developers in producing running systems from the specification. Even though, the original requirements textual descriptions of system functions are separated from the developed design models, which lack the capability to capture the exact behavioral semantics from what is stated in the functional requirements [3].

Hence, these behavioral semantics need to be expressed in a more flexible and abstract manner to avoid coupling with actual developed systems and at the same time ease the adaptability process. The domain expert's role in defining the behavior of the systems expressed in comprehensible business rules is then a matter to take into account since their business knowledge can be transformed in adaptability solutions. There are a number of proposals that include tools with interfaces for non-skilled users, more than personalization, they either allow rapid development of prototypes [4], [5] or provide for the visual expression of simple rules, which, although powerful enough in certain cases, is somewhat limited in the application domain. Therefore, it would be beneficial to explicitly involve the final users and allow them to provide part of the desired configuration for system adaptation, since they will be familiar with their own environment and their requirements.

II. Background

There are some methods used usually to adapt applications to existent business models. One of such methods include the Model-Driven Architecture (MDA) [3], [6] and [7] which promotes the production of business models with sufficient detail so that they can be used to generate or be transformed into executable software, running on target systems [8].

MDA proposes a Platform-Independent Model (PIM), a highly abstracted model, independent of any implementation technology. This is translated to one or more Platform-specific Models (PSM). The translation is based on a particular technological implementation including specific constructs and features of the implementation [9]. PSM is translated into code in a similar pattern.

The transformation process of PIM to PSM and finally code starts from the design products rather than requirements models. Hence, it requires highly creative work [6] to build a PIM from narrative requirements documents. This results in high costs in requirements change because of the need of

skilled software engineers. Furthermore, as stated in [13], UML alone is not able to capture some semantics in its diagrams and a combination of UML and OCL [7] is used in MDA. However, OCL constraints are static and used in the design stages rather than the requirements stages. Moreover, MDA relies heavily on the tools which are supposed to have strong transformation capabilities from PIM to PSM and then to code.

MDA can reproduce object oriented OO systems despite the intrinsic static nature of object structure and behavior, code being regenerated from models. However, changes cannot be made to systems at runtime without interruption. Another important issue is that some business representation cannot be directly formed as objects, such as business rules. Additional maintenance problems would be otherwise added to systems if business rules were hard-coded [10]. These weaknesses MDA have led to the exploration of an alternative component technology at a higher level abstraction, being capable to retrieve, understand, as well as interpret business knowledge directly and dynamically.

There are a number of different technologies that may be used to express this sort of information. Almost any language that supports some form of rule-based inference can be used; this includes rule engines such as Drools [11], Jena [12] and Jess [13]. The Java specification request JSR-94 [14] covers the definition of a Java rule engine API, and most commercial rule engines are implementations of this standard. Drools, is an open source business rule management system and inference rule engine implemented in Java [11]. Inference rules are evaluated using an enhanced implementation of the Rete algorithm [15]. Drools natively provides an expressive textual language for defining inference rules, but also supports the integration of a custom rule DSL to improve the productivity of defining rules within certain domains. The underlying model that Drools operates within is simple plain old java objects (POJOs), making it easy to integrate into an existing Java-based software system. The structure of inserted POJOs does not need to be defined as part of the rule base; this means that all metamodel properties and operations are always accessible to a Drools rule. These are the main reasons why to choose Drools in this approach in order to build and execute the rule sets.

III. RELATED WORK

There are some significant studies aimed at providing a mechanism for not skilled users to specify the rules needed by the system in order to be better adapted to their needs. Authors in [4] present an application prototyping tool which does not require coding and instead uses a graphical interface based on controls, which allows context and devices to be collected and rules to be constructed from them by taking only logical–relational operators and restrictions on types of complex conditions. The technique might not be considered suitable for domain users to modify the applications since is actually a prototyping support intended for developers.

In [16] the authors present a programming prototyping environment intended for domain users. The system provides a series of data flows from different inputs where users can select the input flows required for the behavior they want to express. It also specifies the actions to be executed. This proposal makes use of machine learning algorithms to interpret the annotated flows in order to determine the user's intention. Since domain users are familiar with their own activities and environments they are able to tell the environment how it should behave, but they might have

The work described in [17] sketches a visual interface that specifically targets non-expert users based on a drag-and-drop metaphor. It relies on a rule grammar for expressing conditions and rule alternatives. This tool is intended to be implemented in future with an emphasis on providing visual hints and suggestions to facilitate incremental rule construction by end-users, but has not yet been tested with real non-skilled users.

Although these systems are intended to be used by domain experts, they fail in the way to represent the information in a comprehensible way for not skilled domain experts. Some of them use programming languages or domain specific languages that are more suitable for developers in order to express the adaptation rules. The solution proposed in this paper can be more suitable for domain experts since the representation of the rules is done graphically with no special knowledge of the technology used. Moreover, the rules predicates are expressed with a very simple way close to natural language, avoiding complex logical structures.

IV. MATERIALS AND METHODS

A target application developed to be in permanent adaptation by the use of rules needs a previous architecture design where the modules that will be affected by the adaptation process along with invariant ones need to be defined. Moreover, these rules need to be edited and manipulated by domain experts instead of undertake the development of new features by software engineers.

In order to develop such applications using rules, an engineering model able to support integration [18] have been used. The method is composed by the following steps:

Problem statement

The study of the business issues and those exposed to high evolutionary rates is addressed in this step. This step represents an important task within the whole process since the accuracy in identifying these issues will impact future developments or avoid them if possible, saving money and gaining efficiency in a long term.

Domain experts' knowledge represents a valuable source of information in this step. This information describes the general business features and the most frequently scenarios to take into account by software engineers. The business knowledge is taken by software engineers to identify the main core of the system (which is more immutable and thus less subject to change), along with the more dynamic elements that may vary the most in exploitation time.

From the identified elements, those which bring the possibility to be adapted with simpler techniques (e.g. configuration files) are separated. The remaining dynamic elements are classified whether they are sensitive to be adapted with rule-based systems or require new developments.

The final number of dynamic elements sensitive to be adapted by rules, resultant from this classification is big enough to justify the use of rule-based systems.

The elements that require new development in order to be adapted are studied apart. These elements must be designed with architectural patterns that minimize the interdependencies among them and simplify the systems evolution.

Architecture design

This step follows the attribute driven design (ADD) used in [18]. The most dynamic modules are incorporated with a "modifiability" quality attribute and quality scenarios are designed to check this feature. Each of the modules that are adapted by rules receives the classification of rule-based architectural style modules within the architecture context [2].

Rule-based system design

This step describes the design of an architecture module that will be adapted by rules. The rules to be applied along with their attributes and predicates are identified. The component that enables domain experts to interact with the rules' management in an intuitive way is also designed. There are four basic elements needed to address systems adaptability with rule-based systems:

Attributes. Bring the possibility to query any object feature in the system.

Predicates. Code elements that perform complex queries to system elements, evaluates them and return a value that can be processed by rules.

Actions. Situated in the rules consequent, they have effects over the system since they can modify its behavior, reason why it is important not to extra limit their scope. To properly establish actions scope, a set of services are defined (i.e. façade, web services, etc.) this way actions can only trigger these services and do not affect other parts of the system.

Rules. These are the most dynamic aspect of the system. They are intended to be dynamically inserted in the system. Domain experts use the set of rules to design new actions to be executed by the system.

In order to ease domain expert in designing new rules, a rule editor is constructed following the business vocabulary. It is only necessary that the expert have a little notion of logic to interact with the editor. Even though, the editor is intuitive enough to assist the expert in creating syntactically correct rules.

The rules' structural modifiability is restricted only to the set of attributes, predicates and possible actions. In the case that this modifiability has a broader scope, then its structural significance gets bigger than the logical adaptation and the module can be classified as complex system where the adaptations which solutions are commonly structural ones, therefore, they out of this paper scope. In order to solve future structural issues, the intervention of technological teams aided

by domain experts is necessary. This roles' combination enables the construction of modules (which insertion in the system is previously set) typed as: new attributes, new rules and new actions. All modules must be created with the same previously defined constraints.

V. USE CASE

This work presents a design model to adapt a traceability management that is able to handle, in sufficiently short times, the alarms triggered by user actions that do not follow established procedures. The use case address the establishment of a traceability system integrated in the enterprise applications of a transportations company. This company has several quality procedures that require certain records in some specific moments over time within its activities. In particular, the activity studied is the personnel hiring for driver positions.

The process under investigation is composed by the activities performed by the actors involved in hiring a new driver. Every activity generates a corresponding record that is
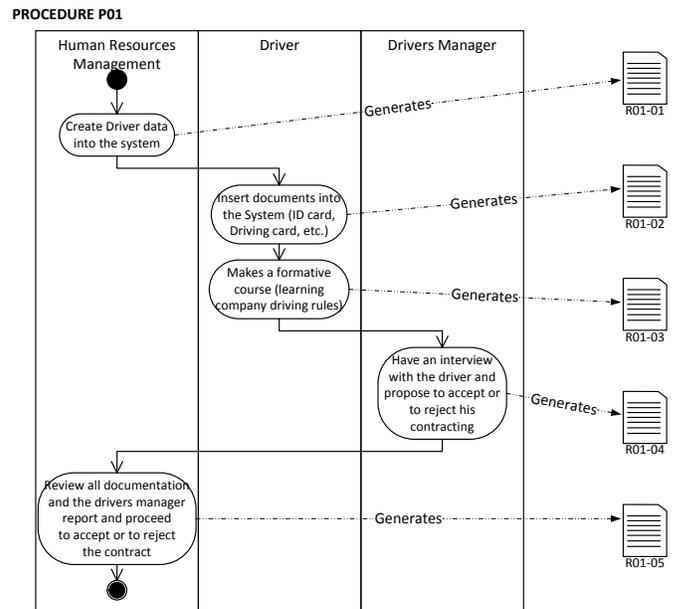
Fig. 1. Description of the procedure for contracting drivers

stored in a record control system (see Fig. 1)

The company's product manager (PM) needs to know whether the procedures are performed properly or not and most important if the drivers' interviews are carried out. Furthermore, he/she requires that the information queries be recorded in order to later be aware of the time spent between the interviews and the actual hiring. It is worth to mention that these queries have a very short lifetime, e.g. the PM might need to have this data during a month with a special increment in accidents, while the next month this information is no longer required. For this reason, to undertake and ad-hoc development in order to achieve the adaptation of queries' information needs results expensive and repetitive. The solution proposed in this work has a reasonable low cost to make viable these kinds of adaptations.

This kind of queries can only be executed against the record database. This represents an issue for the PM since he/she needs this information available all the time without expressly perform the query. Hence, the system needs to be proactive and inform the PM in an autonomous way. This situation cannot be solved with a traditional development technique since every query needs to be adapted to fulfill PM information needs. This context fosters the implementation of rule-based architectural style for this module.

VI. PROPOSED SOLUTION

There are several reasons to decouple traceability systems from business modeling systems, the following are some of the most significant:

- The procedures, in general, are items subject to changes which cannot be executed in monolithic systems that require new developments constantly.
- Actual legacy systems are not integrated with traceability systems. This situation hinders to perform changes in their behavior in order to avoid unordered activities.
- Highly dynamic systems may violate the strict path predetermined for the activities execution within a procedure.

The evolution of business models brings the adaptation to new standards which demand a change in the rules that handle the traceability of the products in a reasonable time. This scenario may not be suitable for traditional software development.

Once identified the main changing points, the system proposed was enriched with a rule-based adaptable module easy to modify by domain experts with no technical skills. This enables the performance of business adaptations in a very short period of time and with a very low cost. In order to achieve such adaptation, a graphical rule editor was implemented.

General system context

The proposed system is formed by three main components:

1. Legacy systems component (green) to model the business without traceability integrated.
2. Record systems component (blue) to interact with legacy systems in order to produce records at the right moment.
3. Information exploitation systems component (orange) to apply the rule-based architectural style in the architecture.

Fig 2. shows the general context of the proposed architecture.

The Information exploitation systems component retrieves the information from the records warehouse and processes it to obtain reports, indicators, etc. that enables the responsible actors to have data about the events and situations being gathered by the traceability system.

As can be shown in Fig. 2, the Information Exploitation Component has two basic modules:

- **Rules Manager**. Manages the rules that respond to the events and explores the available system information.
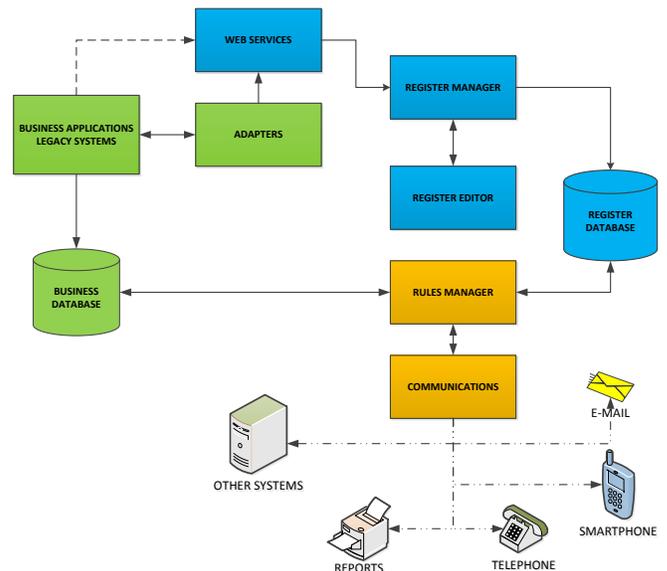
Fig. 2. Architecture context for the entire system

- **Communications.** Manages the users' information communication systems.

A more detailed description of the Information Exploitation Component is depicted in Fig. 3.

Basically, the process consists of the application of a set of rules that identifies different situations that need to be documented in some specific way. These rules are executed in two different ways:

- **On-line rules**. Executed in the precise moment of recording the registration in the database.
- **On demand rules**. Executed on demand by the users with privileges.

Once the rules are executed, if the conditions are met the associated actions are triggered.

The data mining system retrieves the business information needed to fire a rule or to complement the communication of an alarm action. There are four types of actions:

- **Just in time information (Alarms)**. Information that detects situations where some users wants to take just in time information from. These alarms can be configured by non-technical users.
- **Configurable reports**. Generic reports that can be configured to multiple purposes by non-technical personnel.
- **On demand reports**. Specialized reports that require technical personnel intervention.
- **On demand alarms**. Alarms version that cannot be handled by the rule configurable system and requires a technical service intervention.

On demand components perform solutions to more complex design that could not be designed at the development time.

Reports are sent to specific people or to another system by using different information channels; this requires the information adaptation depending on the channel used to send the data. This adaptation task is performed by the Communications Component.

Rules

The rules used follow the predicates logic format. The
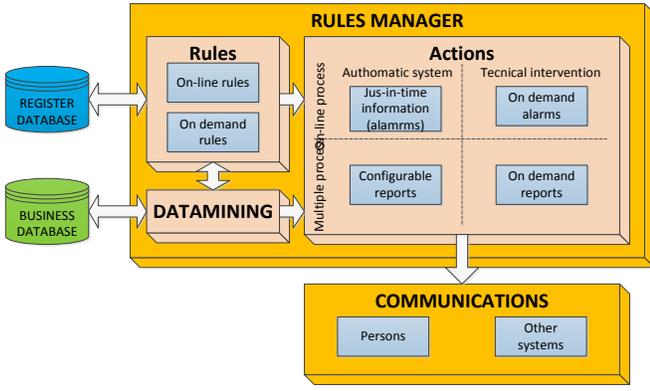
Fig. 3. Basic architecture for the Information Exploitation Component

quantifiers are eliminated since they can be included in the predicates. The rules are fired by triggered events; the basic functioning can be described as (1):

$$event: evaluation(rules\_set) \qquad (1)$$

For each rule, if its evaluation is true, the associated actions are triggered as in (2):

$$IF\ Evaluation\ (Predicates) = TRUE \rightarrow Execute\ (Actions) \quad (2)$$

The general appearance of the rules used is the following (3):

$$P\_1\ (x,...)\ \wedge P\_2\ (y,...)...\rightarrow Action\ (Info,\ Stakeholders) \quad (3)$$

Where *Info* represents the information required for the report, which will be composed by the *Action* itself along with the data mining component that seeks the information in the database. *Stakeholder* is the user that will receive this information. The parentheses are allowed in order to establish the priorities and associations when evaluating the predicates. The connectors are ∧: Connective "AND", ∨: Connective "OR", ¬: Denial and →: Implication.

