D4.2

PLATFORM AVAILABLE FOR USER TEST 1ST ITERATION

March 2014

ABSTRACT

This document describes the “Pervasive Games Platform” available for user test (1st iteration). The description includes the architecture of the platform and the supplied Specific Enablers. Moreover, a roadmap briefly points out Enablers in upcoming releases of the “Pervasive Games Platform” and a brief discussion outlines the deployment of Enablers and the technical infrastructure used for the first experimentation cycle.

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DISCLAIMER

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EXECUTIVE SUMMARY

The “Pervasive Games Platform” consists of a number of Specific Enablers that are relevant for games on mobile devices with a focus on Augmented Reality applications and social interaction. The first release of the platform has been delivered in project month 6 (i.e. September 2013). Some implementations of the Enablers were already finished for the first release and some are in an early state and will be improved and completed before the next release of the platform.

With the goal to enhance development of such games we have three tiers in mind to reflect different technical challenges for a number of scenarios: Tier 1 is for small scale indoor settings including marker tracking and toy tracking applications. Tier 2 consists of location based games where the players will be able to play a game at certain prepared locations, usually adapted to the special setting of that location. With city-wide games, Tier 3 has the technically most challenging scenarios where tracking and localization need to work without control of the environment.

By demonstrating the use of Generic Enablers in combination with the Specific Enablers of the Pervasive Games Platform we hope to greatly simplify the work for new developers. On this base we will perform experiments to verify functionality or identify missing features. We try to realize the showcases of our platform with today’s web-based technologies. However, we further resort to the widely used Unity 3D engine for games with stronger performance requirements.

Moreover, we grouped our Specific Enablers according to the portfolio of a dedicated feature set. For instance, the SEs in the Reality Mixer group improve the augmentation of real content with virtual ones to achieve seamless integration and the Enablers in the Augmented Reality group focus on visual tracking algorithms.

The following Enablers will be provided in the first release of the platform:

- **The Reality Mixer - Reflection Mapping SE** takes environmental lighting into account.
- **The Reality Mixer - Camera Artifact Rendering SE** applies effects to computer generated content to mimic the behavior of the device’s camera and enhance the integration.
- **The Augmented Reality - Marker Tracking SE** is used for 2D-marker tracking.
- **The Augmented Reality - Fast Feature Tracking SE** provides efficient markerless 2D-feature tracking.
- With the **Leaderboard SE**, high scores can be submitted and retrieved.
- The **Game Synchronization SE** provides a simplified way to ensure that all game objects and properties have the same state on all devices.
- The **Spatial Matchmaking SE** helps to find other players ready for a game in the vicinity.

For the next releases of the platform the following Specific Enablers are planned:

- The **Game Server SE** will be a central point to handle internet-game-related requirements.
- The **Reality Mixer - Simulation Continuum SE** includes development of methods for achieving a simulation continuum between real and virtual objects
- The **Cloud Physics Processing SE** will offload intense physics computations from mobile devices to servers with more processing power and memory.
- The **Reality Mixer - Augmented Audio SE** will improve immersion by adding correctly located sound effects.
- The **Augmented Reality - Skeletal Tracking SE** will be used to detect the pose of toys or players.
- The **Augmented Reality - Image Marker Tracking SE** will be used for natural feature tracking of predefined images.
- The **Networked Virtual Character SE** will help to synchronize the sequence of motions across multiple clients

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ABBREVIATIONS

API	Application Programming Interface
AR	Augmented Reality
CG	Computer Graphics
DPC	Data Processing Center
DWDM	Dense Wavelength Division Multiplexing
FAQ	Frequently Answered Questions
FI	Future Internet
FI-PPP	Future Internet – Public Private Partnership
FIRE	Future Internet Research and Experimentation Initiative
GE	Generic Enabler
GPS	Global Positioning System
GPU	Graphics Processing Unit
PMT	Parc Mediterrani de la Tecnologia
POI	Point of Interest
RTS	Real-Time Strategy
SE	Specific Enabler
XML3D	Three Dimensional Extensible Markup Language

1 - INTRODUCTION

1.1 - Overview

The Pervasive Games Platform is a collection of tools and techniques, designed to enable the creation of Augmented Reality video games and interactive experiences, on mobile devices and the web. This technical portfolio takes advantage of established game development tools, of specific technical contributions (FIcontent Specific Enablers), and generic Future Internet technology (FI-WARE Generic Enablers).

