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SERENDIPITY enabled CYBER GAMES (SeCG)

In Response to RFI Announcement #IARPA-RFI-13-03: **Using Alternate Reality Environment to Help Enrich Research Efforts (UAREHERE)**

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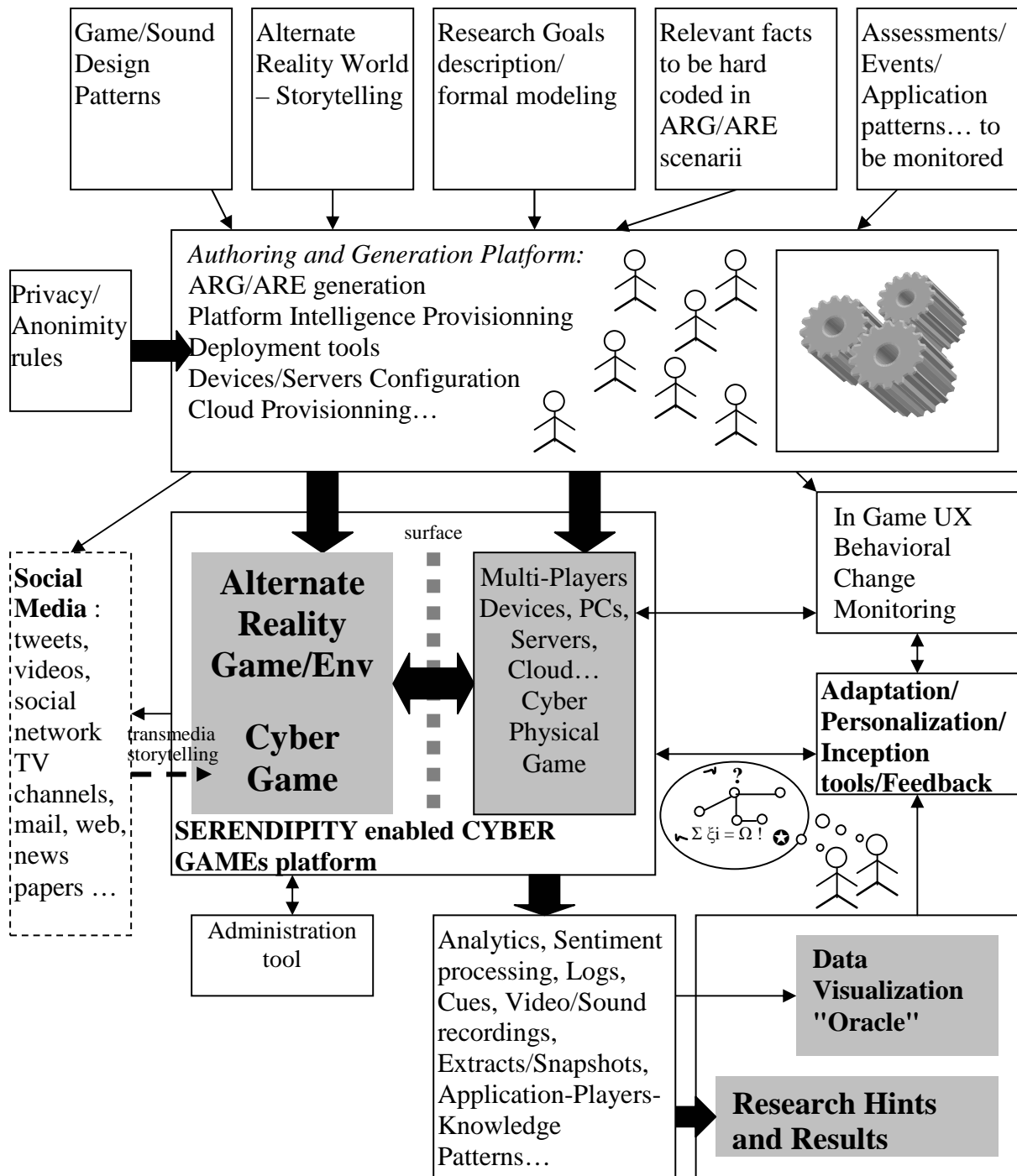**UAREHERE Approach – Using Alternate Reality Environments to Help Enrich Research Efforts RFI-IARPA-13-03**