As a further constraint every predicate must be an object that allows a Boolean evaluation as in (4):

Record_written_at_DB_event:
IsProcedure(P1)∧IsRegistry(R1.5)∧¬(ExistsRegistry(R1.3)∨ExistsRegistry(R1.4)→Alarm(Info,Stakeholders) (4)

Previous rule formulates the following predicate: IF the procedure is P1, the registration in course is registry R1.5 from the mentioned procedure and the registries R1.3 or el R1.4 does not exist then the alarm is raised.

Every time an alarm or report is created, rules that triggers actions related to them are generated. These rules are in a rule set that has different subsets which are evaluated against the rule engine depending on events detected. For example, there is a subset of temporal events that contains all the rules to be executed when a time-out is reached. When this event takes place, the rules related with it are evaluated. Another important subset is the one that is evaluated every time the system receives a new registry. The objective is to optimize system responses in order to enable the growing of rules number since not all of them are evaluated in every event.

The identified predicates list by default is depicted in Table II.

All the predicates should be in context. The possible contexts are:

- **Default Procedure**. It is the procedure that is generating

TABLE II
PREDICATES CLASSIFICATION

Predicate	Description
IsProcedure(string)	Returns TRUE if the procedure name **matches** with the given string.
IsRegistry(string)	Returns TRUE if the registry name **matches** with the given string.
ExistsRegistry(string)	Returns TRUE if the registry named by string **exists** in the execution of the procedure
RegistryNumberGreaterEqual(string, num)	Returns TRUE if during the execution of the current procedure, the registry name (string) has been repeated **equal or more** times than the number in num.
RegistryNumberGreater(string, num)	Returns TRUE if during the execution of the current procedure, the registry name (string) has been repeated **more** times than the number in num.
RegistryNumberEqual(string, num)	Returns TRUE if during the execution of the current procedure, the registry name (string) has been repeated **equal** times than the number in num.
RegistryNumberLess (string, num)	Returns TRUE if during the execution of the current procedure, the registry name (string) has been repeated **less** times than the number in num.
RegistryNumberLessEqual (string, num)	Returns TRUE if during the execution of the current procedure, the registry name (string) has been repeated **equal or less** times than the number in num.
TimeBetweenTwoRegistriesGreaterEqual (string1, string2, num)	Returns TRUE if the time consumed between two registries named as string1 and string2 is greater or **equal** to num in milliseconds.
TimeBetweenTwoRegistriesGreater (string1, string2, num)	Returns TRUE if the time consumed between string1 and string2 is **greater** than the num in milliseconds.
TimeBetweenTwoRegistriesEqual(string1, string2, num)	Returns TRUE if the time consumed between string1 and string2 is **equal** to the num in milliseconds.
TimeBetweenTwoRegistriesLess(string1, string2, num)	Returns TRUE if the time consumed between string1 and string2 is **less** than the num in milliseconds.
TimeBetweenTwoRegistriesLessEqual(string1, string2, num)	Returns TRUE if the time consumed between string1 and string2 is **equal or less** than the num in milliseconds.
LastRegistryTimeGreaterEqual(num)	Returns TRUE if the time consumed from the last registry of the studied procedure is **greater or equal** to num in milliseconds.

the current register to be stored. It refers to the procedure template.

- **Instance procedure**. It refers to the current execution of the procedure.

The predicates could be added to the system by means of new development processes, for improving the configuration possibilities.

Actions identification

Actions associated with system are basically those that generate reports. Generally, actions' information processing goes across three stages:

- Information recovery
- Information treatment
- Presentation to users

These stages can be executed on-line, just like alarms, or require elements to store the information temporally (recovered and/or treated) in order to compose the report when a period ends.

Alarms

Alarms are information from specific identified events usually on-line. When an event or an unexpected situation that has been programmed as an alarm appears, the traceability system sends the configured information to the defined users.

For example, when registering the information in the database, if a rule detects that some procedure step has been ignored and that step is important enough to inform some person then an alarm is programmed as in (5).

$$IF\ R1.3\ \wedge\neg R1.2 \rightarrow Alarm\ (Info,\ list\ (Stakeholder)) \qquad (5)$$

A more complex example can be the following: when R1.5 (last registry that closes the procedure) arrives and some of the previous registries are missing (i.e. R1.0, R1.1, R1.2, R1.3 or R1.4), then the corresponding alarm is raised as in (6).

$$IF\ R1.5\ \wedge\neg\ (R1.0\ \vee R1.1\ \vee R1.2\ \vee R1.3\ \vee R1.4) \rightarrow Alarm\ (Info,\ list\ (Stakeholder)) \qquad (6)$$

Configurable reports

These reports can be configured by domain experts with no technical skills and may be used in different scenarios. A report can be received periodically containing a set of completed procedures, i.e. those which has completed the last registry. These reports may also contain information about procedures opened but not completed, or lacking of some step registration. Generic reports like these enable to obtain information about some processes execution, this information represent a business report for domain experts. When adapting these reports to be sent by email, e.g. to the personnel manager, they contain the last month hiring processes summaries, the hiring that did not followed the process correctly, the people hired and the ongoing hiring.

On demand reports

This is the component that tries to solve the structural modifications the system allows. These reports or alarms are adapted to a specific situation and created with software development processes by software engineers. They are integrated in the system by means of plug-ins and behave like basic actions. On the other hand the events the system responds to are:

- **New registry event.** Launched when a new registry is stored in the database.
- **Error event.** Launched when some of the next errors is generated: *incomplete registry error*, *repeated registry error* or *login error*.

Rules editor

The last step is the construction of a rules editor in order to simplify domain expert's work. The editor enables experts to model the conditions as a predicates tree and the actions as lists that can be configured. Fig. 4 depicts the rules editor interface where the left panel shows the available predicates
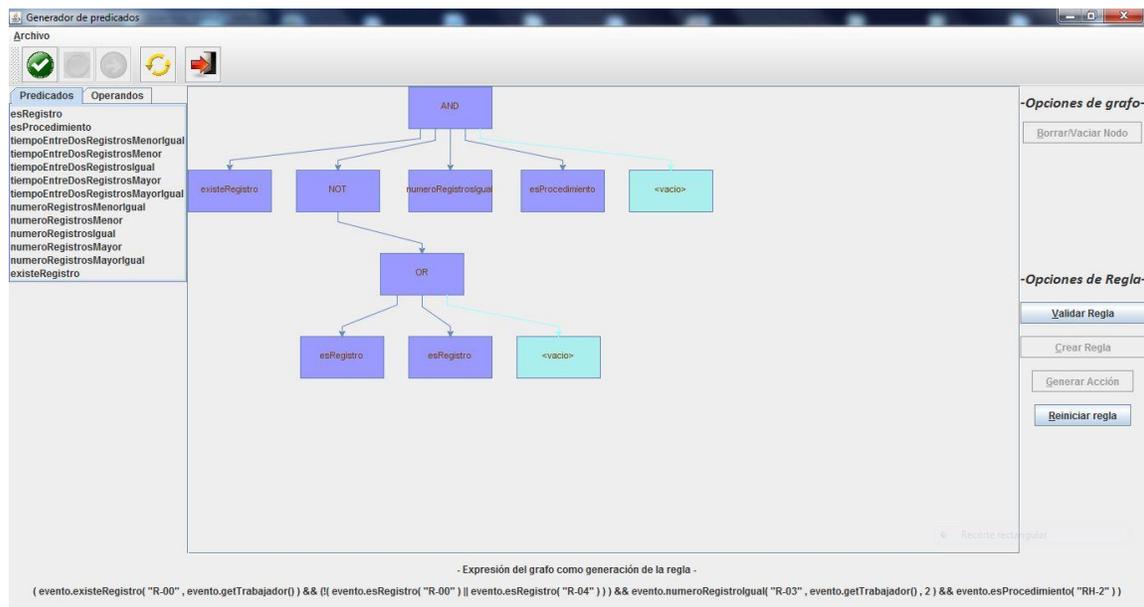
Fig. 4. Rules editor interface

and the logical operators. These options allow the graphical composition of the rules in the central panel with a tree style.

This prototype enables the configuration of the events that fires the rules' evaluation along with the configuration of each predicate and action. It also brings the visualization of the rule list defined for the system. In Fig. 4, the composed rule is being performed at the bottom of the window editor.

VII. CONCLUSIONS

This work proposed a solution to software adaptability reducing the development time with no, or few, technical intervention. A set of automated production rules has been used to achieve software adaptability. Furthermore, a use case that implements this kind of development was used in a real scenario and a prototype developed. It can be said the development time needed to adapt new software solutions to business model is reduced by using the approach presented in this work. Also, this proposal increases the possibilities of domain experts in modeling the most frequent adaptations by using the graphical rules editor developed. As far as the concern of the authors, evaluating the results of this work, rule systems have shown a high suitability for the adaptation of very dynamic systems in reducing the time and cost of putting those systems into exploitation. Furthermore, the rule-based architectural style has been implemented in order achieve systems adaptation to frequent changes with minimal effort.

REFERENCES

[1] M. Fayad and M. P. Cline, "Aspects of software adaptability," Communications of the ACM, vol. 39, no. 10, pp. 58–59, 1996.

[2] R. . Gamble, P. . Stiger, and R. . Plant, "Rule-based systems formalized within a software architectural style," Knowledge-Based Systems, vol. 12, no. 1–2, pp. 13–26, Apr. 1999.

[3] M. Fowler, UML Distilled. Addison-Wesley, 2004, p. 192.

[4] T. Sohn and A. Dey, "iCAP: an informal tool for interactive prototyping of context-aware applications," in Human-Computer Interaction, 2003, vol. 2, pp. 974–975.

[5] Y. Li, J. I. Hong, and J. A. Landay, "Topiary: a tool for prototyping location-enhanced applications," in Proceedings of the 17th annual ACM symposium on User interface software and technology, 2004, vol. 6, no. 2, pp. 217–226.

[6] A. G. Kleppe, J. Warmer, and W. Bast, MDA Explained: The Model Driven Architecture: Practice and Promise. 2003.

[7] Omg, "OMG Model Driven Architecture," Object Management Group, vol. 2009, no. Marh 13th. pp. 1–5, 2009.

[8] S. J. Mellor and M. J. Balcer, Executable UML: A Foundation for Model-Driven Architecture. Addison-Wesley Professional, 2002, p. 416.

[9] J. Huamonte and K. Smith, The use of roles to model agent behaviors for model driven architecture. IEEE, 2005, pp. 594–598.

[10] T. Morgan, Brought to you by Team-Fly Business Rules and Information Systems : Aligning IT with Business Goals. Addison-Wesley Professional, 2002, p. 384.

[11] "Drools Expert," 2013. [Online]. Available: http://www.jboss.org/drools/drools-expert.html. [Accessed: 21-Mar-2013].

[12] B. McBride, Jena: a semantic Web toolkit, vol. 6, no. 6. IEEE Computer Society, 2002, pp. 55–59.

[13] E. F. Hill, Jess in Action: Java Rule-Based Systems. Manning Publications Co., 2003.

[14] D. Selman, "JSR 94: Java Rule Engine API," Java Community Process, 2004. [Online]. Available: http://www.jcp.org/en/jsr/detail?id=94. [Accessed: 13-Apr-2013].

[15] D. Sottara, P. Mello, and M. Proctor, A Configurable Rete-OO Engine for Reasoning with Different Types of Imperfect Information, vol. 22, no. 11. 2010, pp. 1535–1548.

[16] A. K. Dey, R. Hamid, C. Beckmann, I. Li, and D. Hsu, "a CAPpella: programming by demonstration of context-aware applications," Proceedings of the 2004 conference on Human factors in computing systems CHI 04, vol. 6, no. 1, pp. 33–40, 2004.

[17] L. De Russis, F. Corno, and D. Bonino, "A User-Friendly Interface for Rules Composition in Intelligent Environments," in Ambient Intelligence Software and Applications, 2011, vol. 92, pp. 213–217.

[18] R. Hilliard, "IEEE-Std-1471-2000 Recommended Practice for Architectural Description of Software-Intensive Systems," IEEE httpstandards ieee org, no. IEEE-Std-1471–2000, 2000.

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Application of Multiobjective Evolutionary Techniques for Robust Portfolio Optimization

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Abstract — **On December 20 of 2012 Sandra García Rodríguez defended his PhD at Carlos III of Madrid (Spain), called: "Application of Multiobjective Techniques for Robust Portfolio Optimization". This thesis was supervised by Dr. David Quintana Montero and Dr. Inés M. Galván León. The defense was done in a publicly open presentation held at Carlos III University of Madrid. The PhD was approved, with the highest rating** *Cum Laude***, by the examining committee: Dr. José Manuel Molina López, Dr. Antonio Gaspar Lopes da Cunha and Dr. David Camacho Fernández.**

Kewwords — **Financial Robust Portfolio Optimization, Multiobjective Evolutionary Algorithms, Artificial Intelligence.**

I. ABSTRACT

The choice of the right way to distribute investor's wealth among different investment alternatives is one of the basic problems that investors must face. Each of these possible combinations, known as financial portfolios, have some characteristics that make them more or less desirable to the investor depending on his preferences. Therefore, this is the reason why the problem of determining the best proportion of capital to assign to each investment asset, the portfolio optimization, has been one of the core topics in financial management research. Academic literature on this subject is very large and mostly based on the seminal work of H. Markowitz [1], who suggests the evaluation of portfolios by computing their associated return and risk.

Hence, the mentioned problem can be considered as a multiobjective optimization problem where the goal is both maximizing return and minimizing risk of the portfolio at the same time. The opposing nature of these objectives provokes that maximizing one of them increments the other too, and viceversa. Thereby, the solution does not consist of a single asset allocation, but a range of them. These portfolios are the ones with the best risk/return trade-off found and define the Efficient Frontier. Thus, this set will be used by the decision maker to choose the portfolio that suits him better according to his preferences. Moreover, when this problem is studied within the real financial world, some constraints should be considered that cannot be hold by traditional optimization methods. This is the reason why we use evolutionary computation as it provides the flexibility necessary to deal with real-world scenarios.

One of the major reasons why some practitioners mistrust quantitative methods based on modern portfolio theory is the lack of robustness that show their solutions. Unfortunately, these portfolios may be very dependant on the estimates of parameters that are unlikely accurate due to, for instance, the presence of outliers. When it is the case, portfolios may behave in a unexpected way driving to wrong investment decisions.

For this reason, we face the robust portfolio optimization problem using four evolutionary multiobjective algorithms (MOEAs) [2]. Moreover, we study three approaches that, adapted to MOEAs, are able to generate portfolios with more stability than the ones provided by standard versions or the "Random Matrix Approach" (RMA) proposed by Plerou et al [3]. The first one includes an explicit objective to measure robustness. The second technique handles robustness implicitly evaluating risk and return of new portfolios under different parameters each generation [4]. The last one improves the previous approach adding a time-stamping mechanism to encourage stable individuals [5].

Finally, since our aim is to deal with the lack robustness, we suggested five new metrics that were used to evaluate the robustness of results. Their analysis showed that the three designed approaches achieved robustness improvements from the 9% to the 67.5% over the RMA or the bi-objective basic formulation of the problem. All the observed differences within the three core and RMA algorithms were statistically significant at the 1\% conventional level. There was just one exception that was significant at 5\%. Hence, we expect that this increase in reliability will help portfolio managers to feel more confident about automatic methods for portfolio optimization.

REFERENCES

[1] Markowitz, H., 1952. Portfolio selection. The Journal of Finance 7 (1), 77–91.
[2] P. Seoane, M. Gestal and J. Dorado. Approach for solving multimodal problems using Genetic Algorithms with Grouped into Species optimized with Predator – Prey. International Journal of Interactive Multimedia and Artificial Intelligence. 1(5), 6-13, 2012.
[3] V. Plerou, P. Gopikrishnan, B. Rosenow, L.A.N. Amaral, T. Guhr and H.E. Stanley: 2002, A random matrix approach to cross-correlations in nancial data, Quantitative finance papers.
[4] García Sandra, Quintana David, Galván Inés M., and Isasi Pedro. Multiobjective Algorithms with Resampling for Portfolio Optimization. Computing and informatics. In Press, Corrected Proof.

[5] García Sandra, Quintana David, Galván Inés M., and Isasi Pedro. Time-stamped Resampling for Robust Evolutionary Portfolio Optimization. Expert Systems with Applications. 39(12), 10722-10730. 2012.