This deliverable mainly consists of the first software prototype of the Pervasive Games Platform. Moreover, we provide this additional document with a description of the Pervasive Games Platform and further information such as a development roadmap.

Please be aware about the fact that this document is generated from the FIcontent Wiki [1]. Thus, the document may sometimes still refer to the FIcontent Wiki. All information in this document is also available online. We suggest to use the online version [2] for an advanced reading experience.

1.2 - Terminology

The following table contains terms, which are used in multiple deliverables. Therefore, we provide their shared definitions to ensure consistency across several documents.

Term	Definition
Application or Application software	Software layered on top of one or several platforms for realizing some (presumably) useful tasks for end-users
Architecture	A structure of functional elements organized in a given way and presenting well defined interfaces
Capability	The ability of a component to satisfy a requirement
Conceptual Model	A set of view with written description of the organization of the FIcontent infrastructure to offer services
Enabler Software	Module or web service providing well-specified functionality, accessible and usable by application developers through clearly-described APIs (Application Programming Interfaces)
Experiment or Experimentation	Concrete test with actual users of one scenario in one of the experimentation sites in a given time frame
FI-WARE Tools	The tools put in place by FI-WARE to send requests for Generic Enablers are based on a backlog list in the frame of an agile methodology
Functional requirement	Either calculations, technical details, data manipulation, processing or other specific functionality that define what a system is supposed to accomplish
Generic Enabler	An enabler realized by the FI-WARE project or its follow up sustainability project
Platform	A comprehensive combination of technology infrastructure and Generic Enablers as well as Specific Enablers capable to host and to support development of application software

Term	Definition
Point of Interest	A POI is a place, an area or a journey (short distance) which are geo-located. For example: a place (a restaurant, etc.), an area: a public garden, a journey (a hiking trail, etc.). A POI has possibly features such as : static features (opening hours, address, name description, etc.), Dynamic features (price, menu, number of available places, the delay before the next bus, etc.), Event features (a beginning and an end)
Scenario	Description of foreseeable interactions of users with one or several applications
Specific Enabler	An enabler realized by the FIcontent project. Specific Enablers may be layered on top of, or otherwise make use of, Generic Enablers. Please refer to the definition of a FIcontent Specific Enabler from deliverable D6.1 Architecture specification [3]
Interface	The connections between domains (or sub domain or functional elements) serving the actor's actions by exchanging information
Interoperability	The capability of two or more networks, devices, applications to exchange and use information
Technology	A standard or industry specification that has the capabilities to address requirements

2 - PERVASIVE GAMES PLATFORM ARCHITECTURE

The architecture of the Pervasive Games Platform is a set of integrated, modular Enablers designed to aid building Internet-based games connected with the real world. While moving from native to in-browser execution as browser technology develops, we target real-time, low latency, and high performance goals with the Pervasive Games Platform. Moreover, the platform supports new forms of interactive entertainment of three tiers:

- **Tier 1 -- Digital Consumer Products (Toys).** This tier targets augmented-reality games based on toys, fashion, and other physical products. Games will use the product as a known and structured environment/level and include a limited number of networked uses, for storage and toy-to-toy communication.
- **Tier 2 -- Location Based Games.** Here, we target games developed in an installation such as a museum in which connected, cooperative game experiences are used to make the visit more compelling. This tier builds upon the first tier with real-world locations and a greater number of users.
- **Tier 3 -- City Wide Games.** The third tier targets city-wide games in which larger numbers of players interact in unstructured environments. Testing will take place in large-scale experimentation sites such as Zurich, Barcelona and Cologne. This tier is the most challenging as it requires a high degree of mobile connectivity as well as game dynamics implemented in unstructured locations.

The Pervasive Games Platform is accessible for web developers and provides dedicated features to easily create web-based games with well-known and established technologies. In addition to that, the platform takes advantage of the Unity native engine plugin to support professional game developers by allowing them to work with their accustomed tools.

