Designing IoT services in smart cities through game-based knowledge acquisition

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Abstract. Designing IoT services for smart cities adapted for satisfying the most relevant citizens' needs is not a trivial task. Not all interplays of technology would be accepted or considered natural. Evaluating the reaction of people towards these systems in advance is a necessary step that it is usually performed using surveys or focus group meetings. However, surveys have low response rates and focus groups meetings are expensive. In order to overcome this problem, this work proposes an online game-based approach so that potential users experience the interplay before the actual deployment. The decisions of players are analyzed to extract the most relevant requirements of IoT services and the most desired interaction patterns to guide the development of IoT services.

Keywords: IoT service design, requirements engineering, game-based knowledge acquisition, smart city service specification

1 Introduction

Developing IoT services for smart cities usually requires considerably high costs, specially if it involves the installation of large IoT devices in a large scale. In fact, the high cost of some IoT services has been considered as an obstruction or a barrier for the appropriate progress of smart cities, as one can observe in the critical study with empirical insights from India in this topic [6].

Also, the fact that the trained professionals in smart cities have usually a technological background rather than a social sciences background may be negative towards having more inclusive smart cities [7].

Simulations can help to foresee problems, but they will not reveal issues related with user preferences or human behavior. For instance, a research on traffic lights control system [10] simulates the effect of having a fuzzy control over the lights. However, they do not discuss the effect on human drivers who are used to fixed duration of lights rather than varying ones.

In our previous experience, we built a smart cupboard for measuring memory [9], and we designed an experiment for assessing its accuracy in measuring mem-

ISBN 978-9930-541-79-1

ory. However, we did not analyzed the users' opinions until the smart cupboard was already built.

These uncertainties can be at the core of smart cities failures. Unfortunately, failures in smart cities are rarely subject of academy papers. Digital press covers this gap and identifies side effects such as segregation, loneliness, or privacy [1] because the human factor matters [16].

Prior, less expensive, exploration of these issues could help determining what works and what does not. Rather than surveys (which traditionally have low response rate and many times low quality response) or focus groups (which are expensive), this work follows previous results [8] and proposes using text-based online games.

This work proposes a novel mechanism for rapidly extracting citizens' opinion before developing an IoT service. In particular, it proposes a framework to develop text-based brief games that are both easy-to-build and easy-to-play in any short spare time by casual users. This approach has been illustrated in the context of designing IoT services for avoiding drunk people driving on the streets of a smart city.

2 Related work

The related work considers the problem of how to know in advance with a low investment what is the opinion of users with respect a planned intervention in a city. This approach discards views were more traditional co-creation approaches, such as living labs method, because of their inherent costs.

The problem of advancing user opinion with respect to some urban development has many previous results in the area of Public Participation Geographic Information Systems (PPGIS). PPGIS are about performing online surveys using renderings of maps or other means to explain better what is the expected outcome of the modification. Despite expectations, the PPGIS have 13% average respond rate though greater reach, while paper based surveys have 30% though smaller reach [4].

3D recreations of the environment have been tested as well as a mean to gather information. There are several works in the intersection of human-computer interaction (HCI) and IoT. Mixed reality [15] can be used as well to analyse user and IoT devices interaction. However, the hardware cost for this kind of solutions is not always a low cost one. A cheaper way is to produce 3D simulations which are then coded into videos that others can check and have an opinion about [5]. Nevertheless, videos are not interaction and the reaction of users is hard to record without an important effort.

Some works highlight the need of considering people in the development of IoT services. In particular, [3] identified the main challenges, approaches and enabling technologies to conform people-centered IoT. One of the main challenges they identified was the user-centered requirement analysis. They stated that IoT systems were mainly focused on technical level like performance, interoperability

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and integration, at the time. Most works missed following a user-centered approach, maybe because the lack of interactive e-assessment technologies. In this gap of the literature, we propose a game-based approach for the user-centered design of IoT services.

The systematic mapping study by [2] reviews the existing works that combine IoT and gamification. They showed that in this line of research, the most relevant application domains were energy, health, learning and sustainability in the last three years. In fact, in these domains, IoT applications usually interact with humans. Therefore, users should be considered in the development.

Game-based applications are recently related with IoT services. In particular, serious games have been used in environments with IoT devices for improving personalized healthcare [12]. In addition, [11] proposed a framework for using serious games through users' mobile devices and several sensors from the IoT environments. However, none of these games were designed for extracting the most preferred requirements of IoT services, as the current work proposes.

Therefore, the literature lacks a framework-supported approach for using text-based brief games for rapidly extracting IoT service requirements that are well-accepted by citizens. The presented approach addresses this gap of the literature.

3 Designing games for acquiring user-centric requirements of IoT services in smart cities

3.1 Technique for designing IoT services with a user-centered design

This work proposes to use agile development of games to make users identify their problems in a friendly environment. In this way, the requirements extracted from users are related to their immersion in a story, and these requirements are considered to be relevant, according to the common principles of requirements engineering [14].

This technique proposes to use text-based games because of their agile development. In these games, the player reads a story, and they can express preferences, indicate actions or mention their emotions, among others, by clicking on the links within the text or at the end. In this way, readers can continue the story by deciding on which action to focus in a smooth way. At the beginning of the games developed with this technique, the game instructions encourage players to read all the text of each scene before clicking in any link. In this way, the player is aware of all the options before taking any decision.

This technique recommends IoT-service designers to follow the steps below:

1. *Brainstorming*: The designers should discuss in group about which smart-city IoT service to develop and all the possible options and factors to consider. In case there is only one designer, then they should make notes of all these possible ideas.

