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## Review

## Pervasive gaming: Status, trends and design principles

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## ABSTRACT

Pervasive games represent a radically new game form that transfers gaming experiences out into the physical world, weaving ICTs into the fabric of players' real environments. This emerging gaming mindset is rather challenging for developers exploring technologies and methods to achieve a high quality interactive experience for users, and designing novel and compelling forms of content. This paper follows a systematic approach in exploring the landscape of pervasive gaming. First, we present 18 representative pervasive game projects, following a generations-based classification. Then, we present a comparative view of those projects with respect to several design aspects. Lastly, we shed light on technological status and trends, design principles, developer guidelines, and research challenges for pervasive games development.

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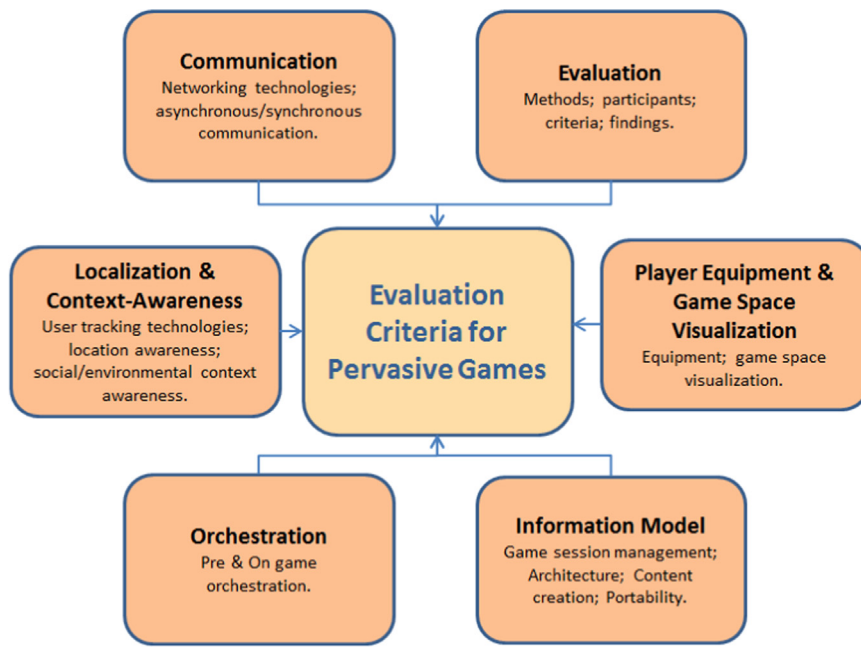


Fig. 1. Design and evaluation aspects of pervasive games.



Fig. 2. Tag cloud depicting most frequently used terms in 1G pervasive games.

## 1. Introduction

Pervasive computing is a post-desktop model of human-computer interaction in which information processing is thoroughly integrated into users' physical environments (both objects and activities). Pervasive gaming represents an emerging field within the context of pervasive computing, defining a major evolutionary step from traditional 'electronic/computer games', i.e., electronic systems that employ some kind of computational machinery to create an interactive interface controlled by players (Magerkurth et al., 2005). Pervasive games shape an exciting and commercially promising new form of computer games that builds upon a combination of hybrid interfaces, mobile device equipment, wireless networking, positioning systems, and context-sensing technologies. These games extend the gaming experience into the physical realm – be it the city streets, the remote wilderness, or a living room. Players equipped with mobile devices move through the world; built-in or external sensors capture information about their current context, used to deliver gaming experiences adaptable to where they are, what they do or even how they feel. The player is released from the console and experiences a game interwoven with the real world, commonly available anytime, anywhere (Benford et al., 2005).

The contribution of this paper is threefold. Firstly, a novel classification scheme is proposed offering a perception of pervasive games evolution. Secondly, we investigate in detail a number

of games from several angles, so as to offer insights on the trends and challenges in pervasive gaming. Last, building upon the main findings of this investigation, we extract design principles and suggest best practices and implementation guidelines for designers and practitioners. The surveyed games are examined with respect to the following design aspects (see Figs. 1 and 2):

- *Communication* refers to wireless technologies enabling the interaction either among players or between players and some sort of game management engine.
- *Player equipment and game space visualization* criteria refer to the devices used by players and the means utilized for the visualization of the game space.
- *Information model* criteria consider the informational and architectural models adopted in these games to support the game scenarios and assist the users in satisfying their needs.
- *Localization and context-awareness* criteria deals with technologies used to track user position as well as personal, social, and environmental aspects triggering changes in the game environment, which may otherwise be static.
- *Orchestration* refers to techniques, human support (e.g., actors), and infrastructure used by developers to manage live game action behind the scenes (Benford et al., 2005).
- *Evaluation* refers to qualitative and quantitative methods utilized to measure the extent to which the game design has met its objectives with regards to several criteria. It regularly aims at extracting generic game design guidelines.

The above-listed design and evaluation aspects essentially capture the research questions mainly addressed in the pervasive games scientific literature and the practical issues investigated by prototype designers and developers. Among them, the first three design aspects reflect the technological and architectural foundations of pervasive games: namely, the wireless technologies that enable the communication between the players and the game engine, the equipment used to access in-game content, the game activity visualization means and the structuring/organization of game engines. Context-awareness represents an organic element in every application field of pervasive computing. Orchestration is

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