User Model in Multiplayer Mixed Reality Entertainment Applications

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ABSTRACT
Most computer games and more generally entertainment applications use implicitly or explicitly a user model as a reference for the gameplay and dramaturgy progression. With mixed reality technology and ubiquitous computing, user-centered design is required now more than ever to provide an adaptable and personal content at any time and in any context. The goal of our research is to provide a narration model correlated to a user model in the design of mixed reality entertainment. In this paper we give a brief survey of the current researches on user model for adaptation and personalization of services and some empirical studies of user model in games and interactive narration. We propose three possible levels of the user model: generic, localized and personalized and three types of narration scheme. We will describe that the user model and narration schemes can be used in a mixed reality system.

Categories and Subject Descriptors
C.0. [Computer Systems Organization]: System Architectures.
H.5.2. [Information Interfaces and Presentation]: User Interfaces – User-centered Design, User Interface Management systems (UIIMS).
I.6.5. [Computing methodologies]: Simulation and Modeling - Model Development.

General Terms
Design, Human Factors, Theory.

Keywords
Mixed Reality, User Model, Multiplayer Online Games, Proactive Game, Location based Games, Ubiquitous System, Context Aware, Adaptive, Mobile, Interactive Narrative.

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ACE ’06, June 14-16, 2006, Hollywood, California, USA.
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1. INTRODUCTION
An increasing complexity of relationships between the real world and the virtual world is arising in the next generation games [4]. For example, there have already been several attempts to use real-time events (sports, variety shows, and even political events) broadcast through media such as radio and TV as the background of a game played on an interactive TV set. It is also well known that Massively Multiplayer Online Games (MMOGs, such as World of Warcraft, Blizzard, 2004) have complex economic systems and that some of the virtual goods produced can be sold on the real market, which has a direct impact on the real economy.

All of these games also develop new types of interaction between the player and the game system. In a near future, this interaction will not be limited in Human-Computer Interaction (HCI), but be expanded in Real world-Gaming system Interaction (RGI). The HCI focuses the ways on how user accedes to the digital data and manipulates or modifies them. These interactions could be classical, tangible or even emotional. But RGI has much larger sense; it’s the interaction between the real world and the virtual system with the user presenting in both worlds, which may be defined as one or several of the following properties:

- Proactive: the game interacts with the player’s life at uncontrolled times through, for example, email and phone.
- Social: the game leads to social interactions between the players.
- Ubiquitous: the game interacts with the player at non dedicated locations through no dedicated objects or concepts of real life.
- Mobile: the gameplay relies on the player’s physical mobility. In Mogi (Newtgame, 2003), there is a mapping between the topology of the virtual world and the topology of the real one: players are searching for virtual treasures in real towns.

The essence of gameplay is to be designed according to the point of view of a potential user [27]. This user is implicitly or explicitly coded in the game: all games, and, more generally, all entertainment applications include a model of the user. In single player games, it starts from a rough classification of the target players and a limited memory of player's actions in the game, but it can also be a complex cognitive model (see next section). In multiplayer games the model contains social attributes and behaviours. In multiplayer ubiquitous games, the model must be cognitive, social and related to the history and to the current situation of the player in both the virtual and the real world. This paper investigates the nature of the user model from a narrative goal point of view: which kind of memory system must be used to
generate some narratives having themselves social or psychological goals. We aim to provide narration models correlated to a user model in the design of mixed reality entertainment. It will allow producing adaptable contents according to different user profiles, more precisely, it will supply response to each player's individual needs and current situations. The goal of our research is to define a model of mixed reality interactive narration able to:

- Define the global principle of the game: goal of the game, why the user is interested to play and what type of interactions are involved.
- Define the ludic and narrative principles, the objects in the real and the virtual worlds and their semantic relations, and the user model.
- Define the learning process of the user model and the decision process of the ludo-narrative system.

In this paper we first present briefly related works of user model. In previous work [26] we analyzed and classified mixed reality applications and the complex relationships they create between the real and virtual worlds. Then we recall a feedback scheme that we have defined. The next section considers three possible levels of the user model: generic, localized and personalized. Considering the model of the user as a key element of the game system, we propose three types of narration scheme: global, context-oriented and character-based. We describe the relations between the user's model and the narration then, we introduce a possible framework for the system architecture. Next, we give some possible scenarios to show the possibility of using them in a mixed reality application. In the end, the conclusion and future work are given.