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2. *Identification of the key factors*: The designer(s) should select which are the key factors in their IoT services concerning the users.
3. *Determining options for each factor*: The most relevant options will be associated with each factor to analyze which option(s) users generally prefer.
4. *Design the storyboard of a game*: The storyboard should consider all the necessary steps to make players feel identified with a certain problem. In addition, the storyboard should include scenes that cover all the key factors of step 2. In addition, each game scene associated with a key factor should provide the proper links for all the associated options from step 3 for extracting the player's preference about these.
5. *Write the game script*: In order to extract the user preferences, it is necessary that the story is enough detailed to make the player engaged with the game and identify their problems in the game scenarios. It should be enough brief to avoid making the game boring or excessively long. This script associates each storyboard element with some text to be presented to the user.
6. *Develop the game*. The user can develop the game from the script thanks to the proposed software framework for developing text-based for prototyping IoT service options.

3.2 Software support for developing games for facilitating the user-centered design

We have developed a framework in the PHP programming language for facilitating the development of text-based games for facilitating the prototyping of IoT services for smart cities. This framework includes the following components:

- *Header template*: This header is designed to be include in all the scene files. It gathers all the functionality regarding the registering of information through URL parameters.
- *Footer template*: This is designed to be included in all the scene files, and complements the header file.
- *Main Functions file*: This includes the necessary function for storing the information in both the logs files and the MySQL database.
- *Game example*: This includes an example of game so the framework users have an example to understand how to define a game with this framework.
- *Style template*: This CSS file provides a default style for the framework and can be adapted for each game.
- *Database script*: This file contains the necessary queries for creating the database.

In order to develop a game from the storyboard and the script, the developer has to perform the following steps:

1. *Create a scene for each storyboard element*: Each scene is a PHP file with a name representative of the storyboard element. It includes both the header and the footer files at the beginning and end of the file respectively.

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2. *Include the text of the script*: The text of the script associated with each storyboard element will be included in the corresponding scene, by just including the text in the corresponding PHP file.
3. *Include the transitions of the storyboard*: Each transition of the storyboard will be represented with an HTML link to the relative path of the file that represents the corresponding scene. If this transition corresponds to an option of a key factor, the link will include URL parameters with the names "factor" and "msg" to represent the corresponding option selected. Some transitions may not be related to any key factor, and in these cases only the "msg" parameter is used.

The generated game will record the transitions in a table called "events" in the database, indicating the factor if any, and the preferred option or message in the column "msg". This information will be analyzed to detect the most common preferences of users regarding the corresponding factors. The database table includes "none" for the factor column and the corresponding message, if a recorded transition is not related with any key factor. All the events are associated with the date and the time, in the "datetime" column.

4 Case study: user-centered design of a IoT service for avoiding drunk drivers based on the collaboration of citizens

Figure 1 shows the storyboard of the game for designing and IoT service for avoiding drunk drivers. Figure 2 presents an example of the information stored in the events table of the database, after player several times to the game for testing. One can observe the names of factors and the corresponding message options selected. Table 1 shows the key factors, their brief descriptions and the options for each factor.

Figure 3 shows the initial screen of the game after the instructions. This screen introduces the user in the situation of being in a party in the Complutense University of Madrid. Then, the player starts dreaming that Madrid smart city can help in avoiding this situation. They have to select the preferred system, which can be a mobile app (a device very commonly used for accessing other IoT services), a smart traffic light (a ground-breaking device at least in Madrid, in which the user can interact with the traffic light), or a hand gesture (representing an advanced computer-vision software using common traffic cameras). This online game can be visualized in different kinds of devices properly, including smartphones, tablets, PCs and laptops, for include a wide range of players including the casual ones. In particular, this game snapshot was taken from a smartphone. This game was written in Spanish to facilitate the participation of Spanish participants. The game is available from a website[1] dedicated for the experiments.

[1] http://igarciam/epizy.com/instead/

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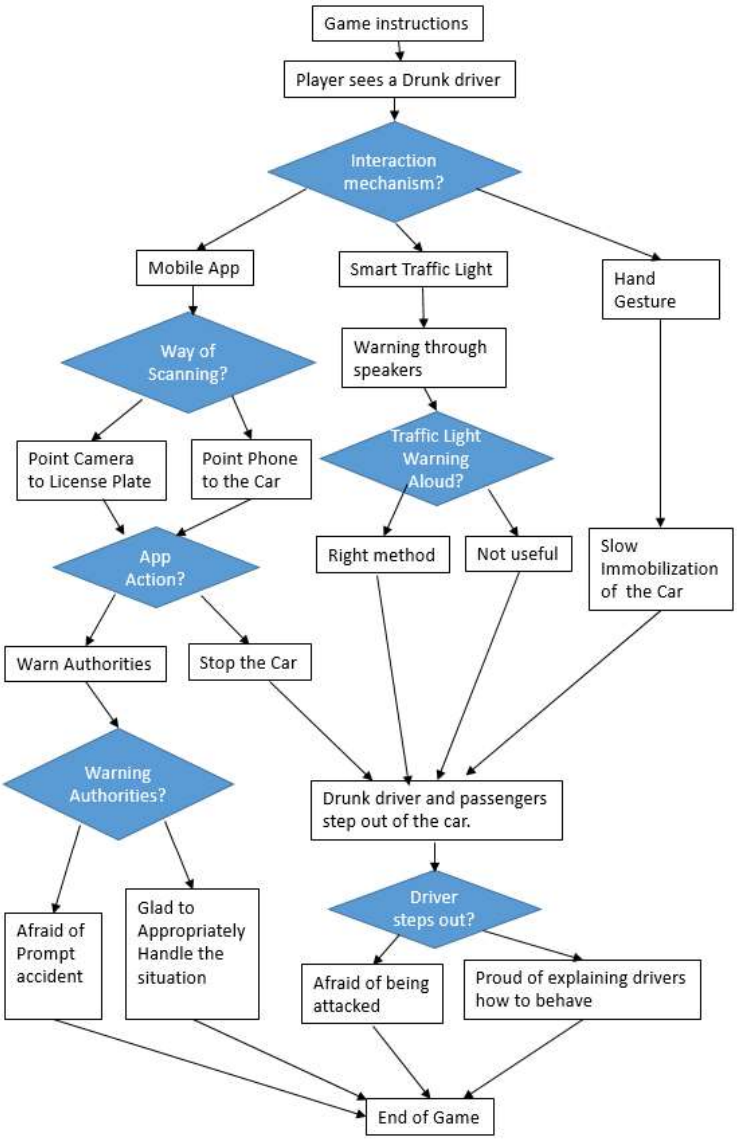