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Infected Fruit Part Detection using K-Means Clustering Segmentation Technique

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Abstract — **Nowadays, overseas commerce has increased drastically in many countries. Plenty fruits are imported from the other nations such as oranges, apples etc. Manual identification of defected fruit is very time consuming. This work presents a novel defect segmentation of fruits based on color features with K-means clustering unsupervised algorithm. We used color images of fruits for defect segmentation. Defect segmentation is carried out into two stages. At first, the pixels are clustered based on their color and spatial features, where the clustering process is accomplished. Then the clustered blocks are merged to a specific number of regions. Using this two step procedure, it is possible to increase the computational efficiency avoiding feature extraction for every pixel in the image of fruits. Although the color is not commonly used for defect segmentation, it produces a high discriminative power for different regions of image. This approach thus provides a feasible robust solution for defect segmentation of fruits. We have taken apple as a case study and evaluated the proposed approach using defected apples. The experimental results clarify the effectiveness of proposed approach to improve the defect segmentation quality in aspects of precision and computational time. The simulation results reveal that the proposed approach is promising.**

Keywords — **K-Means, Defect Segmentation, Fruit Images, Image Processing.**

I. Introduction

Digital images are one of the most key medium of conveying information. Extracting the information from images and understanding them such that the extracted information can be used for several tasks is an important characteristic of Machine learning. Using images for the navigation of robots is an example of the same. Other applications such as extracting malign tissues from the body scans etc form an integral part of Medical diagnosis. Image segmentation is one of the initial steps in direction of understanding images and then finds the different objects in them.

Modern agricultural science and technology is extreme advance. The value of fruit depends on the quality of fruit. It is an important issue how to assay quality of fruit in agricultural science and technology. The classical approach of fruits quality assessment is done by the experts and it is very time consuming. Defect segmentation of fruits can be seen as an instance of the image segmentation in which we are interested only to the defected portion of the image.

Image segmentation entails the separation or division of the image into areas of similar attributes. In another way, segmentation of the image is nothing but pixel classification. The difficulty to which the image segmentation process is to be carried out mostly depends on the particular problem that is being solved. It is treated as an important operation for meaningful interpretation and analysis of the acquired images. It is one of the most crucial components of image analysis and pattern recognition and still is considered as most challenging tasks for the image processing and image analysis. It has application in several areas like Analysis of Remotely Sensed Image, Medical Science, Traffic System Monitoring, and Fingerprint Recognition and so on.

Image segmentation methods are generally based on one of two fundamental properties of the intensity values of image pixels: similarity and discontinuity. In the first category, the concept is to partition the image into several different regions such that the image pixels belonging to a region are similar according to a set of predefined criteria's. Whereas, in the second category, the concept of partition an image on the basis of abrupt changes in the intensity values is used. Edge detection technique is an example of this category which is similar to the boundary extraction. Researchers have been working on these two approaches for years and have given various methods considering those region based properties in mind. But, still, there is no fixed approach for the image segmentation. Based on the discontinuity or similarity criteria, many segmentation methods have been introduced which can be broadly classified into six categories: (1) Histogram based method, (2) Edge Detection, (3) Neural Network based segmentation methods, (4) Physical Model based approach, (5) Region based methods (Region splitting, Region growing & merging), (6) Clustering (Fuzzy C-means clustering and K-Means clustering).

Histogram based image segmentation techniques are computationally very efficient when compared to other image segmentation techniques because they usually require only a single pass through the image pixels. In this technique, a histogram is calculated from all of the image pixels, and the

peaks and valleys are detected in the histogram. Now the image pixels between two consecutive peaks can be considered to a single cluster. A disadvantage of this method is that it is not able to categorize when the image has no clear gray level histogram peak. Another disadvantage of this method is that the continuity of the segmented image regions cannot be ensured. We should focus on global peaks that are likely to correspond to the dominant image regions for the histogram based segmentation method to be efficient.

The edge detection method is very widely used approaches to the image segmentation problems. It works on the basis of the detection of points considering abrupt changes at gray levels. A disadvantage of the edge detection method is that it does not work well when there are many edges in the image because in that case the segmentation technique produces an over segmented output, and it cannot easily identify a boundary or closed curve. For an edge based segmentation method to be efficient, it should identify the global edges and these edges have to be continuous.

Neural Network based image segmentation relies on processing small regions of an image using a neural network or a set of different artificial neural networks. After this, the decision-making method marks the regions of an image on the basis of the category recognized by the artificial neural network. Kohonen self organizing map is a type of network designed especially for such type of problems.

The physical model based image segmentation technique assumes that for an image, individual regions follow a recurring form of geometrical structure. This type of segmentation methods uses texture feature.

The region based image segmentation method uses the similarity of pixels within a region in an image. Sometimes a hybrid method incorporating the region based and edge based methods have been proved to be very useful for some applications. The seeded region growing method was the first region growing method.

Clustering based image segmentation methods are also used by many researchers [1] [2]. The segmentation method incorporating clustering approaches encounters great difficulties when computing the number of clusters that are present in the feature space or extracting the appropriate feature. This type of image segmentation is widely used due to the simplicity of understanding and more accurate result.

This paper presents an efficient image segmentation approach using K-means clustering technique based on color features from the images. Defect segmentation is carried out into two stages. At first, the pixels are clustered based on their color and spatial features, where the clustering process is accomplished. Then the clustered blocks are merged to a specific number of regions. Using this two step procedure, it is possible to increase the computational efficiency avoiding feature extraction for every pixel in the image of fruits. Although the color is not commonly used for defect segmentation, it produces a high discriminative power for

different regions of the image.

The rest of the paper is organized as follows: Section 2 presents a brief overview of the related work. Section 3 describes the K-means clustering method. In section 4 the proposed method for the defect segmentation of fruits based on color using K-means clustering technique is presented and discussed. Section 5 demonstrates the experimental results obtained with apple as a case study. Finally, section 6 concludes with some final remarks.

II. A BRIEF OVERVIEW OF RELATED WORK

Color image segmentation has been a difficult task for the researchers over the past two decades. It is an essential operation in image processing and in many computer vision, pattern recognition, and image interpretation system, with applications in industrial and scientific field(s) such as Remote Sensing, Microscopy, Medicine, content-based image and video retrieval, industrial automation, document analysis and quality control [3]. The efficiency of color image segmentation may significantly influence the quality of an image understanding system [4]. A detail review on various image segmentation techniques are provided by Pal & Pal [5].

Among myriads of existing segmentation techniques, many have used unsupervised clustering methods. For example, image segmentation on the basis of region merging is analogue of agglomerative clustering [6]. Graph cut methods such as normalized cut and minimal cut characterize the problem of clustering in a graph theoretic way [7]. A major problem for this kind of methods known as the problem of validity is how to decide the number of clusters in any image. Since the problem is basically unresolved, most techniques need that the user should provide a terminating criterion.

Soft computing techniques have been used for segmenting color image by Sowmya and Sheelarani [8]. The soft computing techniques they used were competitive neural network and Possibilistic C means algorithm (PCM). Researchers also used Fuzzy set and Fussy logic techniques for solving segmentation problem. Borji et al. presented CLPSO-based Fuzzy color image segmentation [9]. Cheng et al. used Fuzzy homogeneity approach for the segmentation of color image [10]. Besides this, Genetic algorithm (GA) and artificial neural network (ANN) techniques also have been used for the image segmentation [11].

There are various segmentation techniques in medical imaging problems depending on the region of interest in the image. There are region growing segmentation methods and atlas-guided techniques. Some of them use a semi-automatic method and still need some operator relations. Other techniques use fully automatic methods and the operator has just a verification role.

Automatic image segmentation by integrating seeded region growing and color edge detection was proposed by Fan et al. [12]. They have used fast Entropy thresholding for the extraction of edges. After they have obtained color edges that

provided the foremost geometric structures in an image, then they have determined the centroids between these adjacent regions and considered it as the initial seeds. These seeds were then replaced by centroids of the generated homogeneous edge regions by incorporating the additional pixels step by step.

Another method using seeded region growing was proposed by Adams and Bischof [13]. Shih and Cheng proposed another image segmentation method using regions in the image [14] where based on the standard deviation in a neighbor, initial seeds are selected. This method assigns each pixel in that region as seeds after checking whether the value is under a threshold. They have applied region growing and region merging techniques after the selection of seeds. As discussed above color image segmentation has been widely used by the researchers.

Authors in [17], [18] have used the concept of k-means clustering for background subtraction. They segmented the region of interest (i.e. foreground) with the background by making two clusters one for foreground and one for background. In the case of fruit diseases more than one disease may be present at a time so we have to use more than two clusters to segment the infected part with fruit and background.

III. K-MEANS CLUSTERING ALGORITM

The food image processing using clustering is an efficient method. Clustering technique classifies the objects into different groups, or more specifically, partitioning of a data set into clusters (subsets), so that the data in each cluster (ideally) shares some common trait - often according to some defined distance measurement. Data partitioning is a usual technique for the analysis of statistical data, which is used in many areas, including machine learning, image analysis, pattern recognition, bioinformatics and data mining. The computational task of partitioning the data set into k subsets is often referred to unsupervised learning.

There are many approaches of clustering designed for a wide variety of purposes. K-means is a typical clustering algorithm (MacQueen, 1967) [15]. K-means is generally used to determine the natural groupings of pixels present in an image. It is attractive in practice, because it is straightforward and it is generally very fast. It partitions the input dataset into k clusters. Each cluster is represented by an adaptively changing center (also called cluster center), starting from some initial values named seed-points. K-means clustering computes the distances between the inputs (also called input data points) and centers, and assigns inputs to the nearest center.

K-means method is an unsupervised clustering method that classifies the input data objects into multiple classes on the basis of their inherent distance from each other [16]. Clustering algorithm assumes that a vector space is formed from the data features and tries to identify natural clustering in

them. The objects are clustered around the centroids $\mu i \forall i = 1 . . . k$ which are computed by minimizing the following objective

$$V = \sum_{i=1}^{k} \sum_{x_j \in S_i} (x_j - \mu_i)^2 \qquad (1)$$

Where k is the number of clusters i.e. Si, $i = 1, 2, \ldots, k$ and μ_i is the mean point or centroid of all the points $x_j \in S_i$.

As a part of this work, we implemented an iterative version of K-means algorithm. The algorithm requires a color image as input. The algorithm of K-means clustering is as follows

Step 1   Compute the distribution of the intensity values.

Step 2   Using k random intensities initialize the centroids.

Step 3   Repeat the step 4 and step 5 until the labels of the cluster do not change any more.

Step 4   Cluster the image points based on the distance of their intensity values from the centroid intensity values.

$$c^{(i)} := \arg \min_j \left\| x^{(i)} - \mu_j \right\|^2 \qquad (2)$$

Step 5   Compute new centroid for each cluster.

$$\mu_i := \frac{\sum_{i=1}^{m} 1\{c_{(i)} = j\} x^{(i)}}{\sum_{i=1}^{m} 1\{c_{(i)} = j\}} \qquad (3)$$

Where k is the number of clusters, i iterates over all the intensity values, j iterates over all the centroids (for each cluster) and μ_i are the centroid intensities.

IV. DEFECT SEGMENTATION

Image segmentation using k-means algorithm is quite useful for the image analysis. An important goal of image segmentation is to separate the object and background clear regardless the image has blur boundary. Defect segmentation of fruits can be seen as an instance of image segmentation in which number of segmentation is not clearly known. Figure 1 shows the framework for the fruits defect segmentation.

The basic aim of the proposed approach is to segment colors automatically using the K-means clustering technique and L*a*b* color space. The introduced framework of defect segmentation operates in six steps as follows

Step 1.   Read the input image of defected fruits.

Step 2.   Transform Image from RGB to L*a*b* Color Space. We have used L*a*b* color space because it consists of a luminosity layer in 'L*' channel and two chromaticity layer in 'a*' and 'b*' channels. Using L*a*b* color space is computationally efficient because all of the color information is present in the 'a*' and 'b*' layers only.

Step 3. Classify Colors using K-Means Clustering in 'a*b*' Space. To measure the difference between two colors, Euclidean distance metric is used.

Step 4. Label Each Pixel in the Image from the Results of K-Means. For every pixel in our input, K-means computes an index corresponding to a cluster. Every pixel of the image will be labeled with its cluster index.

Step 5. Generate Images that Segment the Input Image by Color. We have to separate the pixels in image by color using pixel labels, which will result different images based on the number of clusters.

Programmatically determine the index of each cluster containing the defected part of the fruit because K-means does not return the same cluster index value every time. But we can do this using the center value of clusters, which contains the mean value of 'a*' and 'b*' for each cluster.

Defected Fruit Image

↓

Transform Image from RGB to L*a*b* Color Space

↓

Classify Colors using K-Means Clustering in 'a*b*' Space

↓

Label Each Pixel in the Image from the Results of K-Means

↓

Generate Images that Segment the Input Image by Color

↓

Determine the defected cluster
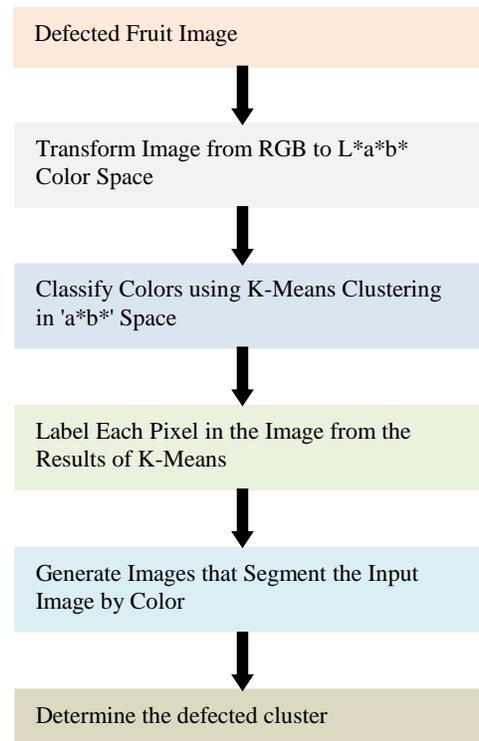
Fig. 1. Fruits defect segmentation.

(a)

(b)