2. RELATED WORKS

A user model represents the set of information needed to predict some user behaviours under a set of possible stimulation. The user model contains some evaluations of the physical situation, and some psychological and social parameters deduced from existing cognitive and sociological models. For example, players have intrinsic personal motivation and extrinsic social motivation [23]: personal motivation refers, for example, to challenge, curiosity, feeling of control, and fantasy; the social motivation refers to cooperation or competition with other persons, and personal recognition. All this data is the result of a calibration process based on real practices of an interface. On the basis of the user model, a system can provide the user with services or information fitting the user's specific need, and form the compatible interaction and adaptive interface to the user's specific context.

User modeling is one of the major subjects of HCI research [13]. Over the past ten years, the research area on user model has covered several different domains such as natural interaction between system and user, human-computer interaction, intelligent agent, information retrieval and high-functionality applications [14]. These works concentrate on two axes: one is called adaptation of user interaction and the other personalization of services (or information). The goal of the first type of research is the adaptation of the user interface according to its context of usage; the second type of work tries to personalize a given application to the user's preferences and needs.

In the first case the user model relies on the technologies of mobile computing and ubiquitous computing [35]. A new concept of "Adaptive Hypermedia" appeared in the beginning of 90s [5]. For example, the Aura Project at Carnegie Mellon University proposes contextual information services adapting to the user's current location and surrounding [16]. A survey of the context-aware applications could be found in [20]. In general the user model is the conceptual basis of the proposal and not an operational tool (represented in the system) of the adaptive interaction.

The work of Picard [30] focuses on the personalization of service point of view. In this case, the user model contains knowledge of user's emotions, affection states, motivations and performances. The user's model proposed by [34] has three levels: "user modeling, which includes a profile of an individual user; user clustering, which is based on similarities between user profiles and forming a user cluster using some form of automated technique; and community modelling, which includes a profile about the social group as a whole, not as the sum or the average of its individual member's profiles". These three levels of knowledge can be used simultaneously in multi-user application to control social and individual influence of the content. Most computer-aided teaching environments apply a user mental model as a guideline or method to select content or to dynamically generate suggestions, which can match the user's interests, motivations and skills. All the user models include a more or less complex estimation of the student learning curve, and some evaluations of their emotional states: "attentive", "distracted", "slumped", "showing pleasure", "showing displeasure" [1] or the conceptualisation capability of the student [25]. The formal representation of this knowledge is generally a probabilistic automaton. This type of work provides fundamental brick for new interactive user-centered design, but translating these approaches into operational game design rules and the corresponding authoring tools is an open problem.

In digital game research, the idea of a player model started from the analysis of player behaviors in Massively Multiplayer Online Role-Playing Games (MMORPGs). Players with similar motivations can be grouped into the same "Player types" [2]; achievers, explorers, socializers and killers. Based on Bartle's prior model, more researches are being carried out on player types with their quality (behavior) indicators by social cognitive theory [31], on motivations and psychological experiences of MMORPG players [18, 36], on emotional response patterns in game design [6, 15]. Several authors have analyzed the player behavior from the analysis of violence and addiction to positive psychological effects in players [3, 17, 32]. Game designers also try to find solutions using Artificial Intelligence (AI) techniques to produce more adaptable gaming experiences: case-based plan recognition is used in games to predict the player's actions [12]; intelligent interfaces for game adaptation provide a perceptual and functional interface between each individual player and game [9]. Some explicit player modeling aspects can be found in adaptive games and player-centred digital games [8, 19]. A machine learning technique is used to smooth the learning curve and enhance the individualized gameplay experience.

These works use the user's states to improve the playability (game is re-playable) of the game. Few works have been found or exploited on the content creation that can be adaptable in...
elaborated schemes to orient the game directions and to generate or mobile gaming environments. Thus a game narration can take into account the knowledge of user's states or behaviors in the system design, it will be helpful to employ and utilise the user model proposed by most of these works is only usable and utilisable in certain specific domains. Considering the user's activity space embedded with computing and information systems becomes ubiquitous and proactive, our point of view is to consider the interaction between the real and the virtual world in a mixed reality mode, and the possible actions of the user in both universes. For understanding and modelling the user experiences during the system design, it will be helpful to employ and integrate a user model in the system. The user model will not only take into account the knowledge of user's states or behaviors in classical online gaming situations but also in augmented outdoor or mobile gaming environments. Thus a game narration mechanism responsive to this complex user model requires more elaborated schemes to orient the game directions and to generate the feedback in the real world.