Fig. 1. Storyboard of the game-based case study for designing IoT service for avoiding drunk drivers

5 Experiments

5.1 Protocol

In order to assess the utility of the game-based extraction of requirements of the presented case study, we asked some of our contacts through What-

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datetime	factor	msg
2019-11-27 09:23:35	none	begin
2019-11-27 09:23:38	interactionMechanism	app
2019-11-27 09:23:39	wayOfScanning	scanNumberPlate
2019-11-27 09:23:41	appAction	stopVehicle
2019-11-27 09:23:45	driverStepsOut	scareOfDrivers
2019-11-27 09:23:47	none	restart
2019-11-27 09:23:51	interactionMechanism	trafficLight
2019-11-27 09:23:53	trafficLightAloudWarning	OkTrafficLightFunctioning
2019-11-27 09:23:56	driverStepsOut	possibilityToExplain
2019-11-27 09:23:58	none	restart
2019-11-27 09:24:04	interactionMechanism	handGesture
2019-11-27 09:24:08	driverStepsOut	scareOfDrivers
2019-11-27 09:24:10	none	restart
2019-11-27 09:24:14	interactionMechanism	trafficLight
2019-11-27 09:24:17	trafficLightAloudWarning	NotOkTrafficLightFunctioning
2019-11-27 09:24:18	driverStepsOut	possibilityToExplain
2019-11-27 09:24:20	none	restart
2019-11-27 09:24:23	interactionMechanism	trafficLight
2019-11-27 09:24:25	trafficLightAloudWarning	NotOkTrafficLightFunctioning
2019-11-27 09:24:28	driverStepsOut	possibilityToExplain
2019-11-27 09:24:30	none	restart
2019-11-27 09:24:33	interactionMechanism	trafficLight
2019-11-27 09:24:36	trafficLightAloudWarning	OkTrafficLightFunctioning
2019-11-27 09:24:38	driverStepsOut	possibilityToExplain
2019-11-27 09:24:40	none	restart
2019-11-27 09:24:43	interactionMechanism	app
2019-11-27 09:24:44	wayOfScanning	pointWithPhone
2019-11-27 09:24:51	appAction	warnAuthorities
2019-11-27 09:25:00	authorities	authoritiesFine
2019-11-27 09:25:02	none	restart
2019-11-27 09:25:05	interactionMechanism	app
2019-11-27 09:25:07	wayOfScanning	pointWithPhone
2019-11-27 09:25:09	appAction	stopVehicle
2019-11-27 09:25:23	driverStepsOut	possibilityToExplain
2019-11-27 09:25:27	none	restart
2019-11-27 09:25:32	interactionMechanism	trafficLight
2019-11-27 09:25:34	trafficLightAloudWarning	OkTrafficLightFunctioning

Fig. 2. Events stored in the database

sApp to participate in this experimentation with just the following instructions (translated to Spanish): "Try this game, which only takes half minute, and you will help us in our research about avoiding traffic accidents in smart cities: http://igarciam/epizy.com/instead/ Thank you very much!". No other instructions were given, as we have designed a easy-to-play game with the appropriate brief self-contained instructions. The game did not stored any personal information such as names, emails, telephones or postal addresses to ensure the privacy rights of participants, and consequently all stored data were anonymous. The participation was completely voluntarily and had no economic compensation or any other compensation. Participants may have been driven by the desire of having fun playing the game, curiosity or the willing of helping our research.

We started contacting people at 17:25 on Wednesday November 27, 2019. We selected this hour, as some people may stop working around this time and

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Table 1. Key factors of IoT services for avoiding drunk drivers based on the collaboration of citizens

Factor	Description	Options
Interaction Mechanism	It determines the preferred way of citizens fo communication with smart city	(1) A mobile app, (2) a smart traffic light, and (3) hand gesture detected by cameras.
Way of scanning	It determines how a mobile app could identify a car	(1) Scan the number plate and (2) point with the phone to the car
App action	It indicates the preferred action from the mobile app	(1) Stop the vehicle, (2) warn authorities
Warn authorities	It determines whether warning authorities is perceived as a feasible solution for urgent matters. For example, users could wonder whether it would be better to stop the car immediately	(1) Afraid of prompt accident, (2) glad because warning authorities is fast enough for handling the situation properly.
Traffic light warning aloud through speakers	It determines whether asking drivers through speakers to stop is perceived as an appropriate method or not	(1) right solution, (2) not useful
Driver steps out	It determines whether people identifying drunk drivers want to keep anonymous	(1) Afraid of being attacked by the drivers, (2) proud of having the possibility explaining the driver the risks of their behavior.

they may have some spare time for this casual playing and contributing to the research about this social problem. We analyzed the results with all the data collected this day and the next one.

5.2 Sample of participants

We sent the request to groups of friends, family, former and current PhD students, and parents of some children from the School "Colegio La Purísima y Santos Mártires" of Teruel. We only contacted adults (i.e. above 18 years old) in Spain. We received WhatsApp messages of 10 participants confirming that they have played the game, although more participants played the game as we observed in the database. Out of the 10 confirmed participants, six of them lived in Madrid, while the other four lived in Teruel. The database registered the game was started 31 times from the beginning (this excludes the ones that restarted the game, registered through a different event). Thus, we assume that we had 31 participants.