Game/Sound Design Patterns	Alternate Reality World – Storytelling	Research Goals description/ formal modeling	Relevant facts to be hard coded in ARG/ARE scenarii	Assessments/ Events/ Application patterns… to be monitored

Privacy/ Anonimity rules

Authoring and Generation Platform:
ARG/ARE generation
Platform Intelligence Provisionning
Deployment tools
Devices/Servers Configuration
Cloud Provisionning…

Social Media :
tweets, videos, social network TV channels, mail, web, news papers …

transmedia storytelling

surface

Alternate Reality Game/Env

Cyber Game

Multi-Players Devices, PCs, Servers, Cloud… Cyber Physical Game

SERENDIPITY enabled CYBER GAMEs platform

In Game UX Behavioral Change Monitoring

Adaptation/ Personalization/ Inception tools/Feedback

$\Sigma \xi i = \Omega$!

Administration tool

Analytics, Sentiment processing, Logs, Cues, Video/Sound recordings, Extracts/Snapshots, Application-Players-Knowledge Patterns…

Data Visualization "Oracle"

Research Hints and Results

Figure 1. SERENDIPITY enabled CYBER GAMEs overview

SERENDIPITY enabled CYBER GAMES (SeCG):
a Framework for AREs/ARGs to Help Enrich Research Efforts

1. Introduction: CNAM-CEDRIC, SRI International, and Business-2-Any are pleased to present SERENDIPITY enabled CYBER GAMEs (SeCG) in response to IARPA-RFI-13-03. We draw upon our team's extensive prior experience in the field of cyber-games research to address Questions 3 and 4 in that solicitation. Specifically, we discuss some key elements to incorporate when designing or using AREs/ARGs for research purposes, and also some issues concerning the process of combining periods of controlled data collection with periods of free play.

2. Previous experience: Authors of this proposal have been deeply involved in different research projects related to pervasive games, alternate reality games, learning and gaming, cyber systems:

- AREs/ARGs: SoundPark [PEL2010], augmented paintings [HAB2010], Paris Overnight University (POU-PLUG[1]) [AST2011], ARTSENSE [ART2013], Alterland [ALT2011],
- Characteristics of human behaviours in multiplayer game environments and virtual worlds [MUR2012, LAW2012],
- Behaviour change: The Secret of the Museum PSM-PLUG [GEN2009a, GEN2009b], electric car driving gamification [ODE2013],
- Adaptive instruction, interactive learning and mobile gaming [DIE2009], POU-PLUG [AST2011],
- Platforms for pervasive gaming: GASP [PEL2005], uGASP [PEL2008, PEL2010], pervasive gaming middleware and player profile management [PEL2009], adaptive and pervasive games [GRE2011], Cloud Computing for MMO pervasive games in the context of the PLAY ONLINE project [CAP2010] supported by Cap Digital[2], cyber physical games [CHO2013],
- Knowledge modeling for pervasive/cyber systems: Internet of Things [GAU2011, GAU2013], [KIM2010], [KIM2012], [KIM2013], [CHO2013].

3. Project Presentation: The name of the project "SERENDIPITY enabled CYBER GAMEs" (SeCG) came up from the word cloud, generated with Wordle [WOR2013] and provided below Figure 2. This cloud has been issued from key words of our research topics; from some texts we wrote down and from conference calls where we would like to publish our results on next generation AREs/ARGs. "serendipity", "cyber" and "games" are relevant and match features we want to address.

Our projects in a cultural context [AST2011] or related with behavioral change [ODE2013] showed us the importance of pervasivity for learning. As [GUS2010] explained, pervasivity makes easier what classic learning theory calls "transfer", that is: apply abstract knowledge learned in everyday life. For these reasons, pervasive gaming is a basis of our approach.

The following sections describe most hints and key features of the next generation Alternate Reality Environments/Alternate Reality Games (AREs/ARGs) to answer the RFI-IARPA-13-03, UAREHERE – "Using Alternate Reality Environments to Help Enrich Research Efforts". The SeCG framework is depicted Figure 1, page 2 of this document.