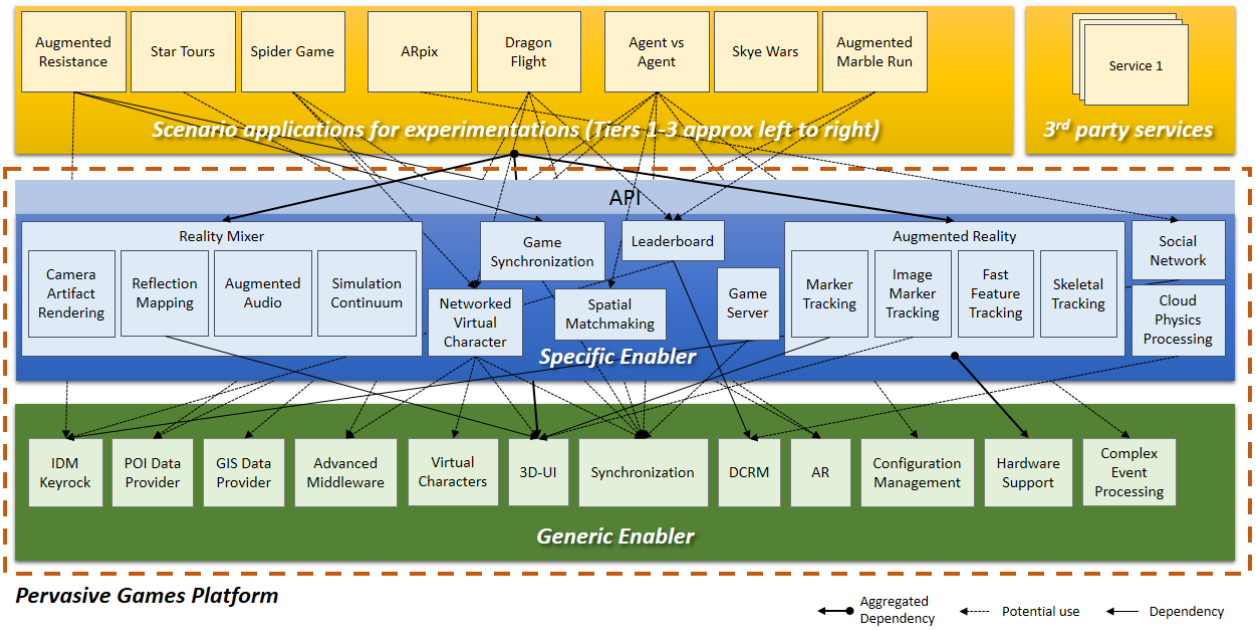

Figure 1 High-level architecture of the Pervasive Games Platform

The Pervasive Games Platform acts as an intermediate layer between the Generic Enablers provided by FI-WARE and the applications built on top of the platform. Further, it exposes the APIs of the Specific Enabler shipped with the platform to the application developers. A selection of applications showcase specific features or Enablers of the platform as illustrated in the figure above. Each application is dedicated to one scenario of the three tiers supported by the Pervasive Games Platform. The scenarios are described in detail in deliverable D4.1.

2.1 - Architecture Description

The core components of the Pervasive Games Platform are shaped by the Specific Enablers dedicated to domain-specific gaming scenarios. Thereby, the platform takes advantage of Generic Enablers from FI-WARE as well as common Specific Enablers developed in FIcontent. All of these Enablers may form groups, as shown in the figure below, and cover a range of features in game development, such as the group Augmented Reality SEs, which provides several tracking methods, or the group of Reality Mixer SEs, which focus on seamless augmented reality applications.