5.3 Results

From all the game matches of all the participants, we received 122 events. The database registered that the game was started from the beginning 31 times, and

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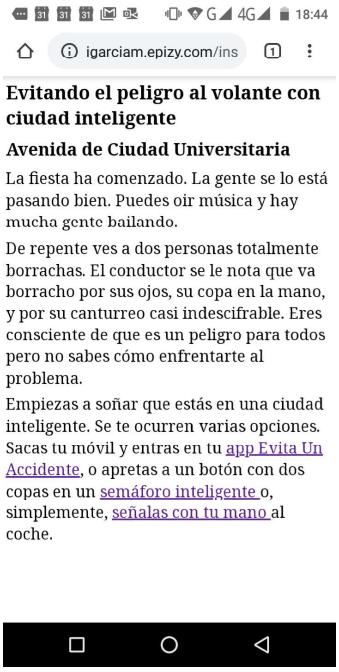

Fig. 3. Initial screen of the game after the instructions

the first decision was taken only 27 times. Thus, 87.1% of the users were probably enough engaged to take the first decision (i.e. the one about the preferred interaction mechanism).

Figure 4 shows the participation of players in the decisions related to each key factor. Notice that the participation in the decisions about each factor varies, since depending on the storyboard and the decisions taken, each player only reaches to the scenes related to some key factors.

Table 2 provides information about each key factor, indicating (a) the number of participants that took each particular decision regarding a key factor (column "# decisions"), and (b) the percentage of each preference about each factor considering all the decisions taken concerning the corresponding factor (column "% preference"). Figure 5 graphically presents these percentages of preferences about each factor.

Figure 6 shows the hours in which participants had interactions with the presented game.

6 Discussions

In only 30h of experimentation without any compensation, we achieved experiments from 27 users. This reveals the potential of our approach of very-quick game-based approach for extracting requirements, as a promising tool. We think

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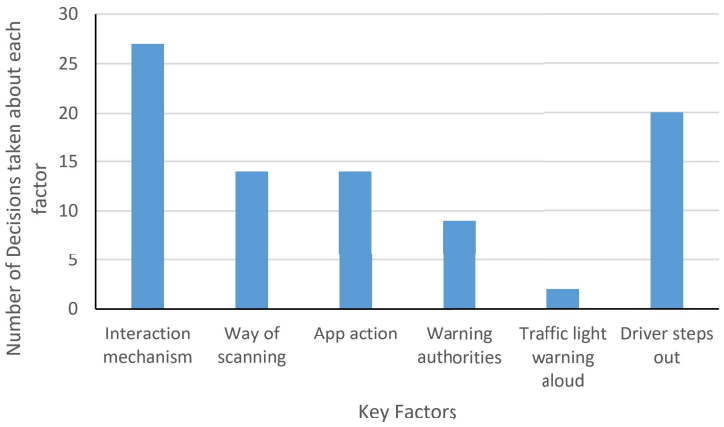

Fig. 4. Participation in decisions related to each key factor

Table 2. Numbers of decisions and percentage of preferences for each factor

Factor	Decision	# decisions	% of preference
Interaction mechanism	App	15	55.6
	Hand Gesture	11	40.7
	Traffic Light	2	7.4
Way of scanning	Point with phone	7	50.0
	Scan number plate	7	50.0
App action	Stop Vehicle	8	57.1
	Warn Authorities	6	42.9
Warning authorities	Authorities Fine	8	88.9
	Authorities Not Fast Enough	1	11.1
Traffic light warning aloud	Not Ok traffic light functioning	2	100.0
	Ok traffic light functioning	0	0.0
Driver steps out	Possibility to explain	12	60.0
	Scare of driver	8	40.0

that just letting the user play without any questionnaire afterwards made the experiments attractive enough to easily enroll users. Most other user studies require much more time [13].

It is worth highlighting that the text-based nature of the proposed kind of games with the presented framework makes this approach quick enough to design requirements extractions. The proposed case study only took 5h and 33min in being designed and written, once the topic of the IoT system knowledge extraction was conceptualized. The development work of the framework is excluded

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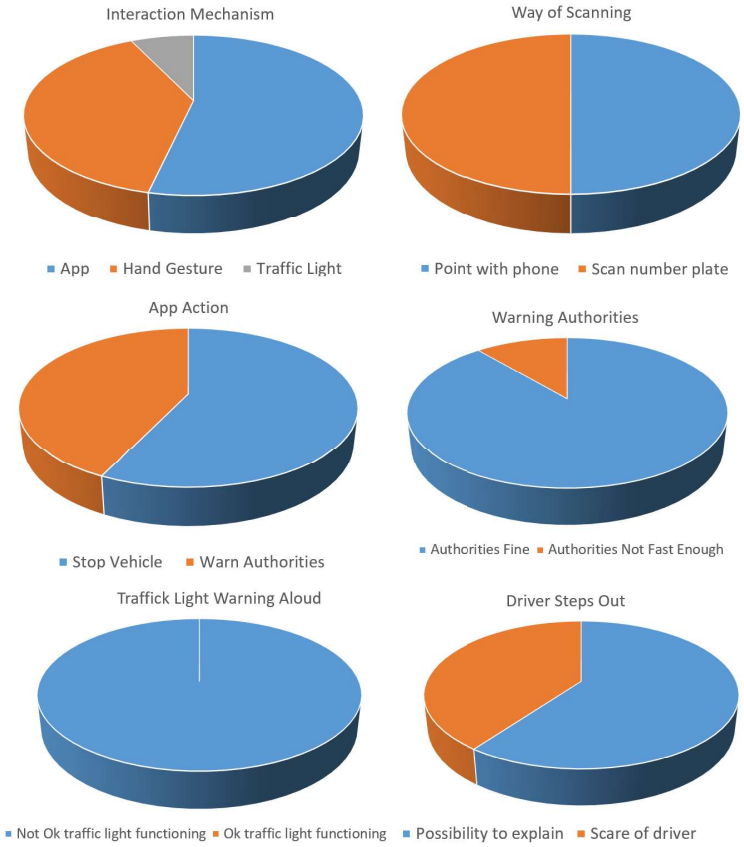

Fig. 5. Percentage of different decisions for each factor

from this measurement, given that this framework can be reused in other case studies.