(c)
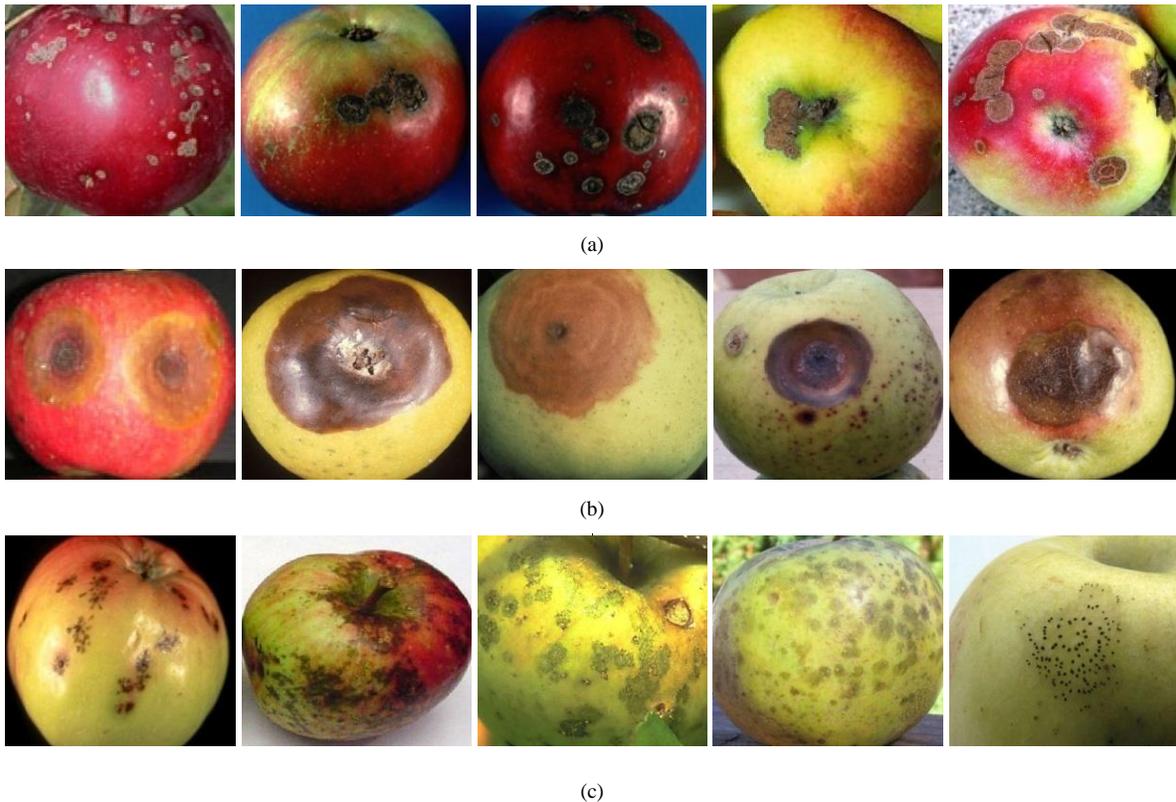
Fig. 2. Sample images from the data set infected with (a) apple scab, (b) apple rot, and (c) apple blotch diseases.
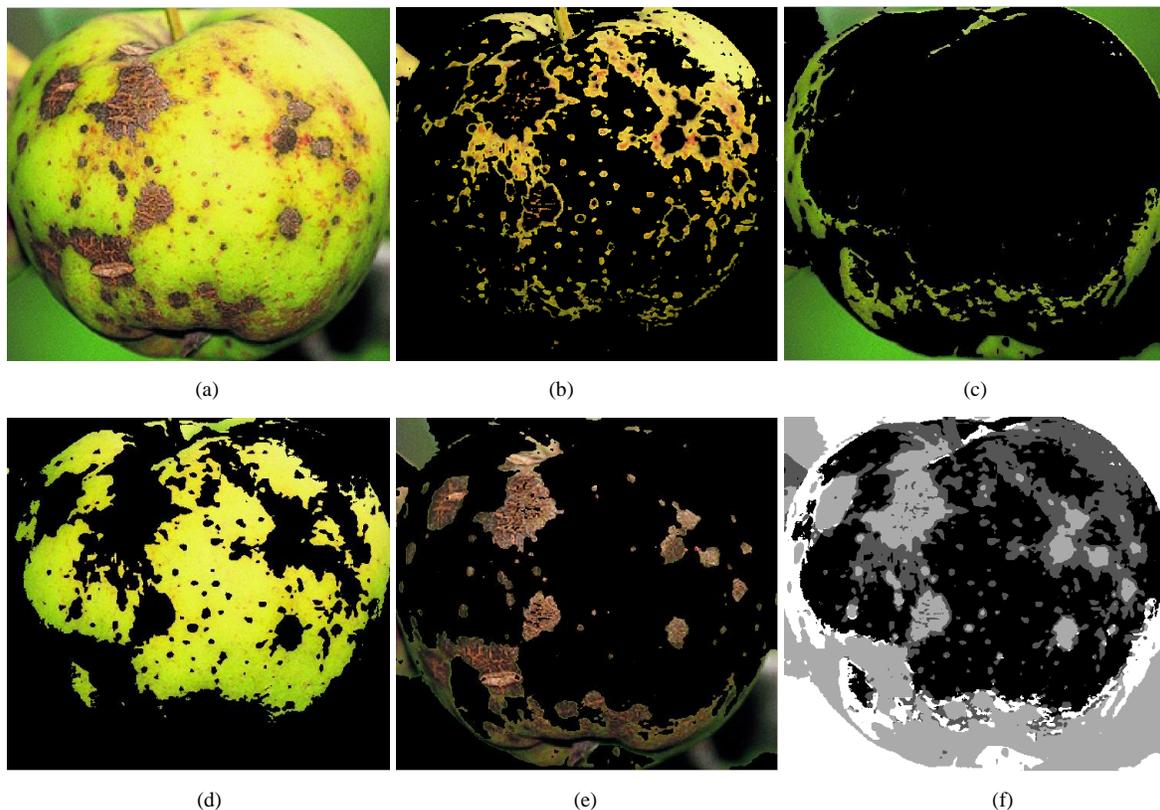
Fig. 3. K-Means clustering for an apple fruit that is infected with apple scab disease with four clusters (a) The infected fruit image, (b) first cluster, (c) second cluster, (d) third cluster, and (e) fourth cluster, respectively, (f) single gray-scale image colored based on their cluster index.

V. EXPERIMENTAL RESULT

To demonstrate the performance of the proposed approach, we have taken apples as a case study. The introduced method is evaluated on the defected apples. We have taken some of the diseases of the apples such as apple scab, apple rot and apple blotch for the defect segmentation. Figure 2 shows some images of the data set infected with various diseases. Presence of a lot of variations in the data set makes it more realistic.

Figure 3 shows the defect segmentation result of an apple fruit infected with the apple scab disease using K-means clustering technique. We have segmented the input image into four clusters in Figure 3 and it is clear that fourth cluster correctly segment the defected portion of the image. From the empirical observations it is found that using 3 or 4 clusters yields good segmentation results. So, in this experiment input images are partitioned into three or four segments as per requirement.

(a)

(b)

(c)

(d)

Fig. 4. Defect detection results when number of cluster is set to (a) 2, (b) 3, (c) 4, and (d) 5 respectively.
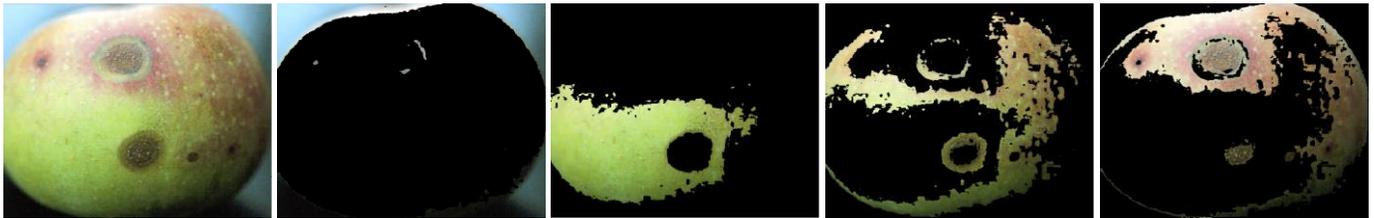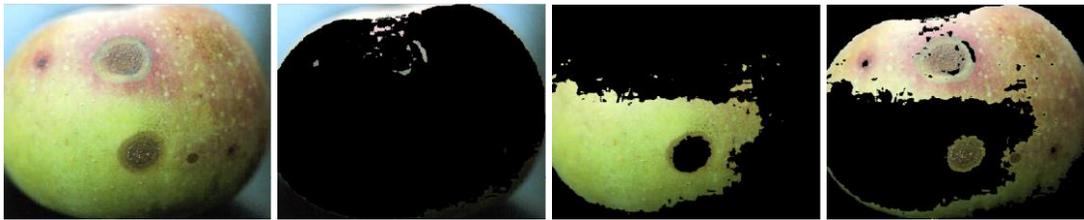
Fig. 5. Comparison of result while using 3 and 4 number of clusters.

Figure 4 shows the detection result on an image infected with apple rot while considering different number of clusters for K-Mean clustering. When number of cluster is set to 2, one cluster contains fruit part while other one contains defected part and background. But if we increase the number of cluster to 3, then defected part is separated with background. If we further increase number of clusters to 4 and 5, then we are not able to segment all defected portion in a single cluster (i.e. single segment) as shown in figure 4. But, in some cases using 3 clusters is not sufficient such as in the example taken in figure 5. In this figure, we have considered an image of apple infected with apple scab.

In figure 5, segmentation result is better for 4 clusters than 3 clusters because the area of infected portion in apple scab is less than the apple rot and the color of infected part is quite similar to the color of fruit part. Only 3 clusters is sufficient in the case of figure 4 because it is infected with apple rot which have generally larger area of infected portion. So, we can say that if defected area is larger, fewer clusters will be required while if defected area is smaller more clusters will be needed. It means number of clusters required for the defect detection from the infected image is invertionally proportion to the defected area.

Figure 6 shows the results of defect segmentation of two defected apple fruits using K-means clustering method with only three clusters. Whereas, in Figure 3, we have used four clusters because using three clusters was not sufficient in that case due to the natural variability of skin color in the input apple fruit image. In the first case of Figure 7, there is the presence of the stem/calyx in the input image of defected apple, and using only three clusters our proposed approach are able to segment the defected portion with the stem/calyx of the image. Figure 7 shows more segmentation results using proposed approach of defect segmentation of fruits using K-means clustering technique. The experimental results suggest that the introduced method for defect segmentation in this paper is robust because it can accurately segment the defected part with the fruit region, background and stem/calyx.

(a)   (b)   (c)   (d)
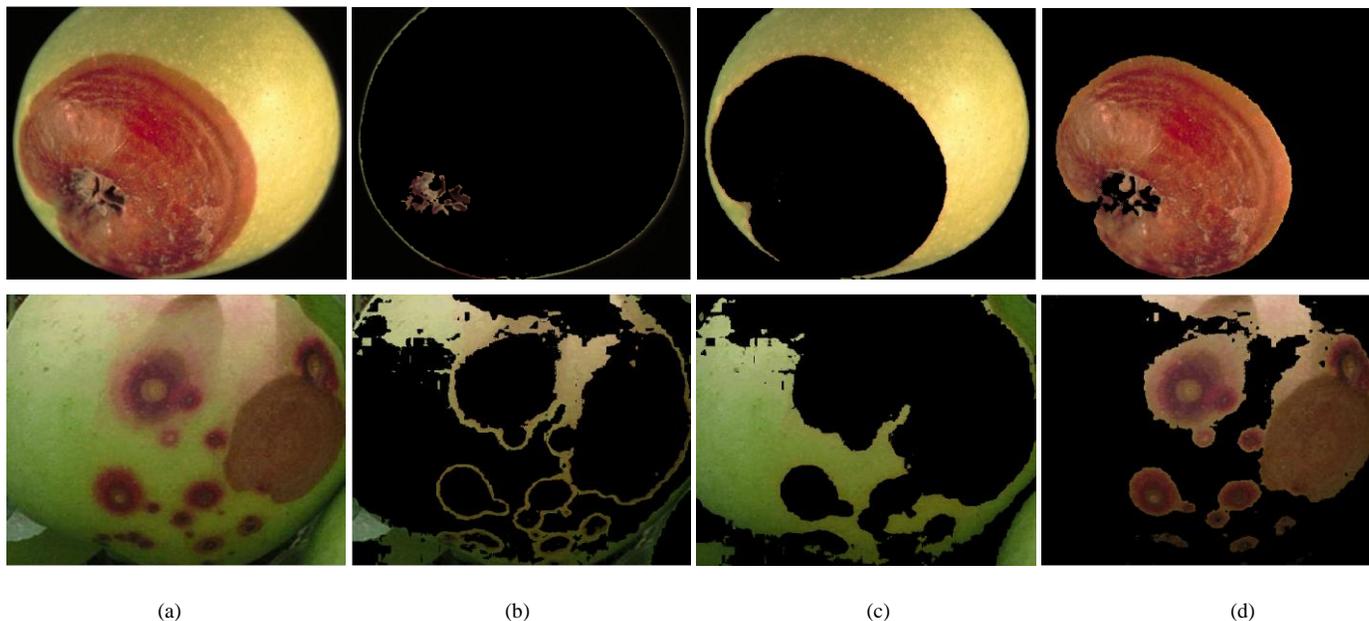
Fig. 6. K-Means clustering for defected apples with three clusters (a) The infected fruit images, (b) first cluster, (c) second cluster, and (d) third cluster

(a)

(b)
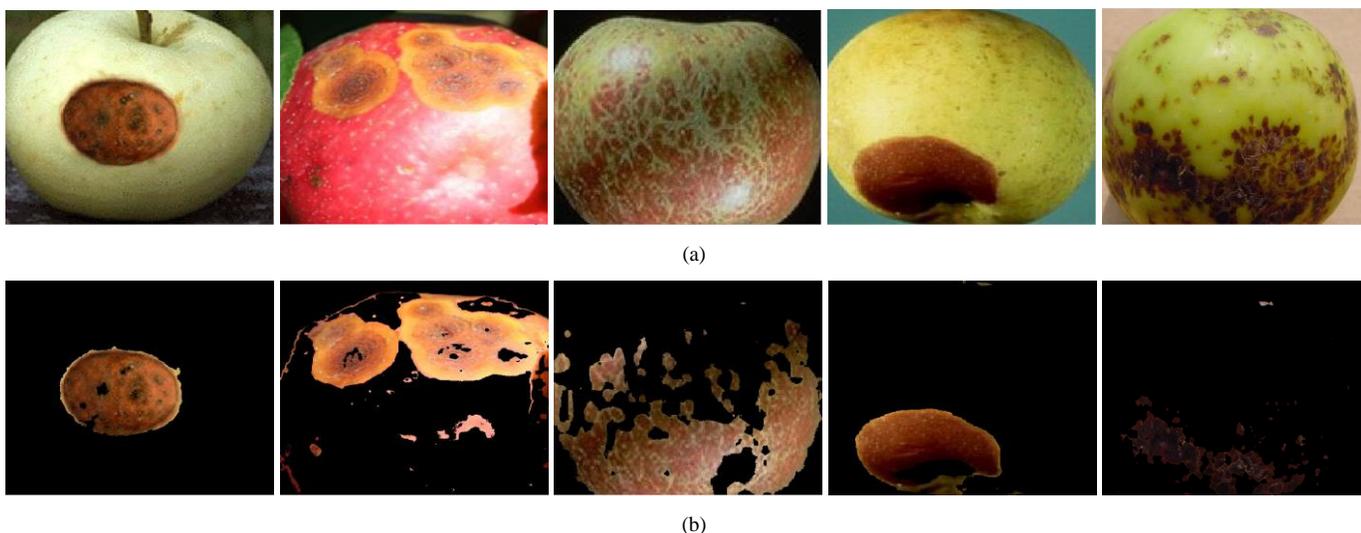
Fig. 7. Defect segmentation results of apples (a) Images before segmentation, (b) Images after segmentation.

accurately.

VI. CONCLUSION

A framework for the defect segmentation of fruits using images is proposed and evaluated in this paper. The proposed approach used K-means clustering technique for segmenting defects with three or four clusters. We have used defected apples for the experimental observations and evaluated the introduced method considering apples as a case study. Experimental results suggest that the proposed approach is able to accurately segment the defected area of fruits present in the image. K-means based defect segmentation approach is also segment defected area with the stem and calyx of the fruits. The future work includes automatic determination of number of clusters required to segment the defects more

REFERENCES

[1] Y. Li and Y. Shen, "Robust image segmentation algorithm using fuzzy clustering based on kernel-induced distance measure," in *Proceedings of the International Conference on Computer Science and Software Engineering*, 2008, vol. 1, pp. 1065-1068.

[2] D. E. Ilea and P. F. Whelan, "Color image segmentation using a spatial k-means clustering algorithm," in . *Proceedings of the Irish Machine Vision & Image Processing Conference 2006 (IMVIP 2006),* Dublin City University, 2006, pp. 146–53.

[3] R. D. Silva, R. Minetto, W. R. Schwartz, and H. Pedrini, "Satellite image segmentation using wavelet transforms based on color and texture features," in *Proceedings of the 4th International Symposium on Advances in Visual Computing*, Part II, 2008, pp. 113-122.

[4] H. C. Chen and S. J. Wang, "Visible color difference-based quantitative evaluation of colour segmentation," in *Proceedings of the IEEE*

Conference on Vision Image and Signal processing, 2006, vol. 153, no. 5, pp. 598-609.

[5] N. R. Pal and S. K. Pal, "A review on image segmentation techniques," *Pattern Recognition*, vol. 26, no. 9, pp. 1227-1294, 1993.

[6] H. Frigui and R. Krishnapuram, "Clustering by competitive agglomeration," *Pattern Recognition*, vol. 30, no. 7, pp. 1109-1119, 1997.

[7] Y. Boykov, "Graph cuts and efficient N-D image segmentation," *International Journal of Computer Vision* (IJCV), vol. 70, no. 2. pp. 109–131, 2006.

[8] B. Sowmya and B. Sheelarani, "Colour image segmentation using soft computing techniques," *International Journal of Soft Computing Applications*, vol. 4, pp. 69-80, 2009.

[9] A. Borji, M. Hamidi, and A. M. E. Moghadam, "CLPSO-based fuzzy color image segmentation," in *Proceedings of the North American Fuzzy Information Processing Society*, 2007, pp. 508-513.

[10] H. D. Cheng, C. H. Chen, H. H. Chiu, and H. Xu, "Fuzzy homogeneity approach to multilevel thresholding," *IEEE Transactions On Image Processing* (TIP), vol. 7, no. 7, pp. 1084-1086, 1998.

[11] P. M. Birgani, M. Ashtiyani, and S. Asadi, "MRI segmentation using fuzzy c-means clustering algorithm basis neural network," in *Proceedings of the 3rd International Conference on Information and Communication Technologies: From Theory to Applications*, 2008, pp. 1-5.

