SeCG: SERENDIPITY enabled CYBER GAMES project

E. Gressier, I. Astic, S. Natkin
CNAM-Cedric Lab
292, rue St Martin
75141 Paris Cedex 03 France
+33 (1) 402 722 96
{name}@cnam.fr

J. Murray, M. Kim, C. Talcott
SRI International – CSL
333 Ravenswood Av
Menlo Park California, USA
+1 (650) 859-2000
{jxm,mkim,ctl}@csl.sri.com

P. Gautier
Business2Any
30, Boulevard Bellerive
92500 Rueil-Malmaison France
+33 (6) 191 300 25
pgautier@business2any.com

ABSTRACT
In this paper, we describe important elements and key features of the next generation Alternate Reality Environments/Alternate Reality Games (AREs/ARGs). The aim of the project is to provide a framework able to help to solve research problems through cyber-games.

Categories and Subject Descriptors
I.2.1 Applications and Expert Systems; K.3.1 Computer Uses in Education; H.5.1 Multimedia Information Systems;

General Terms
Algorithms, Human Factors, Experimentation

Keywords
ARG, pervasive games, transmedia storytelling, networked cyber physical systems, problem solving, cyber objects, knowledge modeling

1. INTRODUCTION
From the outset, the SERENDIPITY enabled CYBER GAMEs project, SeCG for short, has been an initiative intended to help enrich research efforts using Augmented Reality Environments as described in the call UAREHERE [12] from the US government. The aim of the project is to provide a framework able to help to solve research problems through cyber-games. 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. Problem solving through games has already been tested [13] but we aim to provide a general framework.

Analyzing our previous projects in a cultural context [2] showed us the importance of pervasivity for learning. As [10] explained, pervasivity improves what classic learning theory calls “transfer”, that is: the application of abstract knowledge learned in everyday life. For these reasons, pervasive gaming is a starting point of our approach.

Laval Virtual VRIC’14, April 9-11, 2014, Laval, France.

Networked Cyber-Physical Systems (NCPSs) are typically designed as a network of interacting nodes that sense and affect their environments [14]. NCPSs are the next generation of distributed embedded systems. Application patterns have been studied in the context of networked cyber-physical systems such as pervasive game [14] and we deeply believe that this approach is a foundation to build cybergames.

The following sections describe the key features of the next generation Alternate Reality Environments/Alternate Reality Games (AREs/ARGs) that are needed to Help Enrich Research Efforts. The SeCG overall framework is depicted Figure 2, next page of this document.

2. BEHAVIOUR MODELING
Behaviour modelling is a key issue of SeCG, and may be one of the trickiest. Behaviour modelling is embedded inside the overall SeCG framework. Its aim is to understand how people think, react and adapt as single entities through 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.

- **Modelling:**

Modelling is a preliminary step, and, right now not considered as an automated part of the project. Modelling needs a fine grain tuning. It relies on three tasks: model contexts, model behaviour, model AREs/ARGs.

1) Model contexts. It will be used to experiment behaviours, then further to understand how human beings apprehend/react/adapt in those contexts.
   - Definition of contexts: Identify and describe relevant contexts for experiments.
   - Modelling of contexts: Elements of the relevant contexts in order to feed further testing of behaviours.
   - Iterations of modelling based on the feedback from experience. This step illustrates the recursive way the modelled behaviours will be processed. The initial models will be extended or enhanced throughout experiences.
2) 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