Considering the experiment results regarding the key factor of interaction mechanism, a mobile app is the most preferred one (56% of preferences). Maybe the reasons might be that (a) the citizens are familiar with these devices, and (b) they may think that this solution is the most realistic and easy to be implemented soon. The usage of computer vision with the existing cameras for detecting hand gestures is also selected by a high number of participants (41% of preferences).

Only 7% of participants selected novel smart traffic lights as the preferred interaction mechanism. In addition, the proposed behavior of the smart traffic lights (i.e. stopping the car and inform the driver aloud) was not considered appropriate, although the number of players reaching to the corresponding scene of the storyboard may not be representative (only 2 clicks registered in this scene). This quick requirement extraction can save a lot of investment of novel smart devices if they are not accepted by citizens. In addition, this case reveals

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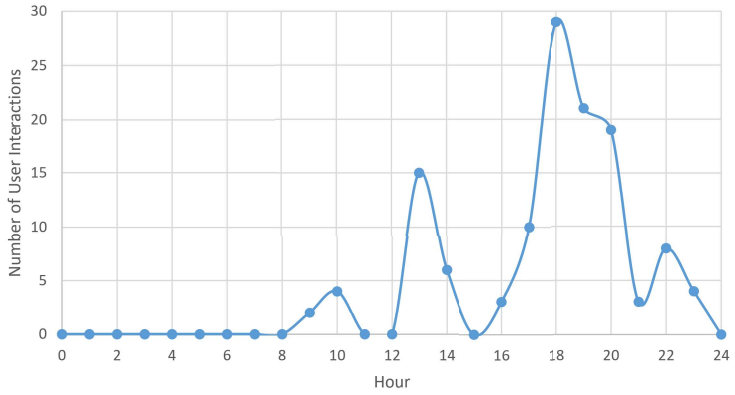

Fig. 6. Number of user interactions per hour

that this approach has the limitation that the factor analyzed in some branches may not be representative when very few participants get to a branch of the storyboard. This can be ameliorated by either (1) increasing the participants sample size or (2) making more branches get to the most relevant key factor. The latter was applied for the key factor of whether the citizens can feel afraid of drunk drivers if they notice who is the one reporting their action.

These experiments revealed that a great ratio of users (40%) may feel afraid of the drunk drivers if they find out who is accusing them. This shows that privacy of citizens reporting drivers is relevant for achieving well-accepted IoT systems in this context. From this study about requirements, developers could for example consider adding some random delay before taking actions after some citizens reported drunk drivers in the IoT services, so that the drivers cannot notice by whom they are reported.

In the distribution of day hours for playing the game, one can observe that most participants selected the evening (i.e. between 17:00 to 20:00) time for doing the participants and also around the Spanish lunch time (i.e around 13:00). These hours usually coincide with the spare time of people that work in office hours. Notice that the tests were performed on Wednesday and Thursday, which are commonly working days. Thus, the extraction of requirements is compatible with the spare time of participants without barely interrupting their daily activities. Notice that the experiments took only about one minute for each user, and was integrated in the context of a game, so participants were motivated for participating in this study.

This case study was useful to detect the most preferred whole interaction mechanism considering the path of the storyboard with the most frequent decisions. In particular, the experimentation revealed that the most accepted path was to use a mobile app to indicate that a car driver was drunk. They would either scan the license plate or just point to the car with their smartphone, to

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immediate stop the car, feeling proud of being able to explain the driver the risks of driving under the alcohol effects.

7 Conclusions and future work

This work has presented a new approach for analyzing possible new IoT services with a light-weight mechanism or requirements extraction, which needs low effort from both the developers and the potential users. This approach has been illustrated for exploring which options are well-accepted by citizens in IoT services for avoiding drunk drivers based on real-time collaboration of citizens.

In the future, we plan to compare the proposed requirements technique with other requirements techniques to quantify the improvement of the proposed approach over them. We also plan to further develop the tool by giving users the opportunity to explain their reasons for taking the decisions. The proposed approach will also be tested in more case studies.

Acknowledgment

We also acknowledge "CITIES: Ciudades inteligentes totalmente integrales, eficientes y sotenibles" (ref. 518RT0558) funded by CYTED ("Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo") and "Diseño colaborativo para la promoción del bienestar en ciudades inteligentes inclusivas" (TIN2017-88327-R) funded by the Spanish council of Science, Innovation and Universities from the Spanish Government.

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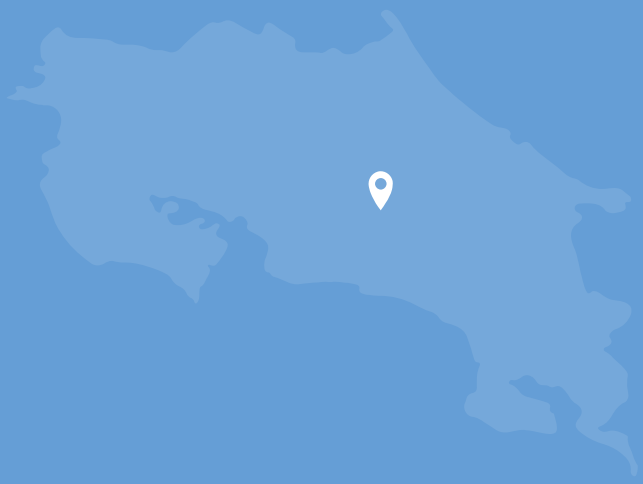
ISBN 978-9930-541-79-1

Proceedings of the III Ibero-American Conference on Smart Cities

(ICSC-CITIES2020)

Hosted by the Costa Rica Institute of Technology

from November 9th to 11th



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Cover design by Andrea Rojas

Editors: Carlos Meza, Luis Hernández-Callejo, Sergio Nesmachnow, Ângela Ferreira, Vicente Leite.