4. Behaviour modeling: Behaviour modeling is a key issue of SeCG, and may be one of the trickiest. Behaviour modelling is embedded inside the overall SeCG framework. It is the

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[1] PLUG stands for PLay Ubiquitous Games and play more, 2008-2010 (27 months). The consortium with academics and enterprises (http://cedric.cnam.fr/index.php/labo/projet/view?id=13, french). It is a French research agency funded project. It is related to cultural heritage and ubiquitous gaming to learn and play. Two ubiquitous games have been delivered PSM and POU. Eric Gressier-Soudan was the coordinator of the project.
[2] Cap Digital(http://www.capdigital.com/en/) is a French business cluster for digital contents & services in Paris.

reason why it doesn't appear in Figure 1. Its aim is to understand how people think, react and adapt as single entities thru the ARG/ARE. That is to say understand, in some specific situations and for many different users, how users: settle their objectives (aims, motivations…), feel (apprehend, sense), analyze (internal mechanisms, mental schemes, culture…), react (skills, know-how), adapt (auto-organize, i.e. use auto-learning curves to feel/analyze/react in case of unknown situation, return over experience); prioritize their own objectives, depending on the situation, change their objectives in case they cannot feel/analyze/react (adaptation to avoid cognitive burn-out). Several tasks have been identified to provide an efficient framework.

Figure 2. Cloud word related to next generation pervasive games

- **Modeling:**

1) *Modeling contexts* will be used to experiment modeled behaviours, then further to understand how human beings apprehend/react/adapt in those contexts.
    - Definition of contexts: Identify and describe relevant contexts for experiments.
    - Modeling of contexts: Model and automate (if required) elements of the relevant contexts in order to feed further testing of modeled behaviours.
    - Iterations of modeling based on the feedback from experience. This step illustrates the recursive way the modeled behaviours will be processed. The initial models will be extended or enhanced throughout experiences.

2) This task will be to *model single person behaviours*. Behaviour in the context of person modelling implicitly refers also to knowledge and learning. Step by step, achieving the goal to obtain accurate models of human behaviours that would feed further work on artificial intelligence for different purposes: marketing, military, industry, etc.
    - Definition of behaviours: Identify and exhaustively describe relevant behaviours of human beings when facing different contexts.
    - Model and automate human behaviours on the basis of a systemic and cybernetic method formerly used in the French army and the Industry.
    - Iterations of modeling based on the statements provided by experiences. This step will be also iterated. Tangible behaviours will be the ones that have been refined through a parallel process of testing.

3) The third task will be to *model some AREs* that will be experimented on modeled behaviours, then further understand how human beings change their perception, reaction or adaptation in several contexts with those AREs/ARGs. This modeling work is an iterative process. Different information or stimuli extracted from the AREs/ARGs will then feed the modeled behaviours.
    Modeling relies on "intelligent" avatars, CyberAvatars, executed on computers and that exchange data. Computers can be mobile devices or servers on the Cloud. One or more avatars can model a user and its behaviour.

- **Model Testing:** Tests and result analysis must be driven with stakeholders of the project and by experts on cognitive/social/behavioural and psychological research. A comparison between modeled and real behaviours is part of this work.

1) The first task will be to *test single behaviour models* in contexts. This stage is about testing the modeled behaviours in different contexts to check whether the modeling is correct or not. This is actually the refining phase of the process that would allow, in an iterated way, to obtain a tangible and usable model of human behaviour.

2) The second task will be to *analyze how ARE/ARG can impact human cognitive state*. It will be useful for the researchers to understand how ARE(s) can influence, impact or change human cognitive balance.

3) The last task will be to *use real people* for testing purposes. This process is a parallel one in the project. The use of people for testing issues will only be relevant when: the modeling of behaviours is impossible through an abstract work, and additional observations of real humans immerged in the same situations are required.

Sections just after explain different building blocks of SeCG, given in Figure 1. The Social Media component is very standard and then not explained. It can also feed the ARE/ARG if the game design is transmedia storytelling based.

5. Provisioning the Authoring and Generation Platform:

- **Game Design and Storytelling:** The game should be carefully designed. The balance between goals to be reached and play is difficult to achieve. We partially failed in PSM-PLUG, fun was the heart of the game. And we succeeded in POU-PLUG, because learning was driving the design of the pervasive game before fun. In POU-PLUG, flow [CSI1990] and magic circle [HUI1949] also helped to guide the design. Mobility, different kinds of media and multiple connected devices allowed some transmedia storytelling that helped to foster players' immersion. The ARG Alt-minds is a significant example of a successful transmedia storytelling [ALT2012].