[12] J. F. David, K. Y. Yau, and A. K. Elmagarmid, "Automatic image segmentation by integrating color-edge extraction and seeded region growing," *IEEE Transactions On Image Processing* (TIP), vol. 10, no. 10, pp. 1454-1466, 2001.

[13] R. Adams and L. Bischof, "Seeded region growing," *IEEE Transaction on pattern analysis and machine intelligence* (PAMI), vo1. 6, no. 6, pp. 641-647, 1994.

[14] F. Y. Shih and S Cheng, "Automatic seeded region growing for color image segmentation," *Image and Vision Computing* (IVC), vol. 23, no. 10, pp. 877-886, 2005.

[15] J. B. MacQueen, "Some methods for classification and analysis of multivariate observations," in *Proceedings of the 5th Berkeley Symposium on Mathematical Statistics and Probability*, Berkeley, University of California Press, 1967, pp. 281-297.

[16] T. Kanungo, D. M. Mount, N. Netanyahu, C. Piatko, R. Silverman, and A. Y. Wu, "An efficient k-means clustering algorithm: Analysis and implementation," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition* (CVPR), 2002, pp. 881-892.

[17] S. R. Dubey and A. S. Jalal, "Robust Approach for Fruit and Vegetable Classification", *Procedia Engineering*, vol. 38, pp. 3449 – 3453, 2012.

[18] S. R. Dubey and A. S. Jalal, "Species and Variety Detection of Fruits and Vegetables from Images", *International Journal of Applied Pattern Recognition* (IJAPR), vol. 1, no. 1, pp. 108 – 126, 2013.

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Legal Issues Concerning P2P Exchange of Educational Materials and Their Impact on E-Learning Multi-Agent Systems

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Abstract — **The last years have known an impressive change in the use of technologies for the sharing and dissemination of knowledge, thus affecting deeply all the traditional means used by education in all its shapes and levels. This transformation has not been fully understood by the society at large for its immense impacts and its short life. This paper describes in the question emerging from the clash of the rights to education in a wide sense and the rights derived from authorship and how that issue is affecting the design of e-learning multi-agent tools.**

Keywords — **Education, Law, Multi-agent Systems for eLearning, Intelligent Knowledge Sharing**

I. INTRODUCTION

In the last years we have fully entered in a social environment generally known as Information and Knowledge Society (IKS), which is essentially characterized in that it is a society that is largely driven by technology and technological advances that occur almost daily.

This new society which we refer to has received over recent years different names such as Cibersociety or Networked Society [5], but it is from a legal point of view that a greater uniformity has been achieved in the sense that both the different agencies of the European Union and those of Spain have preferred to use a broader concept such as the Information Society when legislating, which leads to the concept mentioned above of the Information and Knowledge Society, taking into account what Professor Davara [3] affirms, that information is an element that gives great power to its owners already from the beginning of time, emerging therefore a class of people: the owners of information.

It's not enough to own pieces of information, it is mandatory to know how to look for it and how to handle it, it becoming stronger who knows better how to handle with it, it being an asset which does not get exhausted with their consumption but it is enriched instead by its being used. This allows that its expansion is taking place with the creation of more information by means of the development of telecommunication systems.

This concept of information should be put in touch with another concept that has been widely used in recent years under the context of the Information Society, such as it is that of Knowledge, because the latter is no more than stored information, which is preserved and treated by its recipients the same, i.e. the people.

The study of this IKS begun already in the late nineteen-sixties and early 70's by various thinkers. Those studies were consolidated in the two decades following the 80 and 90, in which a key event took place in the development IKS too, such as the emergence of the PC. In recent years of present decade, the expansion of the IKS has been so voracious by means of the monstrous development of computer technology that have led the personal, social, economic and cultural relationships to be influenced to a greater or lesser extent by such information technologies or information technologies.

No field of knowledge, from economics to law, have been untouched by this technology boom, including of course the field of Education, whose study we will address here, although we will be analyzing in it from a legal point of view the impact that it is produced by the emergence of different technologies. All this has given rise to what some authors have called Information Processing and Digital Competence, that is, the skills that a student should have acquired by the end of their educational years and which involves being more than a simple user of ICT. It involves being an autonomous, efficient, responsible, critical and reflective person at the time of processing, selecting, and using the information, its sources and its supporting media [7].

Teaching is no longer just a platform through which the teacher discloses his knowledge using lectures as it was the case until recently. It has become an area in which both the teacher and the student form an inseparable element, through which they are jointly engaged in the task of teaching and learning both connected via ICT, whose mastering brings about the possibility of using them as a tool for searching, processing, communication ... in short, as a basic tool for knowledge acquisition. This is how the concept of digital natives emerges, as persons who are characterized by the following [4]:

They receive information quickly
They like to work in parallel and multitasking
They prefer images to text
They prefer random access

They work best when they work in a network
They thrive on instant gratification and frequent rewards
They prefer to play games than to work seriously

At this point we must highlight a key element for the development of digital natives, that is, the emergence, consolidation and development of Internet usage (essential piece of the new Information Society), which has caused a transformation unimaginable a few years ago in the customs of students in their academic habits. The digital text analysis, the search of online resources or the monitoring of teaching through virtual campuses have become hallmarks of our society that has led us in many cases to a delocalization of the University, the student has access to it at any time and from any place she wishes to.

Apparently the new digital world in which we live offers many advantages in education, and certainly so, but we should not forget to keep in mind that misused technology can cause major problems especially in regard to the effects that it may have in the fundamental rights of the people.

An instrument that offers many possibilities is file sharing networks. These networks allow users to exchange information and documentation so that they disseminate what we have previously called Knowledge. It seems clear that from an educational point of view we may encounter tools that have immense potential. The problem arises at the moment that technology allows us to perform (via these networks) file sharing (e.g. textbooks or reference books) that are protected by intellectual property rights. At this point we should question if these networks are a valid tool in education since access to culture is above the right of the author, or if on the contrary we should curtail the use of them (in the case we just find the a mechanism to do so).

But what are these file sharing networks?

At the end of the decade of the 90s emerged the so-called peer to peer (P2P) or networks among friends or individuals. It is a network that allows the exchange of information among peers which has had an extraordinary boom with the advent of the Internet and that is closely linked with the MP3 format. The MP3 is simply a format for data compression, a standard developed by the Fraunhofer Institute in 1987, with which you get that a minute of music with quality similar to an audio CD occupies only a megabyte, reducing its size by about 12 times [8].

At present P2P networks operate as a decentralized network that has neither fixed clients nor servers, but it has a number of nodes that behave simultaneously as both clients and servers of the other nodes in the network. The emergence of these networks has been opposed not only by the authors of these works and holders of intellectual property rights, but also of the Managing Entities of Intellectual Property Rights, which argue the great losses suffered by the industry as a result of these actions. In contrast to the detractors of the use of these

networks is an important part of Internet users who postulate the law as fundamental argument that everybody should have free access to culture and knowledge, and the necessary adaptation of the legal rules to the new possibilities offered by technology.

One of the first cases of P2P was Napster. It was a file download program created by Shawn Fanning, a student of Computer Science in 1999. Its main problem was that it had a centralized directory from which could be known both existing files on the computers of users and the members that were online. A user accessed the directory, and if the requested file was there and the user who had it was connected, the download proceeded. The existence of this directory or central server provided the basis for considering that it was breaking the rules on copyright, and in July 2001 a U.S. judge ordered the closure of Napster servers. If Napster was closed primarily by the existence of a central server, the goal was clear: to provide the same service as Napster through a decentralized network. Thus numerous programs were created that managed to achieve this purpose: KaZaA, eDonkey, Morpheus, eMule, etc. [1]. They obviously omitted to use a central server and all computers connected to the system functioned simultaneously as both clients and servers, that way as new users download the software, the network grows exponentially.

The emergence of these networks allows the enjoyment of music or books for free (although they have many more utilities such as sharing and file search, internet telephony systems, scientific computing to process large databases, etc..) , and it has been opposed not only by the authors of these works and holders of intellectual property rights on them, who have seen it as an element giving away the result of their work for free in breach of current legislation intellectual property, but also of the Managing Entities of intellectual property Rights, which argued the heavy losses suffered by the sector as a result of these actions, and that has made recently in the month of May 2009 that a class action from several management institutions against Pablo Soto Bravo was filed in Spain as the creator of a number of P2P programs (Blubster, Piolet and Manolito [6]) on the grounds that it violates the rules of intellectual property and claiming a significant compensation for damages. Without delving further into this matter, it should be noted that one thing is that the file download behavior may constitute a crime, and another one is that the software that allows such activity must be given the same consideration, which in principle is difficult to share with the claimants of the aforementioned process.

The 'case Soto' started in June 2008 when, for civil proceedings, the recording industry, represented by Promusicae, Warner, Universal, EMI and Sony sued the software developer of Pablo Soto for 13 million euro in damages, for they considered that his programs Blubster, Piolet and ManolitoP2P were developed under the MP2P protocol, and that they were intended for illegal sharing of copyrighted music between individuals. Recently, the final decision in this case acquitted Pablo Soto considering that no

offense was committed.

II. SANCTIONABLE BEHAVIORS?

We have certainly made ourselves this question more than once, when we download a book for following a study subject or simply a reference book. Of course if we make the download paying the amounts that we are required, this download will be perfectly legal, but if we do it through a file sharing network which I accessed through a links page to? Do I commit any offense? What can happen to me? And what about the administrator of website who hosts the links page?

The answer to be given is that nothing can happen to us, or at least that was the situation we were before the famous so-called Sinde Law. And I say nothing on the grounds that I shall try to summarize below.

In the Spanish legal system the possibilities for action against the user or against the administrator of the site is focused on two areas, criminal matters (for the commission of a crime) or civil (for the infringement of a right arising damages, in this case the author's rights).

III. THE CRIMINAL SCOPE

In criminal cases the starting point is the first paragraph of Article 270 of the penal code, which states: "It shall be punished with imprisonment from six months to two years and a fine of 12 to 24 months who, for financial gain and to the detriment of third, reproduce, plagiarize, distribute or communicate publicly, in whole or in part, a literary, artistic or scientific work or processing, interpretation or performance fixed in any medium or communicated by any means without the consent of the holders of the relevant intellectual property rights or assigns."

The debate in this area focuses on the existence of profit in file downloading behavior, because if it did not exist, such conduct hardly could be criminalized.

It seems clear that when a person downloads a book through a P2P network, he gets something that somehow could match that profit, because of the fact that it saves the money it would cost that product on the market. Traditionally the doctrine and the courts have been considering that profit amounts to obtaining any benefit, advantage or utility2 as a result of an activity, so that the mentioned savings could be considered comparable to profit. However, this concept of profit has been developed mainly in the field of criminal offenses against property (robbery, theft, fraud, misappropriation ...) in which it is easier to appreciate and value the gain, and it should not be applicable to those behaviors in which the new tools offered by technology play a key role.

In short, the application of Article 270 of the penal code to the conduct described in the absence of profit would be at least against two basic principles that should govern international penal matters, on one hand the principle of minimum intervention of the criminal law according to which latter should act only in cases of extraordinary gravity and where imposed sanctions are the most severe, and on the other hand the principle of proportionality, clearly perverted if we consider the different sanction which involves a minor theft of a music CD in front of downloading that CD through the mentioned networks (imprisonment under Article 270 of the Spanish penal Code). This position has been followed also by Spanish courts, which have chosen not to include these offenses in Article 270 in the absence of the subjective element of profit. Thus, the Court of Cantabria3 on appeal and, in a supposed Internet download of exact copies of music albums, has held that the defendant's conduct is atypical and therefore not criminally punishable when it had not been proved that he acted with trading profit because he did not collect nor was enriched beyond his personal savings.

The Court of Cantabria takes upon itself a concept of commercial profit that had been used two years ago by the Attorney General's Office's Circular 1/2006, understanding it as a form of profit and thus giving rise to an interpretation of profit in strict sense. In this sense, the memo cited is very enlightening to note that the alleged violation of rights should be relegated to the realm of civil violations in which the purpose of obtaining some advantage or benefit other than commercial may be implicit.

At the same time we must keep in mind that if we access the file sharing network through a page of links, the links page itself is not committing any criminal offence it does not perform the objective behaviour that describes the aforementioned Article 270 since they do not distribute or reproduce or publicly communicate the files, simply because they do not have them. What it does is to allow us to access the network exchange from which in turn we access the files, this conduct does not constitute a crime in our penal code. The Spanish courts have stated so in various resolutions, as it could be illustrated in the Order of July 2, 2009 the Commerce Court of Barcelona and the Order of November 13, 2009 of the Commerce Court of Huelva.

IV. THE CIVIL SCOPE

Having abandoned the criminal procedure it should be considered the possibility of acting in civil proceedings against the users of these networks as a result of the infringement of copyright and therefore in their case demanding compensation for damages.

Within the general rights that are recognized to the authors and leaving aside moral rights (for its unalienable4 nature), it is important to emphasize that among the exploitation rights is fundamentally one which can be inflicted by users of these networks, such as the right of reproduction and also as the case that of public communication.

The regulation of the reproduction right is located in Article 18 of the Spanish TRLPI which qualifies it as "direct or indirect, temporary or permanent fixation by any means and in

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2 Judgment of the Supreme Court of Spain of March 25, 2004.

3 Judgment of the Court of Cantabria of February 18, 2008.

any form of the whole work or part thereof, which makes possible its communication or the production of copies."

In relation to the injury of this right of reproduction whose ownership belongs to the author, there seems no doubt as to those websites that facilitate the direct download of books. Certainly there would be major problems with the downloading activity performed by users of P2P networks, basically for two reasons, firstly the difficulties regarding their identification and secondly the possible inclusion of the downloading activity in any of limiting or exception assumptions collected by the Spanish Law of Intellectual Property.

The first proposed assumption, such as the downloading of files directly through a web, was treated by the Barcelona Provincial Court in its judgment of September 29, 2006, which condemned to compensation for damages to the owner of www.redmp3.com and www.servidormp3.com websites for infringement of intellectual property rights by carrying out acts of reproduction and making works available without permission, that judgment stating that reproducing a work is " incorporating and attaching it into a physical hardware that enables communication and production of copies of all or part of the work." "que queda incluido en el concepto de reproducción la carga y almacenamiento de material digitalizado en la memoria muerta de un ordenador u otro sistema o aparato electrónico que lo retenga de modo estable; de modo que cuando se digitaliza una obra y se fija en un medio que permita su comunicación y la obtención de copias, se ejecuta un acto de reproducción5". Thus, based on Article 9.1 of the Berne Convention which refers that the playback can be performed under any procedure or any form, the abovementioned judgment concludes "that it is included in the concept of reproduction the download and storing of digitized material in the ROM of a computer or other electronic device system which stably holds it, so that when a work is digitalized and fixed in a medium that makes possible its communication and the obtaining of copies, it occurs an act of playback6 ".

In relation to the second mentioned case, the identification of users, it is necessary to know who are the people doing the aforementioned downloads, or in this case the holders of the IP addresses from which such downloads are made, so as to direct against them the corresponding actions. This work of identification encounters many obstacles, mainly derivatives of the right to secrecy of communications and the right to

privacy, regulated both in almost all modern constitutional texts, where constant reference is made to the necessary judicial intervention required to act against this right, a judicial intervention which does not occur because the absence of crime (as we saw in the previous section). The judges put before the right to privacy of the user against the prejudice caused to the author

Whereupon and in short, we face a situation in which the performance of file download of books or music through a file-sharing network does not constitute a criminal offence, and therefore the courts do not allow to take action against users based on their right to privacy (thus excluding them also against civil proceedings). But common sense seems to indicate that this reproduction activity injures or impairs the right of someone (the author) who should somehow be protected.

V. THE SINDE LAW

In the area of the European Union it has been sought to advance in this matter through the creation of new laws, and in this regard a French Law was approved in May, known as Hadopi law, which permits to disconnect from the Internet those users who persist in downloading files after being warned twice through an ad hoc set up body such as the High Authority for the Dissemination of Works and Protection of Rights on the Internet. Contested this law before the French Advisory Council (a body similar to our Constitutional Court), this one has shown to be contrary to it by saying that if it is true that a sanction should be imposed if the existence of illegal downloads is discovered (which seems logical and which is covered by this Council by means of limiting thus the right to privacy of the users), also points out that this High Authority is not competent to impose the penalty, since only a judge may order the cut of the connection to potential offenders.

In similar terms the European Parliament has recently manifested in a report on September 2011, but later and surprisingly on November 5 of that year it changed its position authorizing such disconnections without prior judicial authorization while referring to some concepts that we believe will lead us in any case to the necessary involvement of a judge. The European Parliament states that in order to avoid abuses in the restrictions, they "may only be imposed if they are appropriate, proportionate and necessary for a democratic society," then stating that "we must respect the presumption of innocence and the right to privacy".