How to cite this book:

Meza, C., Hernandez-Callejo, L., Nesmachnow, S., Ferreira, A. & Leite, V. (Eds.). (2020). *Proceedings of the III Ibero-American Conference on Smart Cities*. Instituto Tecnológico de Costa Rica.

ISBN: 978-9930-541-79-1

ABOUT THE EVENT

Smart Cities are the result of the increasingly urgent need to orient our lives towards sustainability. Infrastructure, innovation and technology for cities can be developed to minimize the environmental impact but still to foster life quality of citizens.

The Ibero-American Conference on Smart Cities (ICSC-CITIES) is a discussion forum that aims to create synergies among different research groups to promote the development of Smart Cities, and contribute to their knowledge and integration in different scenarios. The conference is held yearly since 2018 and is sponsored by the Ibero-American Program of Science and Technology for Development (CYTED). The two previous editions, i.e., 2018 and 2019, were celebrated in Soria, Spain.

The Third Ibero-American Conference on Smart Cities (ICSC-CITIES 2020) was hosted by the Costa Rica Institute of Technology from November 9th to 11th 2020 on-line. Fifty-nine technical presentations given by researchers from 12 different countries were presented during the ICSC-CITIES 2020. The aforementioned presentations were divided in four topics, i.e., Governance and Citizenship, Mobility and IoT, Infrastructures, Energy and the Environment and Energy Efficiency. Those contributions were selected from a pool of 99 submitted papers, yielding an acceptance rate of 60%.

ICSC-CITIES 2020 program also included the participation of government representatives from several American countries. More specifically, two panel discussion sessions were held. The first one was related to the role of national governments in the development of smart and sustainable cities. In this panel participated the First Lady of Costa Rica, Architect Claudia Dobles, the Minister of Science and Technology of Costa Rica, Dr. Paola Vega and the Vice minister of Digital Transformation of Colombia, Engineer German Rueda. A second discussion panel was held which was related to the role of local governments in the development of smart and sustainable cities. In this panel participated the former major of Quito, Ecuador, Mauricio Rodas, the first alderman of the City of Guatemala, Carlos Soberanis and the Director of Corporate Strategy of City of Vancouver, Canada, Bryan Buggley.

ICSC-CITIES 2020 was organized by the Costa Rica Institute of Technology with the collaboration of the *Colegio Federado de Ingenieros y Arquitectos*, Costa Rica, the University of Valladolid, Spain, *Universidad de la República*, Uruguay and the *Polytechnic Institute of Bragança*, Portugal.

COMMITTEE

The organizing committee of the Third Ibero-American Conference on Smart Cities was comprised by the following people:

- Dr. Luis Hernández-Callejo, Universidad de Valladolid, Spain, general co-chair and publication co-chair.
- Dr. Sergio Nesmachnow, Universidad de la República, Uruguay, general co-chair and publication co-chair.
- Dr. Carlos Meza, Instituto Tecnológico de Costa Rica, Costa Rica, local chair and program chair.
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- Vicente Canals, University of the Balearic Islands (Spain)
- Yuri Molina, Federal University of Paraíba (Brazil)

PROGRAM

ICSC-CITIES 2020 took place simultaneously in more than 12 countries throughout Latin America, Spain and Portugal. To facilitate the attendance of students, researchers and professionals from these countries, the event was schedule in such a way that it was in a suitable period of the day for everyone. The conference program is shown below at the local time of the hosting institution (UTC-6).

Monday, November 9th

Hour (UTC-6)	Activity	Speakers	
8:00 a 8:30	Inauguration	Carlos Meza Benavides	Local Organizer
		Alejandra Morice Sandoval	President Federal Collegue of Engineers and Arquitects of Costa Rica
		Luis Hernández Callejo	Coordinator CITIES Cyted
		Luis Paulino Méndez Badilla	President, Costa Rica Institute of Technology
8:30 a 10:00	Introductory words from the First Lady of Costa Rica Claudia Dobles Camargo		
	Panel discussion: Perspective of national governments in the development of smart cities.	Dra. Paola Vega, Minister of Science and Technology	Moderator: Dr. Luis Hernández Callejo
		Ing. Germán Camilo Rueda Jiménez, Vice minister of Digital Transformation, Colombia	
10:00 a 12:00	Public transportation and accessibility to education centers in Maldonado, Uruguay	R. Massobrio, S. Nesmachnow, E. Gómez, F. Sosa and S.Hipogrosso	S1. Governance and Citizenship Moderator: Dr. Carlos Meza Benavides
	Reimaging the Book ... Again! A New Framework for Smart Books Using Digital Twins Technology	H. Kolivand, E. C. Prakash, M.C. López Leal, D. Hernández Cárdenas, A. A. Navarro-Newball	
	Experimental Algorithmic Citizenship in the Policy and Design Sandbox as an Alternative to Ethical Frameworks and Governance-by-Design Interventions	D. Reshef Kera	
	Prototype system for remotely monitoring and managing second-hand clothing collection containers	I. Martin Martín, G. López López, S. González Jiménez, B. Corrieu.	
	Smart Fisheries, a key player in ocean sustainability and fair fish trade.	J. Carvajal, H. Sánchez, J.C. Martí	
	Smart city tools to evaluate healthy environments for the elderly	I. Lebrusán, J. Toutouh	
	Crowdsourcing and IoT Towards More Resilient Flooding Prone Cities	J. Ponciano, M. Escamilla-Ambrosio, I. Pulido-Navarro, V. Hernández-Gutiérrez, A. Rodríguez-Mota, M.A. Moreno-Ibarra.	
	Carbon regulation policies in transport: a review	V. de Almeida Guimarães, R. P. Correia Lima, M. de Azevedo-Ferreira, P.H. González.	