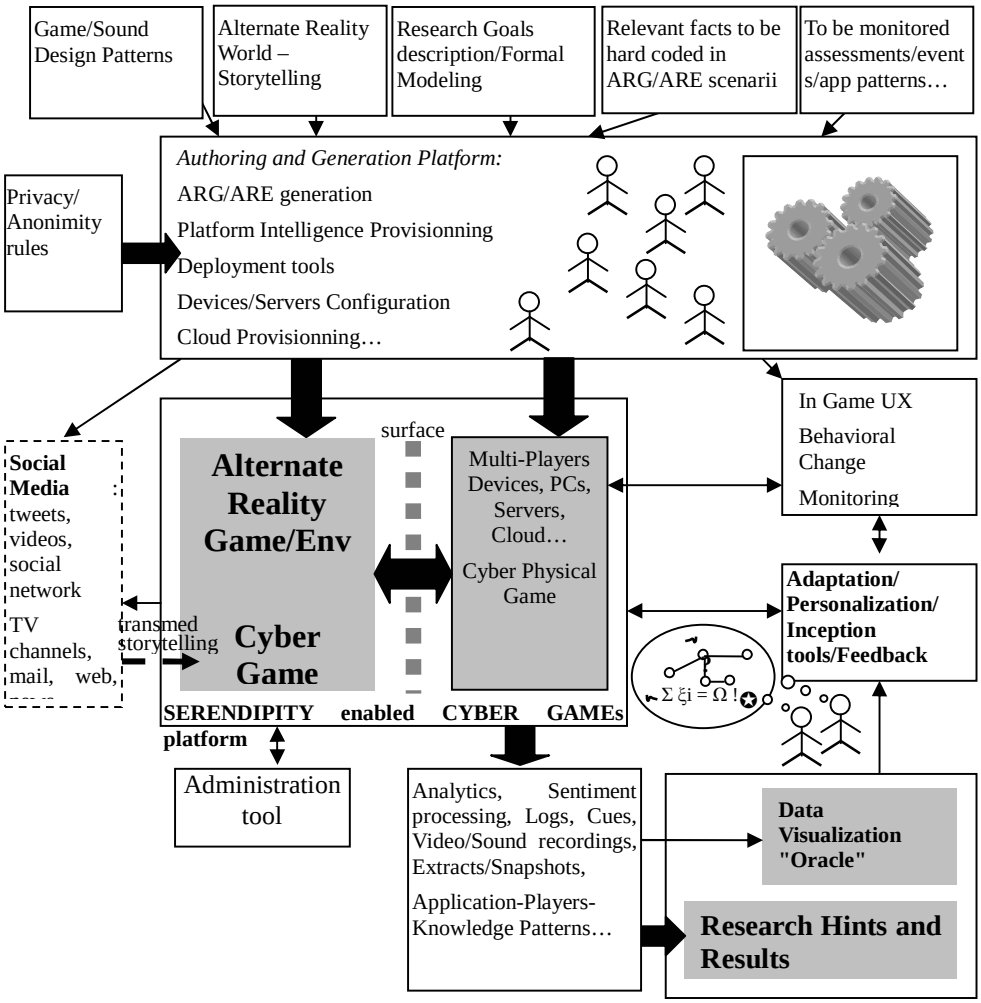

Figure 1. SERENDIPITY enabled CYBER GAMEs overview

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. [25]
- Iterations of modelling based on the statements provided by experiences. Tangible behaviours will be the ones that have been refined through a parallel process of testing.

3) Model AREs. Some AREs will be experimented on behaviours. The aim is to further understand how human beings change their perception, reaction or adaptation in several contexts with those AREs/ARGs. This modelling work is an iterative process. Different information or stimuli extracted from the AREs/ARGs will then feed the behaviours. Modelling 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 modelled and real behaviours is part of this work. Model testing is also not automated in a first phase of the project. We need a sharp analysis of the provided results to be able to tune the modelling process and its impact on the overall SeCG framework.

1) The first task will be to test single behaviour models in contexts. This stage is about testing the behaviours in different contexts to check whether the modelling 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. People for testing issues will only be relevant when: the modelling of behaviours is impossible through an abstract work, and additional observations of real humans immerged in the same situations are required.

The following sections explain the different building blocks of SeCG, given in Figure 1. The heart of the platform is the ARE/ARG. It is fed by models, requirements, game design, relevant facts… through an authoring tool. Results are logs, behaviour patterns and analytics able to tune goals and results.

3. 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. Most of these learnings came from PLUG [2]. We partially failed in the first game of PLUG (The Secret of the Museum, TSM-PLUG), fun was the heart of the game. We succeeded in the second game (Paris Overnight University, POU-PLUG), because learning was driving the design of the pervasive game before fun. In POU-PLUG, flow [6] and magic circle [11] 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 [3].
  During the PLUG project, we made an unexpected discovery. POU-PLUG completely satisfied our goal to learn how an invention emerges. But TSM-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 kiss. This unexpected statement is a demonstration of some kind of serendipity.
- **Goals, Facts and Events modelling**: In the context of the project, relevant research goals, facts and event modelling 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 [5], [3], [4].