In the Spanish case and given the impossibility to act against users, there has been raised in our legal system the possibility of closing the pages of links that provide access to exchange networks for the users. In order to achieve this aim, the so-called Sinde Law have been developed, changing through the Draft Law on Sustainable Economy the Services Information Society and Electronic Commerce Act in its Article 8, establishing the possibility of closing by an organ belonging to

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4 Article 14 of the Spanish Law of Intellectual Property 1996.

5 The above considerations led to the conclusion that the defendant has committed an act of reproduction invading the sphere of the author in accordance with the provisions of articles 17 et seq. of Intellectual Property Law, Article 11 of the WIPO Treaty on December 20, 1996 and Article 2 of Directive 2001/29/EC on the harmonization of certain aspects of copyright, thus corresponding compensation of damages.

6 The above considerations led to the conclusion that the defendant has committed an act of reproduction invading the sphere of the author in accordance with the provisions of articles 17 et seq. of Intellectual Property Law, Article 11 of the WIPO Treaty on December 20, 1996 and Article 2 of Directive 2001/29/EC on the harmonization of certain aspects of copyright, thus corresponding compensation of damages.

the Ministry of Culture those websites that violate intellectual property rights as set out in point 4.4 of the First Final Provision of the said Draft.

This law has been developed through the RD 1898/2011 of 30 December. It has been a very controversial and widely criticized regulation by users the Internet.

Without wishing to dwell on the specific rules governing this regulation, we believe that the main problem that frames the norm is the attribution to an administrative body such as the 2nd Section of the Copyright Commission to decide whether there has been or not a breach of the copyright. This brings us to cases in which a judge has considered that there is no offence in a specific conduct, while this Commission believes otherwise.

After the appearance of the first voices against this lack of legal certainty, there was given a new formulation to the regulation itself now introducing the necessary judicial intervention in two moments. Firstly to ask the intermediary service provider to identify the owner of the links service provider, if not known, and secondly to allow or not the measure of closing the links page which has been taken by the Commission. It is the second case which continues to pose the greatest problems, because the judge's decision will not be determined by the assessment of whether or not there is infringement, because he or she is not allowed get into assessing the facts in deep [2]. He can only pronounce on the implementation of the measure by analyzing the proportionality between the infringement of the intellectual property rights and the rights of Article 20 of the Constitution which may be affected due to the closure of the page, essentially the freedom of expression and the seizure of publications.

VI. IMPACT ON MAS

It is well known that the success of multi-agent systems is largely linked with the solution of security problems associated with its use. The autonomous character of agent behavior implies that the users that give them important tasks must trust them with confidential data. The design of the system must ensure that no other person or agent can access illegally the data carried by the owner's agent [13]. Whereas organizational agents are confronted with general security risks of network-oriented applications, the adoption of open and mobile agents in e-learning tasks introduces a new dimension.

The aforementioned legal issues concerning the downloading of educational material from p2p networks and links pages add a new level of complexity to the design of multi-agent systems which would be able to help students in their tasks [9].

In our prototype e-learning multi-agent system we have added one ontology [10] for the agents to know and learn when a links page is legally reliable, and an ancillary agent role which autonomously questions the explorer agents and web search applications to keep a register of sure pages updated.

Every student is encouraged to keep a repository of downloaded educational materials, such as books, shorter documents, databases, images, videos, audio files, etc… in which the copyright issues can be legally certified [12]. We think that if the tools provided are used to search and bring back that material for everywhere on the Internet, the students would agree to a reasonable degree of control on legal materials.

VII. CONCLUSIONS AND FUTURE WORK

On top of unresolved security problems affecting multi-agent systems, the design of multi-agent systems as e-learning tools has encountered the new educational landscape created along with the tremendous explosion of educational (multimedia and every other type) at the disposal of students. Form childhood on every student counts on the possibility of getting every imaginable document at a few clicks of distance. Mobile or navigational agents are the perfect tool for facilitating the students the task of search and retrieving of knowledge in any form [11]. We should make our agents more copyright-violation conscious than our students likely will be. We are therefore including that ability from the very beginning of their design.

REFERENCES

[1] J. P. Aparicio Vaquero, El intercambio de archivos en redes de pares a la luz del derecho vigente. En: Revista Aranzadi de Derecho y Nuevas Tecnologías No.8. Madrid. pp. 55-72 2005. ISSN: 1696-0351.

[2] J. Carbonel, Josep; M. Sabates, La controvertida Disposición Final Cuadragésimo Tercera: "Ley Sinde". Madrid: Economist & Jurist (150), 2011 pp. 26-31.

[3] M. A. Davara Rodríguez, Manual de Derecho Informático. Madrid: Aranzadi, p.23. ISBN: 84-9767-018-3, 2001.

[4] A. Fumero, Jóvenes e Infotecnologías. Madrid: Instituto de la Juventud, Ministerio de Sanidad, Política Social e Igualdad, 2012, p.17.

[5] L. Joyanes, Cibersociedad. Madrid: McGraw-Hill. p.4 ISBN: 84-481-0943-0, 1997.

[6] R. J. Millán Tejedor, Domine las Redes P2P. Madrid: Creaciones Copyright S.L. p.234. ISBN: 84-96300-20-X, 2006.

[7] A. Perez Sanz,Escuela 2.0. Educación para el mundo digital. Madrid: Instituto de la Juventud, Ministerio de Sanidad, Política Social e Igualdad (92) 2011, pp.63,86.

[8] L. J. Rodríguez Baena, Luis José, Transmisión de la cultura en la era digital. Tesis Doctoral (Doctor en Ciencias Políticas y Sociología.). Madrid: Universidad Pontificia de Salamanca. Facultad de Ciencias Políticas y Sociología, 2001 p. 206.

[9] P. A. Rodríguez, V. Tabares, N. D. Duque, D. A. Ovalle, and R. M. Vicari, "BROA: An agent-based model to recommend relevant Learning Objects from Repository Federations adapted to learner profile", in *International Journal of Interactive Multimedia and Artificial Intelligence*, Vol. 2, March 2013, pp. 6-11.

[10] G. A. Isaza, A. G. Castillo, M. López, L. F. Castillo, M. López, "Intrusion Correlation Using Ontologies and Multi-agent Systems", In proceeding of: Information Security and Assurance - 4th International Conference, ISA 2010, Miyazaki, Japan, June 23-25, 2010. Proceedings 01/2010; pp.51-63.

[11] J. C. Fernandez-Rodriguez, J. Rainer, and F. Miralles-Muñoz, "Engineering Education through eLearning technology in Spain", in *International Journal of Interactive Multimedia and Artificial Intelligence*, Vol. 2, March 2013, pp. 46-50.

[12] Y. Villuendas-Rey, C. Rey-Benguría, Y. Caballero-Mota, and M. M. García-Lorenzo, "Improving the family orientation process in Cuban

Special Schools trough Nearest Prototype classification", in *International Journal of Interactive Multimedia and Artificial Intelligence*, Vol. 2, March 2013, pp. 12-22.

[13] G. Isaza, A. Castillo, M. López, L. Castillo, "Towards Ontology-Based Intelligent Model for Intrusion Detection and Prevention", Computational Intelligence in Security for Information Systems Advances in Intelligent and Soft Computing Volume 63, Springer, 2009, pp 109-116 (Book Chapter).

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L.I.M.E. A recommendation model for informal and formal learning, engaged

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Abstract — **In current eLearning models and implementations (e.g. Learning Management Systems-LMS) there is a lack of engagement between formal and informal activities. Furthermore, the online methodology focuses on a standard set of units of learning and learning objects, along with pre-defined tests, and collateral resources like, i.e. discussion** *fora* **and message wall. They miss the huge potential of learning via the interlacement of social networks, LMS and external sources. Thanks to user behaviour, user interaction, and personalised counselling by a tutor, learning performance can be improved. We design and develop an adaptation eLearning model for restricted social networks, which supports this approach. In addition, we build an eLearning module that implements this conceptual model in a real application case, and present the preliminary analysis and positive results.**

Keywords — **Technology-enhanced Learning, eLearning, Personalization, Social Network, Conceptual Educational Model**

I. Introduction

Social networks focused on a specific topic or community are a powerful and precise means for user communication and interconnectivity, no matter the role they stand for. These can be learners, teachers, employees, staff, academic managers, or financial directors, who show a very determined attitude, depending on their context and their objectives. Every user can question, answer, start an activity, follow another, comment on someone else's job, score a job made by others, search onto Internet, follow a scheduled test, participate in a video-conference with a teacher, and so on. And, in all these activities, any user can be pro-active, reactive, passive, consumer, producer, dealer, and yet to show some additional facets.

To this extent, we design and develop a conceptual model, L.I.M.E. as for Learning, Interaction, Mentoring, Evaluation. These four vectors are measured and analysed as the pillars for the learning scenario, and they are depicted in various inputs which feed the model. Furthermore, we implement this model in a learning ecosystem, restricted by user access and topic. This implementation of the personalised learning model, which deals with every single input and feature aforementioned, provides the user with adaptive tutoring, thanks to a rule system. In this ecosystem, the users interact one with each other, and with the system, and they get personalised counselling.

Before and after the design and implementation of the L.I.M.E. model as a case study, we have carried out a hybrid approach mainly with qualitative studies, supported by some additional quantitative studies, with various groups of experts and end-users. Hence, we have designed and executed a Delphi study to retrieve and categorize the user requirements, as well as a number of semi-structured interviews. Furthermore, we have organized two focus groups with different experts, and one quantitative questionnaire with the students involved in the application case. In addition, we have elaborated a comprehensive state-of-the-art which combines cross-engaged topics for eLearning processes like, i.e. Education, Communication and Technology.

It is proven that the learning itinerary provided by the L.I.M.E. model is efficient and effective, and therefore, it increases the user performance. To show this approach, we have designed and implemented a learning scenario in a real class, which we have split in two groups (experimental and control) of 24 students, each. We have selected and analysed a subject of an official university online programme, during 4 weeks. This scenario engaged formal and informal activities with a comprehensive approach. The implementation shows successful results which prove the validity of the model. In addition, we have got useful recommendations and promising conclusions for further versions of the model, out of the rounds of expert and end-user consultations.

The combination of 48 learners, along 4 weeks and related milestones, the measurement of 30 inputs focused on informal and formal settings and distributed along the four main vectors, has resulted in a large dataset with sufficient information to retrieve meaningful and significant interpretation. The main outcome highlights that there is a clear and positive influence in the user performance, when the L.I.M.E. model is implemented. Furthermore, L.I.M.E. shows to be effective and efficient. This conclusion is supported by a 10,53% overall average difference between the experimental group and the control group (66,72% - 56,19%), with a peak difference between corners of 37,37% (81,41% - 44,04%). These overall results, along with the partial ones which are presented along this research, support seamlessly the online personalised learning model for thematic, restricted social networks, L.I.M.E.

II. CURRENT DEVELOPMENTS AND ADDED VALUE

In most of the e-learning environment designs, interaction and behavioral strategies have generally been neglected and therefore satisfactory uses of these strategies have rarely been realized, so that informal and formal settings are not engaged in a combined approach. Most learners are not even aware of what they have been studying (Kurt, 2007). Even when students monitor their learning, there is a broad theoretical notion that students experience illusions of competence [1], which leads to inaccurate judgment of their learning progresses and outcomes [2, 3]. For these reasons, learners need to be guided towards reflecting on their learning and improving their cognitive models of expertise. For instance, with the use of meta-cognitive expertise, which becomes crucial [4] in fostering individual's awareness of different cognitive, social, emotional, and meta-cognitive capabilities that are needed, knowledge of when and why they are useful, as well as development of regulatory skills, such as planning, monitoring, and reflecting.

Another approach makes use of recommendation settings. A recommender system is a tool that helps users to identify interesting items from a large pool of objects. It has been widely used in many commercial sites for recommending books, movies, CDs, and news articles (e.g., [5, 6]). Meanwhile, the success of these implementations has been inspiring for e-learning researchers. Multiple efforts have been made to design educational recommendation systems to recommend quality learning resources to learners to help reduce cognitive load and improve learning efficiency [7-10]. However, recommendations alone do not ensure learning performance, and how learners respond to the recommended resources defines the critical part of successful learning. Furthermore, Recommendation Systems emerge as a solution to find the right, personalized information in electronic commerce, knowledge management systems, learning management systems, social networks (open and restricted), and other fields and markets. To this extent, there are various inputs which can be used as information sources like i.e. user similarities with other users, user profile, user preferences, user behavior, user interaction, user ratings, and many other user tracking inputs [11, 12]. All these inputs provide the system and the teacher with valuable data to recommend a personalized learning itinerary and feedback.

Other sources of information are i.e. user interests, goals, and objectives, all of them more useful for educational applications. However, current educational applications lack of enough amounts of data to establish user similarities in a precise way. In this case, recommendations are based on information stored in a user model which is extended explicitly or implicitly. There are also hybrid approaches which ask some minimum information to the user and the rest is obtained in an implicit way, but none of them engage formal and informal learning in a combined model, since expressing user preferences, behavior, interaction, goals and interest with rules can be difficult, in general. Large amounts of data are required to narrow down the recommendation, although this solution comes along with an additional problem: the size and complexity of the rule-set can be unaffordable, and inconsistencies may appear.

In this paper, we design an eLearning model for personalized learning, with special focus on the combination of formal and informal settings in a combined paradigm. In doing so, we cope with the artificial difference between Learning Management Systems and specific, restricted social networks which complement the user formal activity with informal interaction.

III. DESCRIPTION OF THE LIME MODEL

The L.I.M.E. model is based on three vectors:
- What every learner does based on his/her own contribution (**L=Learning**)
- What the learner does to support interaction based and the relation with others, in addition to group interaction (**I=Interaction**)
- and what the teachers/experts value (**M=Mentoring**)
- In addition, there is a forth, transversal vector, being applied to the three previous vectors, focused on evaluation (**E=Evaluation**)
- being the final acronym **L.I.M.E., as of Learning, Interaction, Mentoring, and Evaluation**

In doing so, we take into consideration every single main role in the model (i.e. the learner -individual, group-, the teacher, the expert, and the designer), as well as the main factors for a fine adaptation, such as, i.e. the learner's performance, the group's performance, trust, and reputation. In addition, this model is based on the **knowledge structure** depicted in the beginning of this section that consists of LE (Learning Environment), LO (Learning Object), UK (Unit of Knowledge), and PLN (Personal Learning Network).

In order to define the best setting, the model designer (e.g. teacher) must design a **strategy** and (s)he should follow a step-to-step process to select a number of key elements of the model:
- **Setting**: Balance between formal and informal **settings**: the system collects specific inputs from both settings, keeping an overall balance of 100%. For instance, if the designer requires just a formal setting, the balance should be Informal:100% - Formal: 0%
- **Category**: Balance between Learning, Interaction, and Mentoring **categories**: In the L.I.M.E. model, every category is assigned with a specific weight, keeping an overall balance of 100% Watch that Evaluation is a cross-category. For instance, if individual and group actions matter alike, and there is no mentoring, the balance should be Learning: 50% - Interaction: 50% - Mentoring: 0%
- **Input**: List of specific inputs for each **category** and assigned **weight**: every input should reflect a number of diverse types of potential interaction and-or actions from the user to the community, and vice versa.