  During the PLUG project, we made an unexpected statement. POU-PLUG completely satisfied our goal to learn how an invention emerges. But PSM-PLUG allowed new behaviours in the museum: linearity of the visit was broken, the museum became a social space, and even players discovered a new way to use their Near Field Communication enabled mobile phone. For the team, a peer to peer exchange between two mobile phones was a game action (virtual cards exchange), for the players, it was a new user experience: they called it a digital French kiss. This unexpected statement is a demonstration of serendipity.

- **Goals, Facts and Events modeling:** In the context of UAREHERE, relevant research goals, facts and event modeling are expected to be well defined. Application patterns could have been identified and should be reproduced in the ARG. This step is difficult and requires caution. The relationship between formal methods and game design is an emerging research field [CHOI2013], [BOS2011], [CHA2005].

6. Authoring and Generation Platform: An Authoring and Generation Platform is required in the design phase of the ARE/ARG. The WEZIT platform from Mazedia [MAZ2013] is dedicated to cultural heritage, but it provides a first overview of what a platform for pervasive games should offer. Mainly an authoring and Generation platform helps to build the final ARE/ARG and to gather the different inputs to provide some serious pervasive multiplayer game. Our platform is partially automated, and partially designer driven. Designer should be considered in a broader sense: programmers, game designers, researcher linked to the problem to be solved, psychologists… all stakeholders of the ARE/ARGs project and its results.

Our platform helps to generate and deploy the contents of AREs/ARGs, the code for servers and client devices (apps for example), their configuration (mandatory software components, dynamic ones…) and to provision resources such as Cloud (PaaS approach seems to be

appropriate). The resulting ARE/ARG should take into account privacy rules at least, and if required anonymity rules.

The platform should also include some features to provision the intelligence of the game that will help to discover new research results, new behaviours, all what UAREHERE can expect.

7. SERENDIPITY enabled CYBER GAME environment: This part is the heart of the project. It instantiates behaviour modeling through cyber games. It covers the execution framework of multiplayer pervasive games. It means mostly: the game universe, the game logic engine, levels, sounds, augmented reality enhancements, images, videos… the same framework as described in [MON2010] and that we implemented in [GRE2011]. We are convinced that SeCG can benefit from a networked cyber physical approach on the device side [CHOI2013][KIM2010]. It can help to coordinate group of players on the field while achieving their goals. Moreover the architecture of SeCG needs some specific considerations to connect virtual and real worlds, cyber game and cyber physical game. To ensure this connection, we use the model issued from [YAN2009] able to formalize the relationship between virtual and real objects, avatars and real people… thru sensors and actuators both in the virtual life (ex: virtual sensor) and the real life (ex: real actuator).

Personalisation, Adaptation and Feedback are important features of SeCG. Players would like to define their own in game parameters such as avatars, profile, skills, preferences, buddys, etc. The game should provide means to build different player roles.

While in game, the game should adapt to the players, we made this statement through POU-PLUG where a monitoring tool was implemented to track player behaviour, to provide information to a game master, and to tune the game rules and difficulties for the players. But adaptation is a wider feature in the context of the UAREHERE call. It covers game aspects, but also research aspects embedded in the game, stakeholders should be able to adjust dynamically the purpose of the ARE/ARG.

Also, players can discover their own game patterns that match research goal. These patterns then should be themselves injected into the game. It is a specific case of design pattern that we call "inception" in reference to the movie Inception [NOL2010]. Players should be able to launch their own ARE/ARG inside the original ARE/ARG. Further, a new and deeper immersion can be fostered in the context of the launch. It can go on recursively. This ability to allow inception is the grail of adaptation.

The overall set of features, from monitoring players experience to adaptation, defines a feedback loop that helps to monitor the overall ARE/ARG.

8. Outputs: The execution of the ARE/ARG delivers logs, events, snapshots, traces, cues, recordings (videos, sounds, motions…). These raw data can be processed, through a bigdata approach, to produce two kinds of results: analytics and patterns. Analytics can help to extract metadata that gives a global overview of how the game evolves. Data Visualization can help to express meaningful information. Patterns express application or player behaviour, learning process, knowledge building process. Application patterns have been studied in the context of networked cyber-physical systems such as pervasive game [KIM2010], from which we can leverage ideas of how to design ARG/ARE and collect/analyze behavioural patterns/models using the principled way supported by NCPS framework [CHO2013] and programing paradigm for loosely coupled systems.