3. ARCHITECTURE OF THE MIXED REALITY SYSTEM

3.1 Basic Concepts

The part of the real world (RW) which is concerned by this study is the user's physical environment when he is involved in the dedicated applications and also all the contextual information needed to interpret the meaning of the virtual world in the user's physical and social context. We consider three kinds of real objects which are able to interact with the system:

- Explicitly represented Real Object (ERO). An ERO is a natural RW object explicitly represented in the system. It can be physical variables, like the location of users, or it can be much more abstract, like the users' emotional state estimated through some biometric measurements.

- Implicitly represented Real Object (IRO). An IRO may be some implicit hypothesis about the state of objects in the RW. For example, the game is designed for the oriental knight culture; players should know and respect this knight system to play the game.

- Unpredicted interacting Real Object (URO). A URO appears when the system generates some unpredicted interactions between the RW and the VW. For example, virtual objects can be sold in the RW through the Internet, which is not in the previous concept of game designer, but will have an impact on the RW economy.

We call, at a given time the current value of the state of theses objects, the RW state or context.

A virtual world (VW) is an imaginary space composed of virtual objects governed by simulated physical laws, where the user is represented and where he experiments with the sense of immersion and presence. The virtual objects may include narrative aspects, perceptual features (graphics and sounds) and actions that can be produced by the objects or which can modify the objects. We distinguish two types of virtual objects:

- Image Virtual Object (IVO). An IVO is the image of a real object. It may include some estimates of real world variables. For example, the identification of a user in the virtual space can be a cursor, a car or a character.

- A Purely Virtual Object (PVO) is an object that has no match in the RW. For example, a NPC (Non Player Character) exists only in the game.

We call, at a given time the current value of the state of these objects, the VW state or context.

In our context, the notion "mixed reality" has the following meaning: the real objects and virtual objects can co-exist and interact in the gaming environment. Some real elements of the RW contexts can take part in shaping the entire gaming experience, and the game objects of the VW contexts could also bring the new meanings to the real objects and influence the state of the RW. An experimental example is Human Pacman [10]. It's an outdoor mixed reality role-playing game augmented by computers. In this game system, the RW includes two players and their physical movements, the physical objects as cookie's ingredients and their locations, and the geographical characteristics of the outdoor area, which are all EROs. The VW context is composed by the players' representations as "pacman", "ghost" and "helper" (IVO) plus their locations, and a fantasy VW map (PVO).

The relation between RW and VW can be understood as a reactive system (see Figure 2 in section 3.5). The RW information is represented in a RW model in the system, which may use data (user commands) directly from the user, but can also represent data from other RW phenomenon such as the weather, the location of the user's car or the results of a football championship. Some of this information is measured by dedicated captors; others are taken from general information systems through, for example, the Internet. This information will be IROs or EROs stored in the user model or in the rest of RW model in the system. The VW mechanism gathers all of the EROs and IROs to generate some effects in the VW or to produce some feedback on the RW or on the user through some real actuators.

3.2 User Model

As it was stated previously, the user model represents the set of information needed to predict some user behaviors under a set of possible stimulations. In our context, the user model and the stimulations are used by a narration engine to control the evolution of the game. The user model will take into account general motivations of players. Another kind of knowledge that the user model must understand is the skill of the user in relation to the various challenges he must face. It is a user's learning curve in type of "easy to start, hard to master". So the user model depends on a set of parameters that can be either statically defined by the game designer or dynamically adjusted by the changes of user's states. They could be a consequence of game designer's
prior hypothesis and knowledge about the players, or induced in real time from actions and answers of the player dedicated learning levels and from sample surveys included in the game, or from the whole analysis of the player action in the game. These data may be more or less personalized, which leads to three levels of the user model.

3.2.1 Generic Model (GM)

The generic user model does not distinguish a player from others. It includes general hypothesis about the player (e.g. 65% Male, 35% Female, 34 years old mean age, occidental), a location of all users on the game map, statistics of gamers actions and eventually an evaluation of the social status of the whole player population according to a sociological model.

In the virtual world, the player representation may only be represented by an implicit hypothesis (IRO). Such representation is used in almost all single player games. But a multiplayer game can gather some statistical data of the whole player population (50% of the player spends 80% of the time fighting), and a global instantaneous model of the whole game, including the players (137 players are sitting, waiting for the dragon…).