As an example, we provide a form with the following parameters:
- **Informal**: 40%. Rationale: informal activities matter, however they are not enough to pass

- **Formal**: 60%. Rationale: formal activities (e.g. exam) are key to pass, however, informal activities are required to achieve an optimum score
- **Learning**: 40%. Rationale: individual activities are key in this setting, however they are not enough to pass
- **Interaction**: 30%. Rationale: interaction itself is not enough to pass, although combined with Mentoring and-or Learning, become the key for success
- **Mentoring**: 30%. Rationale: just mentoring is not sufficient, however mentoring inputs provide they key to pass, along with learning or interaction inputs

Specific **inputs**: as listed, looking for a fine distribution between individual and groups actions; pro-active and re-active actions; personal-group-mentoring inputs; formal and informal contribution. This list is not exhaustive, but tentative, and provides a set of inputs based on the analysis of user requirements. These inputs have an assigned **weight**. These weights are shown as an example, and they should be designed and adapted by the designer based on specific requirements and objectives. For clarity's shake, in the following tables, we depict the weight in three columns, showing the **Absolute value (Abs)**, the **Relative value (Rel 100)**, taken as 100% for every Category, and the final **Relative value (Rel 40)**, related to the specific value of the Setting, Category, and Input, taken as 100% for the three Categories (L.I.M.E.). This last column shows the actual values for the final calculation. The Evaluation (E) vector is included in every other vector, and relies on their needs. For instance, in the following table, Evaluation is included in L=Learning (External examination, External continuous evaluation, External essay, External degree thesis), and M=Mentoring (Quantitative assessment, Qualitative assessment). However, these inputs (sub-vectors) might be different, based on the specific model applied to a scenario

IV. DEVELOPMENT OF THE ELEARNING PLATFORM

In order to test and evaluate the L.I.M.E. model, we have developed a software application (i-LIME) to be implemented in a learning scenario, as it will be described afterwards. This application is supported by the Learning Management System of the International University or La Rioja (www.unir.net, http://research.unir.net) and it does not intend to be exploitable, but a prototype, since the final objective of this research is not oriented to programming but to the correct application of the model itself.

i-LIME is a learning environment (LE), built to apply the LIME model, based on Learning, Interaction, Mentoring, and Evaluation. It can be played stand-alone or integrated with another existing LE (e.g. Moodle), via web services. This platform is envisaged as a new cognitive learning concept to create, share and reuse scalable didactic content (Learning Objects, Units of Knowledge), to adapt the content to learners' individual needs, and to share with others (Personal Learning Network), according to the LIME model. In this context, the user becomes consumer and producer at the same time, the minimum unit of learning is based on a variety of resources. User education is also boosted, allowing a) more active

participation in the learning process, b) objective teaching skills assessment, and c) encouraging collaboration with other teachers and tutors and trainees with different expertise.

i-LIME combines the use of didactic contents, and knowledge and learning resources, for online teaching (OT). We develop i-LIME as a technology-enhanced learning (TEL) platform which applies the LIME model, and which will facilitate a more interactive, personalized learning process. i-LIME enhances the user's experience (e.g. teachers and tutors) using a five-pillared architecture [13]: (1) an authoring tool of Learning Objects and Units of Knowledge ; (2) a content management system that incorporates a modular and scalable system to capture, catalogue, search and retrieve multimedia content; (3) an adaptation management system which retrieves information and inputs from the users and the system and provides specific, personalized recommendations for the learning itinerary, based on the LIME model; (4) an evaluation module, which in turn is used as an additional input to the LIME model and the recommender layer [14]; and (5) a social thematic network (restricted to registered users in the same field) for collaborative learning between users, which provides input date on behaviour and interaction to the LIME model and the recommender layer. To this extent, we have installed an instance of i-LIME, fully operational with regards to user inputs, data collection and analysis, and adaptation management system (3, following the afore notation), along with generic functions for end-users.
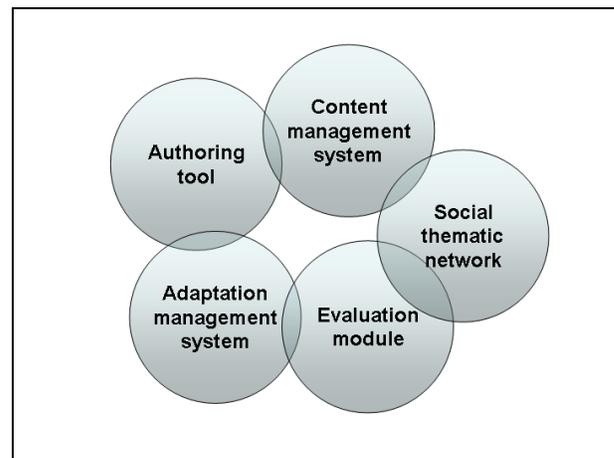
Fig. 1. i-LIME architecture

The first pillar, the **authoring tool for learning objects and units of knowledge (ATH)**, allows the building of scalable didactic content from individual users' knowledge by means of training resources (e.g. video footage) to enhance didactic information. The **content management system (CMS)** works with units of information, in the form of text, video, and audio files, or any other format required to provide useful learning objects.

Users' knowledge management is achieved within the second pillar. The **adaptation management system (AMS)** provides adaptive learning to users based on their progress (formal learning), behavior (informal learning), and other inputs, within their continuous formative path using the environment. Recommendations are given to users regarding

(1) the most suitable contents, (2) colleagues working in the same field, (3) interactions to perform, and (4) given their personal interests and progress in i-LIME, amongst other inputs. To this extent, the adaptation management system makes use of the **Recommendation Layer (Meta-Mender)**, which uses meta-rules in order to provide a new abstraction level suitable for increasing personalization and adaptation.

An important matter when developing a new training process is to develop new objective evaluation systems based on reliable and measurable data, which allow for automatic and immediate feedback and which are always available for trainees. Thus, objective evaluation is a key issue in the i-LIME environment. Thanks to the **evaluation module (EVAL)**, trainees are able to test their knowledge via closed exercises, which are immediately analyzed by the environment, and used to provide input to the **Recommendation Layer (Meta-Mender)**. Formative feedback is provided to trainees by means of corrections and future didactic content recommendations.

The final pillar in i-LIME is the **social network (SN)**, a thematic network restricted to registered members, which allows for the creation of collaborative networks of students and professionals and provides a space where users can debate and work together. In doing so, informal learning is encouraged continuously, and the social network provides feedback to the **Recommendation Layer (Meta-Mender)**, which will return a more accurate, personalized tutoring.

V. APPLICATION SCENARIO: INFORMAL AND FORMAL LEARNING, ENGAGED

The scenario consists of a Learning Environment (LE) adapted to a specific subject that compiles learning resources, tasks, and interactive activities, for future online teachers and tutors. These teachers and tutors have to get up-to-speed with techniques, processes, and strategies to foster, encourage, and facilitate actual learning and a clear methodology between the students. We integrate the i-LIME system in the Learning Environment of UNIR (UNIR LE), and hence the scenario is supported by two components: 1) the Virtual Campus at UNIR (UNIR LE), in which all the degrees lean on, and it is very much focused on daily administrative issues and scheduled events and activities (the formal component); and 2) the i-LIME component (the informal component, namely the Adaptation Management System-AMS) (Figure 2). This technical setting supports the open interaction between peers and between other target groups (i.e. learners, teachers, tutors, admin staff, et cetera). The overall system does require the following minimum software on the client side: Windows XP/7 or Mac OS X 10.x, Firefox 13.x or Explorer 8.x (both with Javascript habilitated). On the server side: the UNIR LE, Drools Engine, Microsoft Excel, PHP 5.x, Apache 2.x.

Our learning scenario (e.g. case study) was deployed from July 2nd, to July, the 29th, 2012. To this regard, we used a graduate course on "Design and management of research projects", in the Master of Science in eLearning and Social Networks, an online, official master degree at the International University of La Rioja (UNIR). This course took place between July, 2nd and July, the 26th, 2012, with 49 enrolled students. All the students but 1 took part in the experiment. Therefore, we count 48 graduate students, between 35 and 45 years old, from 2 countries (Spain -45 students-, Colombia -3 students-) and 2 continents (Europe, South America), with a gender distribution of 28 females and 20 males.
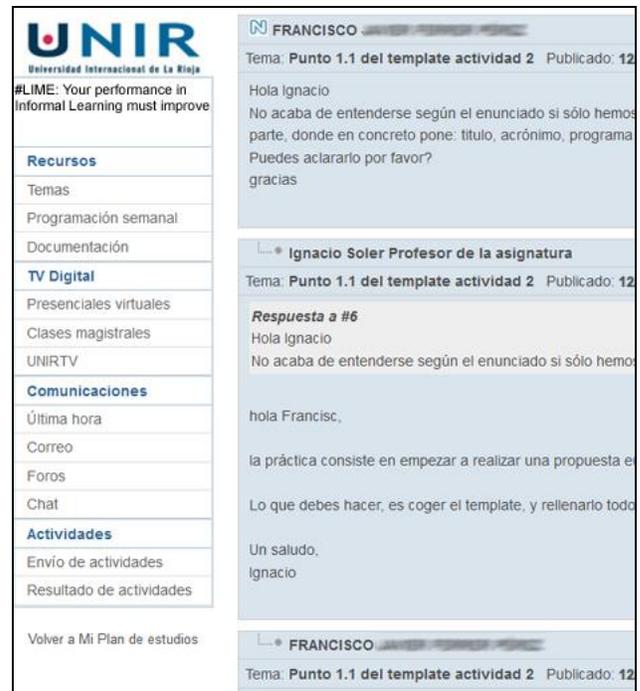
Fig. 2. Screenshot of the UNIR LE engaged with the i-LIME component

The support group consists of a teacher, an online tutor, an academic coordinator, and a master director. In addition, other cross-support departments might provide some assistant (i.e. administrative, legal, counseling, research, library, stages, et cetera). The environment is executed by every user only if the (s)he agrees with the terms described in a formal document, so that the recording of the their private date and tracking are explicitly authorized.

We have split the base group in two, equally distributed (24 members for each group). Group A (experimental) is engaged with the LIME model and receives personalized recommendation based on a number of inputs, including traditional (e.g. teacher, tutor, admin staff). Group B (control) follows the course, without the LIME model, and receives traditional support only. To make a balanced distribution of Groups A and B, on order to achieve a similar starting point, we take the previous results and evaluation. This master degree deploys the subjects in the academic program sequentially, and 9 subjects have already carried out. Therefore, there is a statistical information, quite valuable to evenly distribute members between groups (control and experimental). The final distribution is shown in Table 3 and Figure 3:

This distribution works with the individual average score after 9 subjects, out of 10-point maximum. It splits the final score of every group member in Formal (e.g. presence examination) and Informal (i.e. auto-tests, participation in

online lectures, et cetera). Formal takes 60% of the final score; Formal provides 40% to the final score, based on a total of 100%. According to

TABLE 3: SAMPLE DISTRIBUTION BASED ON PREVIOUS ACADEMIC RECORDS

| Group	Sample	Distribution	Formal	Informal	Total
A	24	Average Group A: Experimental	4,13	3,73	7,86
A	24	Maximum Group A	5,80	4,00	9,80
A	24	Minimum Group A	3,00	2,40	5,40
A	24	Standard Deviation Group A	0,81	0,53	1,19
B	24	Average Group B: Control	4,05	3,69	7,63
B	24	Maximum Group A	5,60	4,00	9,60
B	24	Minimum Group A	1,70	2,40	1,70
B	24	Standard Deviation Group A	0,88	0,58	1,67
Total	48	Average Total Sample	4,09	3,71	7,75
Total	48	Maximum Total Sample	5,80	4,00	9,80
Total	48	Minimum Total Sample	1,70	2,40	1,70
Total	48	Standard Deviation Total Sample	0,83	0,55	1,44
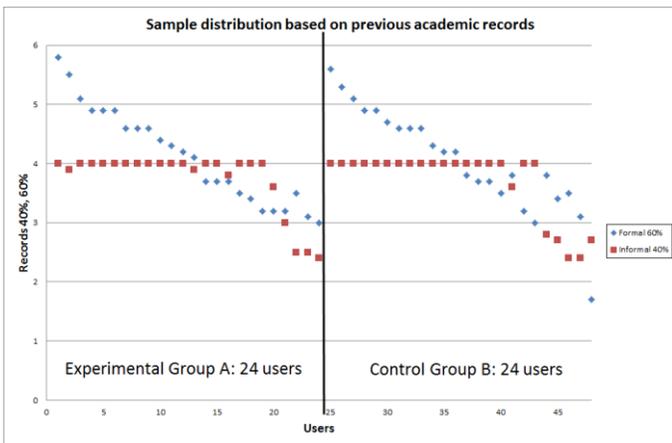
Fig. 3. Sample distribution based on previous academic records

This distribution works with the individual average score after 9 subjects, out of 10-point maximum. It splits the final score of every group member in Formal (e.g. presence examination) and Informal (i.e. auto-tests, participation in online lectures, et cetera). Formal takes 60% of the final score; Formal provides 40% to the final score, based on a total of 100%. According to the data provided in Table 3, there is a balance between Groups A and B that shows similar scores in every category, although the standard deviation is slightly different (1,19 in Group A versus 1,67 in Group B). This difference comes from a single member in Group B, who scores the minimum (1,7), while the previous one scores a total of 5,5. We can conclude that the starting point for both groups is quite similar, so that the experiment starts in the same context.

VI. LIME MODEL APPLIED TO THE LEARNING SCENARIO

With regards to the LIME model, we follow the pattern Informal50-L40-I40-M20, which the following basic rationale**:** "Informal and formal settings matter alike. Inputs from the user and the group make 80% of the total, being Mentoring actions taken as support and collateral ones. The Learning Environment (LE) is taken as the learning and communication platform, as well as the summative and formative resource for assessment". This model allows for an optimum adaptation to the features of the Learning Environment at UNIR, since combines formal and informal contexts, and supports self-learning and learning from others, including mentors (i.e. teacher and tutor). In addition, this pattern encourages the use of Units of Knowledge (UK, made of Learning Objects combined with complementary information), and Personal Learning Network (PLN, made of LO and UK, along with all the interaction elicited from other users).

Based on this model, the level of integration with UNIR's Learning Environment, the learner sample, the subject, and the overall objective, we have defined a set of Inputs, which will be used as a base to write the appropriate adaptation rules that will feed the LIME model (Figure 4**Fig**):

ID	Category	Setting	Input	Weight Abs	Rel 100	Rel 40
	Learning		Input Learning Subtotal	100,00%	100,00%	40,00%
			Input Learning Informal	50,00%	50,00%	20,00%
			Input Learning Formal	50,00%	50,00%	20,00%
			Subtotal Learning	220,00%	100,00%	40,00%
			Subtotal Learning Informal	140,00%	50,00%	20,00%
			Subtotal Learning Formal	80,00%	50,00%	20,00%
L1	Learning	Informal	Post a message	10,00%	3,57%	1,43%
L2	Learning	Informal	Post a discussion topic	20,00%	7,14%	2,86%
L3	Learning	Informal	Meet a milestone	30,00%	10,71%	4,29%
L4	Learning	Informal	Upload a learning object	30,00%	10,71%	4,29%
L5	Learning	Informal	Enrich own learning object	40,00%	14,29%	5,71%
L6	Learning	Informal	Activity rate of recent contribution	10,00%	3,57%	1,43%
L7	Learning	Formal	EVAL: Self examination	20,00%	12,50%	5,00%
L8	Learning	Formal	EVAL: Continuous evaluation	40,00%	25,00%	10,00%
L9	Learning	Formal	EVAL: Self test	20,00%	12,50%	5,00%

ID	Category	Setting	Input	Abs	Rel 100	Rel 40
	Interaction		Input Interaction Subtotal	100,00%	100,00%	40,00%
			Input Interaction Informal	50,00%	50,00%	20,00%
			Input Interaction Formal	50,00%	50,00%	20,00%
			Subtotal Interaction	230,00%	100,00%	40,00%
			Subtotal Interaction Informal	205,00%	50,00%	20,00%
			Subtotal Interaction Formal	25,00%	50,00%	20,00%
I1	Interaction	Informal	Complete the profile	35,00%	8,54%	3,41%
I2	Interaction	Informal	Select topics	25,00%	6,10%	2,44%
I3	Interaction	Informal	Reply a post	20,00%	4,88%	1,95%
I4	Interaction	Informal	Rate a post	15,00%	3,66%	1,46%
I5	Interaction	Informal	Reply a discussion topic	30,00%	7,32%	2,93%
I6	Interaction	Informal	Rate a discussion topic	15,00%	3,66%	1,46%
I7	Interaction	Informal	Discussion activity	35,00%	8,54%	3,41%
I8	Interaction	Informal	Enrich other's learning object	30,00%	7,32%	2,93%
I9	Interaction	Formal	Link from-to an external subject	5,00%	10,00%	4,00%
I10	Interaction	Formal	Collaborative work rate	20,00%	40,00%	16,00%

ID	Category	Setting	Input	Abs	Rel 100	Rel 20
	Mentoring		Input Mentoring Subtotal	100,00%	100,00%	20,00%
			Input Mentoring Informal	50,00%	50,00%	10,00%
			Input Mentoring Formal	50,00%	50,00%	10,00%
			Subtotal Mentoring	285,00%	100,00%	20,00%
			Subtotal Mentoring Informal	105,00%	50,00%	10,00%
			Subtotal Mentoring Formal	180,00%	50,00%	10,00%
M1	Mentoring	Informal	Trust rate from a peer	25,00%	11,90%	2,38%
M2	Mentoring	Informal	Trust rate from an expert	30,00%	14,29%	2,86%
M3	Mentoring	Informal	Reputation rate from a peer	20,00%	9,52%	1,90%
M4	Mentoring	Informal	Reputation rate from an expert	30,00%	14,29%	2,86%
M5	Mentoring	Formal	EVAL: Final assessment	60,00%	16,67%	3,33%
M6	Mentoring	Formal	EVAL: Tracking assessment	60,00%	16,67%	3,33%
M7	Mentoring	Formal	Trust rate from a teacher	20,00%	5,56%	1,11%
M8	Mentoring	Formal	Reputation rate from a teacher	10,00%	2,78%	0,56%
M9	Mentoring	Formal	Interesting topic rate	10,00%	2,78%	0,56%
M10	Mentoring	Formal	Significant contribution rate	10,00%	2,78%	0,56%
M11	Mentoring	Formal	Quality of reply	10,00%	2,78%	0,56%

Strategy		Check
Cat-Setting	Weight	
Informal	50,00%	Ok
Formal	50,00%	
Learning	40,00%	Ok
Interaction	40,00%	
Mentoring	20,00%	

Fig. 4. LIME model for the application scenario. Settings, Inputs and Strategy

This set of inputs gathers most of the requirements of the LIME model, including Trust, Reputation, Assessment, Evaluation, formal activities, and informal actions. In doing so, we select a representative amount of inputs, across a variety of types, which feed (back and forth) the LIME model. We have assigned the EVAL inputs to Formal settings, since the EVAL inputs in Informal settings would have required a specific assessment model for informal learning, which is not a topic of this research, although and interesting one for the future.