Significant cues can lead to reconsider some of the features of the ARE/ARG. The SeCG should make it possible. But modifying dynamically an ARE/ARG is complex and should be carefully handled. It should be achieved through the adaptation functionality.

References:

[ALT2011] Alterland pervasive game video. PLAY ONLINE project. (French) http://www.youtube.com/watch?v=XTndb9LNbPU. Accessed April 16th 2013.

[ALT2012] Alt-Mind. Lexis Numérique. http://www.missing-mhd6.com/?lang=en. Accessed April 16th 2013.

[ART2013] Artsense European Project. http://www.artsense.eu/. Accessed April 16th 2013.

[AST2011] I. Astic, C. Aunis, A. Damala, E. Gressier-Soudan. "An Ubiquitous Mobile Edutainment Application For Learning Science Through Play". Museum and the Web, International Conference for Culture and Heritage Online. April 6-9 2011. Philapdelphia. USA.http://www.museumsandtheweb.com/mw2011/papers/a_ubiquitous_mobile_edutainment_application_fo

[BOS2011] A-G. Bosser, P. Courtieu, J. Forest, M. Cavazza: Structural Analysis of Narratives with the Coq Proof Assistant. ITP 2011: pp55-70.

[CAP2010] Cap Digital Innovation Cluster. Digital Content and Services. 01.2010. http://www.invest-in-france.org/Medias/Publications/818/Cap%20Digital_EN.pdf. Accessed April 16th 2013.

[CHA2005] R. Champagnat, A. Prigent and P. Estraillier . "Scenario building based on formal methods and adaptative execution", ISAGA'2005 (International Simulation and gaming association) Georgia Institute of technology, 27juin-1er juillet 2015.

[CHO2013] J.-S. Choi, T. McCarthy, M. Yadav, M. Kim, C. Talcott, E. Gressier-Soudan. Application Patterns for Cyber-Physical Systems. Submitted to CPSNA'2013. http://www.cpsna.org/

[CSI1990] Csikszentmihalyi, M. 1990 Flow: The Psychology of Optimal Experience. London: Harper Perennial.

[DIE2009] E Dieterle and J. Murray. Realizing Adaptive Instruction (Ad-In): The Convergence of Learning, Instruction, and Assessment. Foundations of Augmented Cognition. Neuroergonomics and Operational Neuroscience, Lecture Notes in Computer Science Volume 5638, 2009, pp 601-610

[GAU2011] P. Gautier, L. Gonzalez. L'Internet des objets : Internet, mais en mieux. (French) AFNOR Editions. 2011.

[GAU2013] P. Gautier. I-O-T INTERNET of THINGS. http://www.i-o-t.org/. Accessed April 16th 2013.

[GEN2009a]A. Gentes, C. Jutant, A. Guyot, and M. Simatic. RFID technology: Fostering human interactions. Proceedings of IADIS International Conference Game and Entertainment Technologies 2009, pages 67–74. International Association for Development of the Information Society (iadis), IADIS Press, K. Blashki, editor, June 2009.

[GEN2009b]A. Gentes, C. Jutant, A. Guyot, and M. Simatic Designing mobility: pervasiveness as the enchanting tool of mobility Proceedings of the 1st international ICST Workshop on Innovative Mobile User Interactivity (IMUI 2009). San Diego, USA, ICST, 29th October 2009.

[GRE2011] E. Gressier-Soudan, R. Pellerin, M. Simatic. "Chapter 10. Using RFID/NFC for pervasive serious games: the PLUG experience". Editors : Syed Ahson, Microsoft, Redmond, Washington, Mohammad Ilyas, College of Engineering & Computer Science, Florida Atlantic University. CRC Press. Taylor and Francis. Sep 23th 2011. pp279-303. ISBN 9781420088144.

[GUS2010] A. Gustafsson, C. Katzeff, and M. Bang. 2010. Evaluation of a pervasive game for domestic energy engagement among teenagers. Comput. Entertain. 7, 4, paper 54. January 2010, 19 p.