4. AUTHORING AND GENERATION PLATFORM

An Authoring and Generation Platform is required in the design phase of the ARE/ARG. Such off the shelf platforms exist. We use some in the context of interactive applications for cultural content. 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 a Cloud based architecture. 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.

5. SERENDIPITY ENABLED CYBER GAME ENVIRONMENT

This part is the heart of the project. 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 [18] and that we implemented in [9]. We are convinced that SeCG can benefit from a networked cyber physical approach on the device side [5][14]. 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 from [20], which enables the formalization of relationships 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 discovery 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 project. 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 [21]. 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 run the overall ARE/ARG.

6. 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 [14], 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 [5] 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. A dedicated function, called adaptation, is provided to enable on the fly changes to the ARE/ARG.

7. PREVIOUS EXPERIENCES AND TRENDS

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 [23], Paris Overnight University [2], ARTSENSE [1], Alterland [24],
- Characteristics of human behaviours in multiplayer game environments and virtual worlds [19], [17],
- Adaptive gaming, interactive learning and mobile gaming [7], POU-PLUG [2],
- Platforms for pervasive gaming: uGASP [23], player profile management [22], adaptive and pervasive games [9], Cloud Computing for MMO pervasive games in the context of the PLAY ONLINE project [24], cyber physical games [5],
- Knowledge modelling for pervasive/cyber systems: [8], [14], [15], [16], [5].

First building blocks related to the game platform are targeted for a transmedia based serious pervasive game for a museum in Paris.

8. REFERENCES

[1] Artsense European Project. 2011. http://www.artsense.eu/. Accessed April 16th 2013.

[2] Astic I., Aunis C., Damala A., Gressier-Soudan E. "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. Philadelphia. USA.

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

[4] Champagnat R., Prigent A. and Estraillier P. "Scenario building based on formal methods and adaptative execution", ISAGA'2005 (International Simulation and gaming association) Georgia Institute of technology, 06/27-07/01 2005.

[5] Choi J.-S., McCarthy T., Yadav M., Kim M. , Talcott C., Gressier-Soudan E.. 2013. Application Patterns for Cyber-Physical Systems. CPSNA'2013. August 2013. Taiwan.

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

[7] Dieterle E, Murray J. 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

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

[9] Gressier-Soudan E., Pellerin R., 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.

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

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

[12] IARPA 2013, Request for Information (RFI) - Using Alternate Reality Environments to Help Enrich Research Efforts (UAREHERE). IARPA-RFI-13-03. http://www.iarpa.gov/RFI/rfi_uarehere.html

[13] Khatib F., DiMaio F., Foldit Contenders Grp, Foldit Void Crushers Grp, Cooper S., Kazmierczyk M., Gilski M., Krzywda S., Zabranska H., Pichova I., Thompson J., Popović Z., Jaskolski M., Baker D. Crystal structure of a monomeric retroviral protease solved by protein folding game players. Nature Structural & Molecular Biology 18, pp1175–1177. 2011 doi:10.1038/nsmb.2119

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

[15] Kim J., Kim M., Stehr M-O., Oh H., Ha S. 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.

[16] Kim M., Stehr M-O., Talcott C. 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.

[17] 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.

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

[19] 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.

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

[21] Nolan C. 2011. "Inception". http://inception.wikia.com/wiki/Inception_(2010_film). December 2013. Accessed April 16th 2013.

[22] Pellerin R., Yan C., Cordry J., Gressier-Soudan E. "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

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

[24] PLAY ONLINE project. 2011. Alterland pervasive game video. http://www.youtube.com/watch?v=XTndb9LNbPU. (French) Accessed April 16th 2013.

[25] Verron G. 1999. Guy Véron, "Conception des systèmes socio-techniques: apport de l'Analyse Décisionnelle", (French) p49-54, L'Armement – revue de la Délégation Générale pour l'Armement, septembre 1999.