Monday, November 9th

Time (UTC-6)	Activity	Speakers	Session
12:00 a 14:00	A Prototype of Classroom Energetically Efficient	D. A. Godoy, S. H. Bareiro, F.E. Favret, J.P. Blariza, G. Colotti.	S2. Energy Efficiency and Sustainability Moderator: Dr. Vicente Leite
	Implementation of home energy management criteria for high school students in the city of Guayaquil-Ecuador	E. Delgado-Plaza, J. Peralta-Jaramillo, I. SosaTinoco, J. Guevara Saenz de Viteri, A.P. Ferreira.	
	REMOURBAN: Evaluation results after the implementation of actions for improving the energy efficiency in a district in Valladolid (Spain)	C. de Torre, J. Antolín, M.A. García-Fuentes, J Gómez-Tribiño, J.J Cubillo, M.L. Mirantes, I.- Tomé.	
	Analysis of residential electricity consumption by areas in Uruguay	J. Chavat, S. Nesmanchnow	
	Low-cost and real-time measurement system for electrical energy measuring of a smart microgrid	O. Izquierdo-Monge, P. Peña Carro, M. Martín Martínez, L. Hernández Callejo, O. Duque Pérez, A. Zorita Lamdarid	
	How the construction parameters influence the thermal loads of a building without internal gains	J.A. Díaz Angulo, S. Soutullo, E. Giancola, J.A. Ferrer Tevar.	
	A methodology for the conversion of a network section with generation sources, storage and loads into an electrical microgrid based on Raspberry Pi and Home Assistant	O. Izquierdo-Monge, L. Hernández Callejo, P. Peña Carro, O. Duque Pérez, A. Zorita Lamadrid, R. Villafafila Robles.	
	A data acquisition pipeline for home energy management systems	I. Munné-Collado, A. Bové-Salat, D. Montensinos-Miracle, R. Villafáfila-Robles	
	A novel algorithm for high compression rates focalized on electrical power quality signals	M. Ruiz, M. Jaramillo, S. Simani	

Tuesday, November 10th

Time (UTC-6)	Activity	Speakers	Session
08:00 a 10:00	Demand response control in electric waterheaters: evaluation of impact on thermal comfort	R. Porteriro, J. Chavat, S. Nesmanchnow, L.Hernández Callejo	S3. Energy Efficiency and Sustainability Moderador: Dra. Ângela Ferreira
	Computational intelligence for characterization and disaggregation of residential electricity consumption	M. Esteban, S. Nesmanchnow, M. Mujica, I. Fiori	
	Study and improvement of the efficiency of a hydraulic pumping system associated with a Pelton hydraulic turbine in a smart microgrid	O. Izquierdo-Monge, P. Peña-Carro, C. Barrera del Almo, L. Hernández-Callejo, A. Zorita-Lamadrid, O. Duque-Perez	
	Photovoltaic cell defect classifier: a model comparison	A. Pérez-Romero, L. Hernández-Callejo, S. Gallardo-Saavedra, V. Alonso Gpomez, M.C. Alonso García, H.F. Mateo Romero	
08:00 a 10:00	I-V tracers for PV panels, topologies and challenges: A Review	J. I. Morales-Aragonés, L. Hernández-Callejo, O. Duque-Pérez, A. Zorita Lamadrid.	S3. Energy Efficiency and Sustainability Moderator: Dra. Ângela Ferreira
	Embedded System for Hot Spots Characterization of Solar Panels	J. Carvajal-Godinez, J. Fonseca Cruz, D. Picado, F. Soto, C.E. Soto	
	The effect of clearance height, albedo, tilt and azimuth angle in bifacial PV energy estimation using different algorithms	H. Sánchez, C. Meza, S. Dittmann	
	Experimental comparison of visual inspection and infrared thermography for the detection of soling and partial shading in photovoltaic arrays	L. Cardinale-Villalobos, C. Meza, L.D. Murillo	
10:00 a 12:00	Panel discussion: Perspective of local governments in the development of smart cities	Carlos Soberanis, first alderman of the City of Guatemala, Gutaemala	Moderator: Dr. Ricardo Sancho
		Mauricio Rodas, Former Major of Quito, Ecuador	
		Bryan Buggley, Director of Corporate Strategy, City of Vancouver, Canada	

Tuesday, November 10th

Time (UTC-6)	Activity	Speakers	Session
12:00 a 14:00	A Way to a Sustainable Universidad de Concepcion: Smart Parking	C. Ramírez-Rendón, I. Sanchez-Rangel, L. García-Santander	S4. Mobility and IoT
	Benefits of the integration of photovoltaic solar energy and electric mobility	M. Dávila-Sacoto, L. González, J. Espinoza, L. Hernández-Callejo	
	The role of the electrical vehicle in sustainable supply chains: a review	F.H. Amaro Verneque, P.H. González, M. Alonso Martinez, V. Almeida Guimaraes.	
	A comparative and exploratory case study of the con-cept of SDI applied to sustainable mobility. Exploring trends and divergences of SDIs in Ibero-American cities	C. Grande, T. Batista, C. Vázquez, L. Suarez, L. Navas, R. Ramírez-Pisco, R. Pérez	
	Computational intelligence for analysis of traffic data	H. Winter, J. Serra, S. Nesmachnow, A. Tchernykh, V. Shepelev	
	Exact and metaheuristic approach for bus timetable synchronization to maximize transfers	S. Nesmanchnow, J. Muraña, C. Risso.	
	Plataforma de Movilidad Compartida Metropolitana (PMCM). Sistema tipo MaaS. Córdoba, Argentina. Ciencia y tecnología al servicio de los vecinos.	L. A. Giménez, C. J. Paz	
	Development of IoT Services Applied to a Photovoltaic Generation System Integrated with Vegetation	M. Camargo-Vila, G. Osma-Pinto, H. Ortega-Boada	
	Mapping the environmental criteria for facility location problems	V. de Almeida Guimarães, P.H. González, L. Hernández-Callejo, G. Mattos Ribeiro	