[HAB2010] O. Haberman, A. Damala, R. Pellerin, E. Gressier-Soudan, U. Haberman. "Exploring Contemporary Painting through Spatial Annotations Using RFID Tags". In

VAST'10, Virtual Reality, Archaeology and Cultural Heritage, The 8th EUROGRAPHICS Workshop on Graphics and Cultural Heritage, Short and Project Papers, Paris, France, September 21-24, 2010, pp. 49-52, Eurographics, 2010.

[HUI1949] Huizinga, J. (1949). Homo ludens: A study of the play-element in culture. London: Routledge.

[KIM2010] M. Kim, M.-O. Stehr, J. Kim, and S. Ha. An application framework for loosely coupled networked cyber-physical systems. In 8th IEEE Int. Conf. Embedded and Ubiquitous Computing (EUC'10), 2010.

[KIM2012] J. Kim, M. Kim, M.-O. Stehr, H. Oh, and S. Ha. A parallel and distributed meta-heuristic framework based on partially ordered knowledge sharing. ELSEVIER Journal of Parallel and Distributed Computing (JPDC), 72(4):564–578, 2012.

[KIM2013] M. Kim, M.-O. Stehr, and C. Talcott. A distributed logic for networked cyber-physical systems. ELSEVIER Journal of Science of Computer Programming, 2013. Available Online http://dx.doi.org/10.1016/j.scico.2013.01.011.

[LAW2012] Lawson, A et al. "Socio-linguistic decisions and gender mapping across real and virtual world cultures". 2nd International Conference on Cross-Cultural Decision Making, July 2012, San Francisco, CA. USA

[MAZ2013] Mazedia. Plateforme Wezit. (french) http://www.wezit-platform.com/. Accessed April 16th 2013.

[MON2010] M. Montola, J. Stenros, A. Waern. "Pervasive Games Theory and Design, Experiences on the boundary Between Life and play". Morgan Kaufmann Publishers. 2010.

[MUR2012] Murray J et al."IARPA Reynard Verus Final Report - AFRL-RY-WP-TR-2012-0286", US Air Force Research Laboratory, Wright-Patterson AFB, OH, November 2012.

[NOL2010] C. Nolan. "Inception". http://inception.wikia.com/wiki/Inception_(2010_film). December 2013. Accessed April 16th 2013.

[ODE2013] L. Odeh, N. Ke-Chen Pong, I. Astic, E. Gressier-Soudan, L. Causse, M. Diaz. Gamification pervasive pour la conduite du changement appliqué au pilotage de véhicules électriques. (french). Submitted to Ubimod'2013. http://ubimob2013.sciencesconf.org/resource/page/id/2.

[PEL2005] R. Pellerin, F. Delpiano, F. Duclos, E. Gressier-Soudan, M. Simatic. "GASP: an open source gaming service middleware dedicated to multiplayer games for J2ME based mobile phones". 7th International Conference on Computer Games CGAMES'05, 28th November, ANGOULEME, FRANCE, pp. 75-82, 2005.

[PEL2008] R. Pellerin, E. Gressier-Soudan and M. Simatic. "uGASP: an OSGi based middleware enabling multiplayer ubiquitous gaming". In International Conference on Pervasive Services, ICPS 2008 Demonstration Workshop, Sorento, Italy, July 6-10th 2008.

[PEL2009] Romain Pellerin, Chen Yan, Julien Cordry, Eric Gressier-Soudan. "Player Profile Management on NFC Smart Card for Multiplayer Ubiquitous Games". Hindawi Publishing Corporation, International Journal of Computer Games Technology, Volume 2009, Article ID 323095, 9 pages, doi:10.1155/2009/323095

[PEL2010] R. Pellerin, N. Bouillot, T. Pietkiewicz, M. Wozniewski, Z. Settel, E. Gressier-Soudan, J. R. Cooperstock. "SoundPark: Exploring Ubiquitous Computing through a Mixed Reality Multi-player Game Experiment". Studia Informatica Universalis. V8. N3. October 2010.p25-45 http://studia.complexica.net/Art/RI080302.pdf

[SCH2010] Jesse Schell. 2010. The Art of Game Design. Pearson Campuspress, November 2010, 540 p.

[YAN2009] S. Natkin, C. Yan. IJCINI. Int'l Journal of Cognitive Informatics and Natural Intelligence, 3(2), 61-83, April-June 2009.

[WOR2013] Wordle. http://www.wordle.net/. Accessed April 16th 2013.