3.2.2 Localized Model (LM)

The second level of the user model adding to the generic model the knowledge of the user's location is the Localized user Model (LM). In this case, the user has an identifier and his current location is the user state variable of the model. This information is interpreted by the game through other contextual variables of the real world known by the game. For example, the game may know, from the location of the user and a map of the real world, that the player is in a cafeteria. In a mixed reality gaming context, the model of the real world can manage very complex data of the RW. This knowledge may concern both macroscopic (geographic, political, economic, temperature…) and microscopic (user body movement, objects' positions…) data. For the former, an example as the game “Geo-Political Simulator” (Eversim, 2005) is an economic and political simulation multiplayer game. In this game, all the countries of the world are represented with their own variables in economic, social, military, foreign and domestic politics, environment and education, etc. These values allow a simulation of our planet evolution. The player's objective is to remain a president, a king or a prime minister… and to further his influence throughout the world. For the latter, most location-based mobile games, like Mogi and Botfighter2 (AliveMobile, 2000) use implicitly a LM (the space contextual information surrounding the player) to analyze events in the real world, to detect the distance between users and virtual objects and also to manage personal exchanges between users according to their proximity. From the history of the user's movements, the LM can induce some parameters of a rough cognitive model and a more elaborate sociological model. This may lead to a basic construction of the next user level: the Personalized Model.

3.2.3 Personalized Model (PM)

The third level of the user model is the Personalized user Model (PM) that keeps complex state variables about each user. Some of these variables are already used in classical games: for example, various kinds of challenges according to the skill level of the user. In MMORPGs each user has a profile which defines his type of avatar, his level in the game and some data used to facilitate social relations. But in mixed reality environments much more complex data can be used: civil status, personal habits, social relationships... With this knowledge the PM may contain an elaborate cognitive and social representation of the user. Some of this data has to be given by the user himself, some can be inferred from his actions in the game.

This kind of model is already being used in many applications. Internet training systems infer from customer behaviors and from their preferences in order to improve Internet navigation. In the simulation/strategy game, *The Sims 2* (Electronic Arts, 2005) uses a player's model to create content suitable for each individual: the player starts the game by predefining his/her own personality and then each Sim (virtual people in the game) develops in a unique way based on the player's choice and influence; as the user's personality grows up, sims collect memories to shape who he/she is, then decide what options he/she could have. [11] presents a game system used to treat autistic children. The game uses a child model which determines, for example, a level of possible attention. The child behaviour is observed by the camera and the game evolution is triggered both by the static data of the patient and by real time observation.

3.3 Narration Model

Single player games, and in particular adventure games, can be considered as an interactive storytelling or an interactive drama system. The main debate in this field is the relative impotence of dramaturgy and ludology as key element of the player's fun. Multiplayer games and competitive multiplayer games work on a very different basis. In general, the main interest of players in these games is related to social goals. The fun of a *Mario Kart party* (Nintendo, November, 2005) does not depend on Mario adventures. Playing *Counter Strike* (Valve Software, November, 2004) is more related to a football match than an evening with friends in cinema. So in multiplayer games the narration is only a mechanism to trigger some social behaviors, as the main interest of players in this kind of games is social. According to [21], the main structure of narrative in games is conflict. So the main goal of an interactive narration model in competitive multiplayer systems is to generate some conflicting events (plots) that induce desired social behaviours of the players.

In this paper, we define an interactive narration model as a system which generates some events produced by the virtual world system, which can be translated into actions in the real world. In general this principle is called emergent narrative. In the context of mixed reality, it means that the narrative emerges from the user's daily life actions or activities. These events can be generated according to the current users' states at the running time and to some social goals defined by the game designer. For example, the narration model can decide at a given time to send a message to all users; this decision is implemented as the generation of an SMS sending to all users' mobile phones. Another scheme is to create virtual objects that generate some plots for the players. A new virtual treasure might induce a battle for example. The great advantage of these approaches is that by controlling the phenomena, the game designer combines the narrative aspect with freedom of the players in reaction to the phenomena and with capacity to develop collective impulses.
We propose three levels of narration models to respond to the user model in different situations according to different needs. We call them a Global narration Model, a Context-oriented narration Model or a Character-based narration Model.