Wednesday, November 11th

Time (UTC-6)	Activity	Speaker	Session
08:00 a 10:00	Human-Computer Interfaces for Smart Bus Stops as Interconnected Public Spaces (IP-Spaces) elements in Smart Cities	D. Gachet, V. M. Padrón Nápoles, J. L. E. Penelas, F. Martín de Pablos, O. García Pérez, R. Muñoz Gil, J. García González, S. Escorial Santa Marina.	S5. Mobility and IoT
	Analysis of alternatives for the acceleration of a Hyperloop system	M. Lafoz, L. García-Tabarés, J. Torres, D. Orient, D. Fons and G. Navarro.	
	Smart Mobility in Cities: GIS analysis of solar PV potential for lighting in bus shelters in the city of Ávila	M. Sánchez-Aparicio, S. Lagüela, J.A. Martín-Jimenez, S. del Pozo, E. González-González and P. de Andrés Anaya.	
	Impact of the covid-19 pandemic on traffic congestion in Latin American cities: An updated five-month study	J. Ortego Osa, R. Andara, L.M. Navas, C.L. Vasquez and R. Ramirez.	
	Conditional Generative Adversarial Networks to Model Urban Outdoor Air Pollution	J. Toutouh	
	Towards a sustainable mobility plan for Engineering Faculty, Universidad de la República, Uruguay	S. Hipogrosso, S. Nesmachnow.	
	Performance assessment of the transport sustainability in the European Union	S. B. Gruetzmacher, C. B. Vaz, A. P. Ferreira.	
	Designing IoT services in smart cities through game-based knowledge acquisition	I. García-Magariño, J. J. Gómez-Sanz.	

Wednesday, November 11th

Time (UTC-6)	Activity	Speaker	Session
10:00 a 12:00	Integration of small wind turbines in a smart microgrid in a peri-urban environment	O. Izquierdo-Monge, L. Hernández-Callejo, P. Peña-Carro, C. Barrera del Amo, S. Soria Franco, G. Martín Jiménez.	S6. Infrastructure, environment and energy Moderator: Dr. Sergio Nesmanchnow
	Modeling of a Controlled Rectifier with Adaptive Control System for Vertical Axis Micro Wind Turbines	M. Aybar, M. Baldera Arvelo, L. León Viltre, D. Mariano Hernandez, M. Baldera Echavarria.	
	Detection of Wind System Faults using Analyze Current Rotor of Aerogenerator	B. Abdelkarim, L. Hernández-Callejo, B. Silmane	
	Study of a photovoltaic plant for the reduction of diesel consumption: case of Dominican Republic	M. E. Aybar Mejía, D. Mariano-Hernández, E. A. Jiménez Matos, A. I. Roa Arias, E. A. Geara Jimenez, G. Frias Lovera, E. Bido Cuello	
	Innovative Smart Microgrid Integrating Pico-hydro Systems: The Silk House Museum	V. Leite	
	Economic optimization of photovoltaic generation system with hydrogen storage	E. Alcover, R. Pujol-Nadal, V. Martínez-Moll, J. L. Rosselló and V. Canals.	
	INBAL Solar Photovoltaic Electricity Generation and Consumption Reduction Programme	J Escamilla-Ambrosio, M. Morales-Olea, O. Espinosa-Sosa, M. A. Ramírez-Salinas, A. Rodríguez-Mota, L. Hernández-Callejo	
	Optimization of the capacity of photovoltaic arrays and modification of the geometry of a turbine-generator system to minimize dependence on the electricity grid	R. López Meraz, L. Hernández Callejo, L.O. Jamed-Boza, J.A. Del Ángel-Ramos, J.J. Marín-Hernández, V. Alonso Gómez	
12:00 a 14:00	Preliminary evaluation of different underground hydrogen storage systems in Spain	C. Sáez Blázquez, I. Martín Nieto, M. Ángel Maté-González, A. Farfán Martín, D. González-Aguilera.	S7. Infrastructure, environment and energy Moderator: Dr. Carlos Meza
	Errors in the design and execution of the well field of low enthalpy geothermal systems.	C. Sáez Blázquez, I. Martín Nieto, M. Ángel Maté-González, A. Farfán Martín, D. González-Aguilera.	
	The Profile of Studies on Renewable Energy in Sustainable Supply Chain	E. Marques, M. de Azevedo-Ferreira, L. Hernández-Callejo, R. Boloy, V. de Almeida Guimarães.	
	Technological architecture for synchrophasor measurement in power systems: an application for Colombia	J. Molina-Castro, M. Alvarez-Alvarez, L. Buitrago-Arroyave, J. Zapata-Uribe.	
	New opportunities of Broadband Power Line Communications for the improvement of the Smart Grids	N. Uribe-Perez, I. Fernandez, D. De La Vega, A. Llano, I. Arechalde, A. Galarreta.	
	Solid Oxide Fuel Cell Electric Vehicle: Cost Reduction Based on Savings in Fixed Carbon by Sugarcane	D. Rodrigues de Moraes, V. de Almeida Guimarães, L. Hernández-Callejo, B. de Noronha Gonçalves, R. Arismel Mancebo Boloy.	
	Battery Energy Storage System Dimensioning for Reducing the Fixed Term of the Electricity Access Rate in Industrial Consumptions	J. Nájera, M. Blanco, G. Navarro, M. Santos.	
	Sizing of Autonomous Microgrid Considering Life Cycle Emissions	I. Jiménez Vargas, G. Osma Pinto and Juan M. Rey.	
	Methane emissions and energy density of reservoirs of hydroelectric plants in Venezuela	R. Pérez, C. Vásquez, L. Suárez, R. Vásquez, William Osal, R. Ramírez	

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