The system retrieves input data and provides recommendation once a week. Since the selected subject lasts 4 weeks (from July 2nd, to July 29th), we have established four milestones in months 8, 15, 22 and 29. These milestones store the specific data for every input and user incrementally, so that we can analyze the evolution of any specific user, with and without recommendation. At the end of the period (M29), every user in Group A (experimental) has received a considerable amount of recommendations, which might or might not lead to a higher performance, and to and improvement throughout the activities and actions in the Learning Environment.

About the timeline, the recommendations are provided through the milestones M8, M15, M22 and M29. However, there is no rule defined to adapt these recommendations to the user progress. Therefore, they have to be taken in close relation to the timeline. For instance, in M8, the recommendation R9 about Evaluation (see Table 4) will be likely provided to everyone, since there is little time since the beginning to the course up to M8 to carry out the activities and actions related to the Evaluation. However, in M15, and in M22, since the course is running for a longer time, it is expected that R9 will be provided to less people, decreasingly, until the final recommendation in M29, which will show the actual performance on Evaluation of every learner. Therefore, the recommendation has to be put in context of the timeline and the user (i.e. learner, tutor, and teacher) has to achieve a contextualized, appropriate reading, in order to act accordingly. Other potential contexts might be: the user status, in relation to previous subjects; the user status, in relation to the group; the user status, in relation to other groups of the same graduation; the group status, in relation to other groups of the same graduation; the group status in relation to historic records; et cetera.

Once the experiment is finished, we analyze the overall data, in order to extract group information, behavior patterns, abnormal actions, and other relevant information which will allow for a refinement of the LIME model and, if possible, the i-LIME software development and implementation.

This stored information is processed by the recommendation rules in DROOLS (language for rules processing), which takes the raw figures, applies the LIME model, and provides a recommendation on the learning itinerary. For our research, we have implemented a rule-set, adapted to this specific learning scenario and context. This rule-set must be defined by the learning designer (e.g. teacher) and it applies the LIME model based on the collected figures, and the style that the designer wants to reach, in addition to group goals and individual

thresholds. In our case, the pseudo-code that describes the rules is as follows (Table 4):

TABLE 4: DEFINITION OF RULES

RuleID	Applied to	RulePseudoCode
R1	Input (e.g. L1 or M3)	IF any input is lower than maximum AND higher than or equal to ½ maximum THEN positive feedback about this specific input
R2	Input	IF any input is lower than ½ maximum THEN warning about this specific input
R3	Subset (Informal-Formal)	IF any subset of inputs in a category is between maximum AND ¾ of maximum THEN positive feedback about the subset
R4	Subset (Informal-Formal)	IF any subset of inputs in a category is between ½ maximum AND ¾ of maximum THEN warning about the subset to the learner and to the tutor
R5	Subset (Informal-Formal)	IF any subset of inputs in a category is lower than ½ maximum THEN warning to the learner and to the teacher, recommendation of interaction with others and the tutor and the teacher, locking of further activities in this category until the threshold (1/2 maximum) is reached
R6	Category (Learning, Interaction, Mentoring)	IF any category is between maximum AND ¾ maximum THEN positive feedback and recommendation of complementary tasks
R7	Category (Learning, Interaction, Mentoring)	IF any category is between ½ maximum AND ¾ maximum THEN warning about the category to the learner, the tutor and the teacher; request of support from other learners
R8	Category (Learning, Interaction, Mentoring)	IF any category is lower than ½ maximum THEN warning to the learner and to the teacher, recommendation of interaction with others and the tutor and the teacher, request of support from other learners, locking of further activities in this category until the threshold (1/2 maximum) is reached
R9	EVAL	IF any EVAL input is lower than ½ maximum THEN locking of activity, request of interactive session with teacher, request of resubmission of activity-action

The specific coding of every rule looks like the following one, described for R1 (Table 5):

TABLE 5: EXAMPLED-PSEUDO CODE FOR RULE R1

RuleID	Rule Coding	Recommendation provided, adapted to L1
R1	IF (L* OR I* OR M* < REL X) AND (L* OR I* OR M* >= 50%*REL X) THEN R1("Positive feedback to USER")	"Well done, when you post a message"

Technically, the raw data were stored in text files, which were translated in tables (XLS type) for easier representation, calculation, and analysis. A software application was created to analyze these files and extract the information from the XLS files. The particular scenario described here should be taken into account in order to interpret the obtained data. Each time the user executed an action foreseen in the LIME model, all the related information from that specific user was written into

a log file. Every record is uniquely identified, and consists of basic ID information (i.e. date and timestamp of the event, action taken, user) and specific values provided according to the input (i.e. reputation, trust, assessment, other rates). There is an additional field with warnings, errors, and comments from the system. The information extracted from the log files was inserted into a database (XLS type) in order to organize the information and to make the information process easier. See Figure 5 for a simplified representation of the described application scenario in combination with the Adaptation Management System, which depicts the information flow from-to the end user.
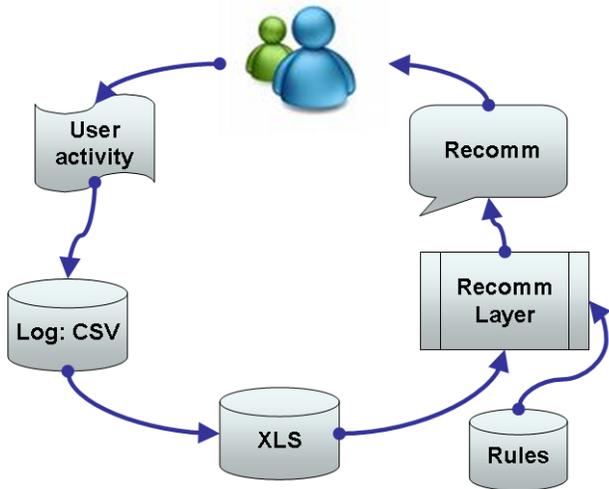

Fig. 5. Application scenario in combination with the AMS. Information flow

VII. RESULTS AND ANALYSIS OF THE APPLICATION SCENARIO
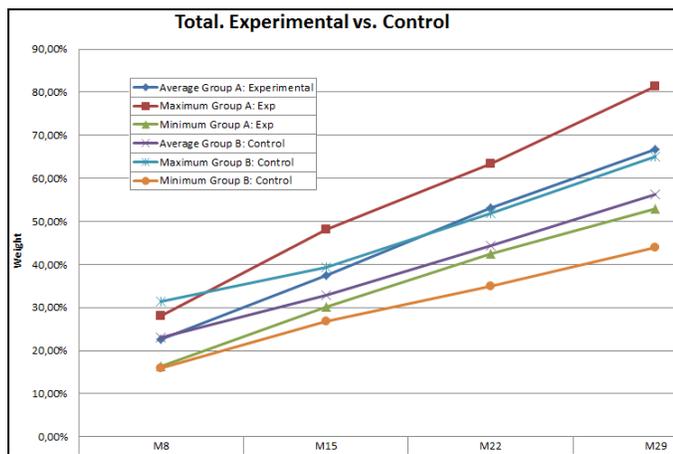
M8	M15	M22	M29
22,61%	37,47%	53,09%	66,72%
28,15%	48,07%	63,36%	81,41%
16,42%	30,12%	42,48%	52,88%
23,01%	32,83%	44,39%	56,19%
31,32%	39,28%	51,94%	65,06%
16,05%	26,88%	35,06%	44,04%

Fig. 6. Total results. Experimental group versus Control group

In Figure 6, we compare final, general results of the experimental group (A) in opposition to the control group (B). We provide data for the four milestones (M8, M15, M22, M29), and three variables per each: Maximum score,

Minimum Score, and Average Score. Therefore, we analyze a six-line web along four weeks. As expected from interviews with end users and the Delphi study, the final score is higher with the experimental group (A:66,72% vs. B:56,19%, in M29, over a 100% top). However, the crossed lines show a higher average position of the control group in M8 (A:22,61% vs. B:23,01%), before a linear increase up to M29. In addition, the maximum score in M8 is higher at the control group (A:28,15%; B:31,32%). These two higher scores at the control group at the beginning show a symptomatic progress of the impact from the recommendation system: although in the beginning A and B can be alike, or even B shows a higher rank, the systematic application of recommendations through the i-LIME environment overcomes the evolution without the LIME model

VIII. CONCLUSIONS AND FUTURE WORK

L.I.M.E. provides an optimized formula which allows for finding the balance between all the inputs related to the online learning, as in our vision. The model describes the right weight for every input, directly related to the effect to achieve along the process and every role. Based on the ground objectives, the learning scenario will define the required interaction between inputs, roles, categories and settings. The model is based on behavior, performance and the relation among the end user, himself and the peers. Furthermore, there are four main pillars or vectors: Learning, Interaction, Mentoring and Evaluation (aka L.I.M.E.). Each of them provides a key to define the relation of the user within the mode, which is translated into a set of interconnected rules. Based on what the user does in the system, and how this web is weaved, the model provides the user with personalised guidance, dynamic along the timeline, which allows for a stable tutoring support along the learning process.

In order to validate the L.I.M.E. model, we have designed and implemented a learning scenario, during 4 weeks, and counting 2 groups (experimental-A and control-B) of 24 members each. The application of the model to the described scenario shows a clear and positive progress of the users in group A, those who received recommendations by the system. The overall average of inputs, categories and students shows a final positive difference of 10,53% between the experimental group and the control group (66,72% - 56,19%), in addition to a maximum difference between corners of 37,37% (81,41% - 44,04%). These results become a tangible proof for the success of the L.I.M.E. model, based on a large number of objective measurements. They back up the conceptual design from a practical experience. Furthermore, they support the combination of inputs and categories provided by L.I.M.E., which facilitates personalized counseling to the end-user, leading to an improvement of his average performance, implemented in the context of a thematic, restricted social network, and learning scenario which engages formal and informal settings, through learning activities and user interaction.

Future work points out at an early definition phase that

should take into account every single role (i.e. student, teacher, admin, et cetera). This involvement should not come from the instructional designer only, but from actual users from every target group. In doing so, the designer builds an ecosystem which plays with every actor from inside, and not only a scenario in which the users are included from outside. In addition, the model would benefit of a more precise balance between settings, inputs and categories. The combination of these is crucial for a good use of the system. In our application case, we use a neutral approach, so that we did not influence the results because of an early selection of these elements. However, no matter what the selection is, since it always affects the result, even for being neutral. A clear definition of the implications and co-lateral effects of each configuration would better support the match between objectives and expectations from students, tutors, and instructional designers

REFERENCES

[1] R. A. Bjork, "Assessing our own competence: Heuristics and illusions," in *Attention and performance XVII. Cognitive regulation of performance: Interaction of theory and application*, D. Gopher and A. Koriat, Eds. Cambridge, MA: MIT Press, 1999, pp. 435-459.

[2] V. Romero and D. Burgos, "Meta-Mender: A meta-rule based recommendation system for educational applications," presented at Proceedings of the Workshop on Recommender Systems for Technology Enhanced Learning, RecsysTEL-2010, Barcelona, Spain, 2010.

[3] V. Romero, D. Burgos, and A. Pardo, "Meta-rule based Recommender Systems for Educational Applications," in *Educational Recommender Systems and Technologies: Practices and Challenges*, O. Santos and J. Boticario, Eds.: Information Science-Idea Group, 2011.

[4] B. White and J. Frederiksen, "A theoretical framework and approach for fostering metacognitive development," *Educational Psychologist*, vol. 40, pp. 211–223, 2005.

[5] G. Linden, B. Smith, and Y. J., "Amazon.com recommendations: Item-to-item collaborative filtering," *Internet Computing IEEE*, vol. 7, pp. 76-80, 2003.

[6] B. Marlin, "Modeling user rating profiles for collaborative filtering," in *Advances in neural information processing systems*, S. Thrun, L. K. Saul, and B. Schölkopf, Eds. Cambridge, MA: MIT Press, 2003, pp. 627-634.

[7] S. Y. Chen and G. D. Magoulas, *Adaptable and Adaptive Hypermedia Systems*. Hershey, PA: IRM Press, 2005.

[8] K. I. Ghauth and N. A. Abdullah, "Learning materials recommendation using good learners' ratings and content-based filtering," *Education Technology Research and Development*, In press.

[9] T. Kerkiri, A. Manitsaris, and A. Mavridou, *Reputation metadata for recommending personalized e-learning resources*. Uxbridge: IEEE Computer Society, 2007.

[10] C. Romero, S. Ventura, P. D. De Bra, and C. D. Castro, "Discovering prediction rules in AHA! courses.," presented at 9th International User Modeling Conference, 2003.

[11] D. Burgos, C. Tattersall, and R. Koper, "How to represent adaptation in eLearning with IMS Learning Design," *Interactive Learning Environments*, vol. 15, pp. 161-170, 2007.

[12] J. J. Rocchio, *Relevance feedback in information retrieval, in the SMART Retrieval System. Experiments in Automatic Document Processing*. Englewood Cliffs, NJ: Prentice Hall, Inc., 1971.

[13] P. Sánchez-Gonzáleza, I. Oropesaa, V. Romeroc, A. Fernándeza, A. Albaceted, E. Asenjoe, J. Nogueraf, F. Sánchez-Margallog, D. Burgosc, and E. J. Gómez, "TELMA: technology enhanced learning environment for Minimally Invasive Surgery," *Procedia Computer Science*, vol. 00, 2010.

[14] Romero L, Gutiérrez M, Caliusco ML. Conceptualizing the e-Learning Assessment Domain using an Ontology Network. *International Journal of Interactive Multimedia and Artificial Intelligence*. 2012;1 (Special Issue on Intelligent Systems and Applications):20-8

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Deploy applications, not servers.

Challenges In Cloud Computing

Automation

- How long to deploy an application?
- What version do I use?
- How do I upgrade applications?

Portability

- How do I change providers?
- What is being used?
- How much does it cost?

Auto-Scaling

- Can my application auto-scale?
- How do I configure auto-scaling?

Disaster Recovery Planning

- Can my application tolerare faults?
- How do I recover my system?

ElasticBox Solution

Automation

- ✓ Automatic Deployments
- ✓ Automatic Configuration
- ✓ Disaster Recovery

Runtime Environment

- ✓ Application Scaling
- ✓ Fault Tolerance
- ✓ Resource Clean-up
- ✓ Replication

DEVELOPERS

IT ADMINS   ARCHITECTS
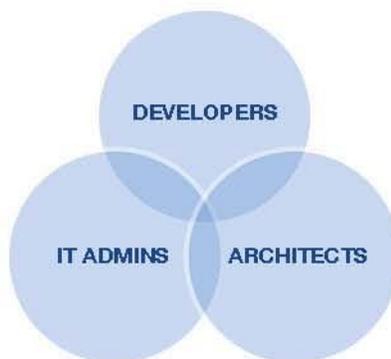
Framework Design

- ✓ Architecture Policies
- ✓ Versioning
- ✓ Platform Management

Infrastructure Control

- ✓ Cost Analysis
- ✓ Policy Management
- ✓ Traceability

amazon webservices™   Windows Azure   hp   rackspace   openstack   EUCALYPTUS