### 3.3.1 Global narration Model

A global narrative model generates events according to a storyline that does not distinguish players’ identities, contexts or histories. This storyline relies on some standard structures of narrative and a global sociological or cognitive model. Its objective is mainly to attract and stimulate players to play the game. This principle is an extension of interactive media of general narrative models used in linear media. Almost all single player adventure games use this scheme. Even in the proactive games like *In Memoriam* (Ubisoft, Lexis Numérique, October, 2003) which has an identification of each user (a mail account), the narration scheme relies on the same principle: the game always develops the same narrative scheme, and sends some mails to the player, which may control this message generation according to the progression of the player in the storyline. The same idea is already used in the design of MMORPG. For example, the narrative scheme can be a social mechanism, which periodically generates revolts; or it may be a natural disaster; or an object like a building or an animal whose evolution causes important events. This principle can also be used in multiplayer augmented reality games. For example, if the narration and the progression of social relations lead to the setting up of a meeting in the real world, the model can send a message to all users announcing some important events in a given location. The result of these generated events provokes a social phenomenon, a public cause for the whole group of players.

### 3.3.2 Context-oriented narration Model

According to the requirement of the real environment surrounding the user (place, physical environment, users’ movements, temperature, or even political or economic information), the narrative system needs a Context-oriented narration Model (CM) to make appropriate responsive reactions. The CM distinguishes different circumstances to trigger different scenarios. For instance, if a group of players is, in a given area, isolated and seems not to respond to a global scenario, the CM can locally generate an event to provoke a meeting or a clash, which brings the players back into the game. Actually the games based on real world information are mostly location-based mobile multiplayer games, such as *Mogi* or *BotFighter2*. The scenario of *Mogi* is to seek and collect virtual objects with a mobile phone in different places of the real city. The goal is to complete collections of these virtual objects. In this game, some virtual objects will only appear somewhere in the city at a fixed time, which enables the player to move to obtain these objects. The CM uses the physical positions of the players in the landscape and the landscape itself to create the virtual objects that will become narrative plots.

### 3.3.3 Character-based narration Model

The system could also identify and generate a personalized storyline and be pertinent for each individual user. The goal of such mechanism, which may be very difficult to put into practice, is to generate much more efficient stimulation according to an individualized cognitive or social model. As a consequence, the user may have a stronger experience while playing the game. A well known example of Character-based Model (CM) is the use of Bartle's classification of players' behaviors in MMORPG [28]. In this case the system tries to develop plots according to the role of players involved at a given time. The CM must have the knowledge of the player's preferences according to Bartle's classification. Consider a localized game where players are fighting in two groups (red and blue). Assume that the system knows Alice is Bob's girlfriend and they are both on the blue team. The system firstly sends an SMS which enables Alice to move to a building full of Red guys. Then it sends an SMS to Bob saying that Alice is in danger and that she needs help. This is exactly the scenario that is shown in the trailer of the MMORPG *Lineage II* (NCsoft, April, 2004) as the basis of building a guild (name of player groups).

It is also interesting to generate plots according to each user's current experiences, interests and history, and his abilities. As in most MMORPGs, the game lets the player create his own character. According to his/her own base, certain activities will be more or less driven in the limit of his/her power and experience. This is a powerful driving force of dramaturgy and personal interest for the game.

### 3.4 Relations between Two Models

As shown in Figure 1, it is clear that a game managing a PM for each user, has enough information to generate plots at three levels of narration. An LM allows Global or Context-oriented narration. A GM only leads to a Global narration. The possibility of mixing the various narrative levels is a way to keep the balance between the interaction of the user and the dramatic control of the system. But the ability to manage a PM depends on various aspects of the game system (technical complexity, social and environmental contexts, privacy constraints). According to its level, the user model may be used in several ways:

![Figure 1. Relations between user model and narration model.](image)

- A first approach relies on a global narration guided by a generic user model. This is the approach taken by many systems. It allows users to explicitly create their general profiles in the system. With these user parameters, the system determines a global information or service for all the users.
- Another way is to provide the system with enough information about the user's contexts which can lead to a local narration besides a global narration. This can be done explicitly or implicitly. If user agrees with the system following his/her trace, the localized user model starts up and thus the system may give local "surprises" according to his/her local context.
A more complex approach is to deal with the personal information. The system will induce his/her special needs and specific interest, and supply him/her with individual narration, by considering the coherence with the context-oriented narration and the global narration.

### 3.5 Architecture of the System

In this section, we present the user model correlated with the generative narration based on the interactions between the real world including the user actions, and the virtual world. We try to introduce the procedure of the user model in the data flow of the whole computing system (see Figure 2).

The user and more generally the whole real world interact with the virtual world through sensors. The user's actions and other input information are interpreted by the learning system according to the user model and the estimation of the current state of the world (ERO). This state and its evolution are used to adapt the user model, as input data for the Reasoning Mechanism (RM) and the computation of the virtual world evolution. This evolution of virtual world objects (PVO) is generated by a virtual world simulator and the AI components, according to the ERO state. The simulator is in charge of the computation of physical or abstract law effects. For example in a game, it can simulate the weather or the economic system of the VW. The AI components deal with the mechanism which makes decisions. So The RM is triggered by the current state of the real and virtual worlds (ERO and PVO) and a storyline scheme which represents the designer's storytelling choices. According to all these data, the RM may generate new plots. These plots can be translated into actions through the system actuators to affect in the real world or to give a feedback in user.

As the core principle of the RM, we propose to use Case-Based Reasoning (CBR) in the system to deduce guidance from the user model. User's state in-situ identified in the user model is modelled as cases in a case database. The user model is composed by the learning system and the Knowledge Library (KL). The learning system records functions of user's progress by governing the learning curve. The KL may have one of the three possible levels (Generic, Localized and Personalized). The Narrative Reasoning mechanism uses the Case-Based Planning [12] to assign story goals or objectives to the user according to the situations identified in KL. Driven by this goal, and considering the current state of the VW, the narration model will decide a narrative mechanism to generate a plot. It may be, according to the storyline, global, context-oriented or character-based.

The design of reasoning process and the plot generation are our next step of work.

### 3.6 Possible Scenarios

We can derive new experiences from the existing elements in the game and combine the different elements to generate various game patterns. A famous example is *World of Warcraft*. It has a large-scale system of virtual objects, a large-scale system of quests, a large-scale system of Non-Player Characters (NPCs), and a large-scale system of professions; its most outstanding feature is that the player himself is free to discover these pleasures in the game.

We may employ NPCs in games to interpret the decisions of the narration reasoning in order to direct the scenario by communicating with players, as traditionally a NPC has some fixed characteristics such as offering task and reward.

In the case of a GM, the condition for the game to trigger an event could be a "click trigger" such as clicking on the NPC if the player is online. GM may know now there are ten explorers (roles in games) wandering in a park zone (in RW). An NPC receives the command from Reasoning Mechanism to launch a Global narration, sends a message to all the users that a precious object (a virtual object) has been stolen and that the one who finds it the quickest in the city (RW) will get 500 gold (virtual money).
In the case of the LM, the real temporal or spatial information is taken into account to trigger some special events. For instance, the system can know, from LM, that the user enters a specific zone such as “a park” in the RW, or the time in the RW is 4 pm on Saturday, so NPC can start a quest (a context-oriented narration) “catching the most wanted” at a fixed time in the park.

In the case of the PM, the system knows the player is a merchant in the game and he wants to sell some objects because he set up a stand in the market two days ago in the game. So the reasoning mechanism decides to use the NPC to inform the player with the most recent information (supply and demand) on the market of the game. The model also informs the system that in the real world another player wandering nearby has been searching for a weapon for two weeks. Consequently, the Reasoning Mechanism induces another player wandering nearby has been searching for a weapon for two weeks. Consequently, the Reasoning Mechanism induces a character-based narration model and sends the command to the NPC. The NPC will send a message to the “merchant” and thus start a transaction between the two players in the RW, which will satisfy both of them. In most games, the NPCs system is usually flexible: once this NPC completes his task, it could be reused in another place. Thus the game could create some so-called “impressive and beyond expectation” plots to different users in different situations.

4. CONCLUSION
The concept of the user model is probably one of the keys of the game design, but it is rarely explicitly implemented in the game. The ubiquitous and proactive games introduce complex relations between the user and the game system. We have presented the outcome of our first step of work: a general framework for the system design and the correspondences between three possible levels of the user model and three interactive narration schemes. In next step, we will work on the implantation of our architecture based on a case-based reasoning system and will evaluate our concepts with some concrete mixed reality gaming situations. Our goal is to use the framework in a family ubiquitous entertainment system.

5. ACKNOWLEDGMENTS
The research work is financed and run at the Studio Créatif of France Telecom Research & Development. We would like to thank Bernard Marquet and Sylvie Jumpertz for their supervision and valuable discussions.

6. REFERENCES