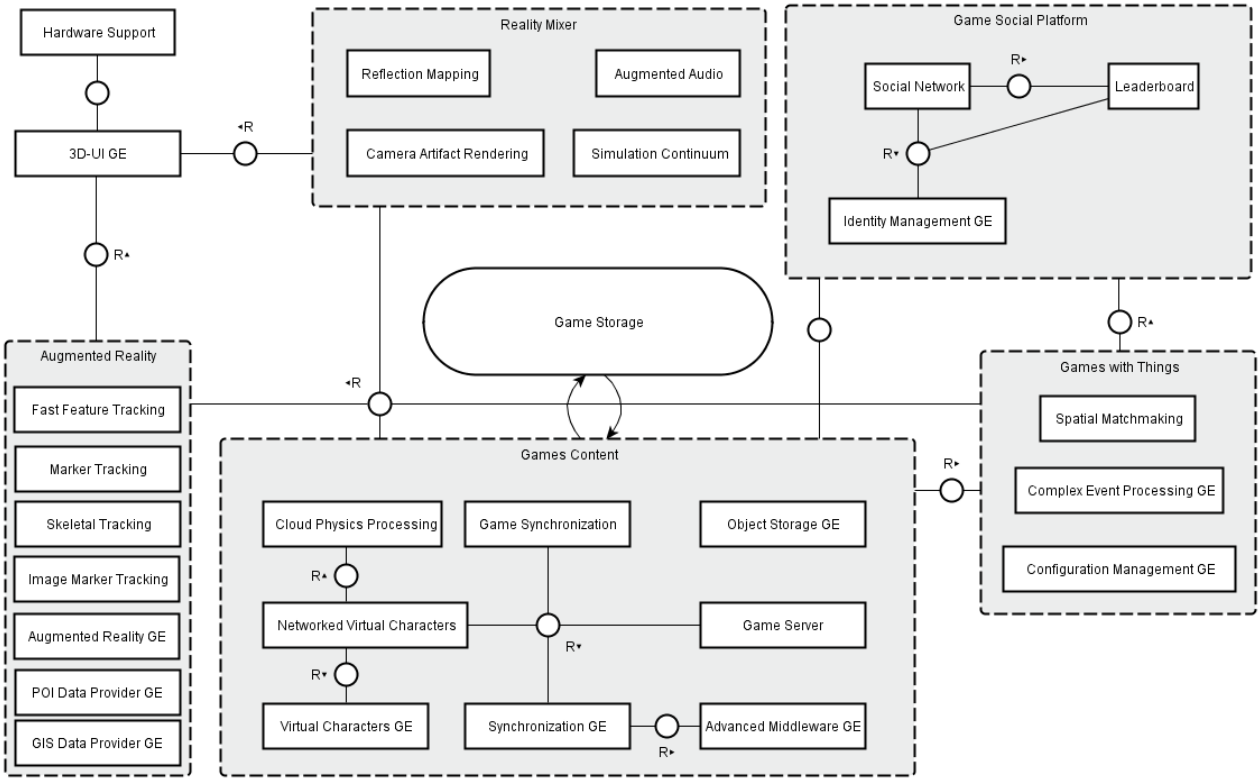

Figure 2 Architecture of the Pervasive Games Platform including the interaction of SEs with GEs from FI-WARE

The following sections describe the main functions provided by each component of the Pervasive Games Platform.

2.1.1 - Augmented Reality

Augmented Reality games break the line between reality and computer generated content by enhancing a real environment. The augmentation of a scene with additional computer generated content requires a very precise estimation of the camera pose. Therefore, we provide different tracking techniques based on the 3D User Interface (3D-UI) GE [4] in order to achieve a fully immersive experience in real-time. In addition to that, we utilize usual positioning methods, such as GPS localization, and provide with the Fast Feature Tracking SE [5] a GPU-accelerated implementation to easily create applications with basic markerless Augmented Reality functionality on today's mobile devices.

Moreover, this component incorporates the capabilities of the POI Data Provider GE [6] and GIS Data Provider GE [7] provided by FI-WARE to attach our content to existing objects in real-world environments. This becomes in particular relevant for Tier 3 applications together with the Game Synchronization SE [8].

2.1.2 - Reality Mixer

A context aware connected interactive experience must focus on the development of methods to integrate and match real or filtered video footage with rendered virtual objects and characters seamlessly. In this way the mobile device acts not as a traditional electronic display, but as a lens onto the real world with transparently aligned augmented reality content.

Moreover, we render augmented reality Computer Graphics (CG) objects that match the artifacts of the device's camera by utilizing the Camera Artifact Rendering SE [9]. Adding synthesized computer images to live action footage, e.g. movie grain, noise, chromatic aberration and providing a reality slider that grades the disparity between video and CG footage achieves a seamless transition for mixed reality applications. In addition to that, stylization and beautification filters applied to both video stream and CG rendered content achieves an artistic goal avoiding the uncanny valley (as employed for example by PIXAR in traditional CG).

Augmented reality experiences further take place with virtual objects placed in the real world. Virtual objects under a physically accurate simulation thus far have no physical effect on real objects and conversely rigid and soft body dynamics captured from real objects have no physically simulated effect in virtual objects. This Enabler group includes methods for achieving a physical Simulation Continuum (see Section 5) between real and virtual objects.

Sound is also common in augmented reality productions. However, sounds are often not located at the correct projected 3D location. Furthermore, these do not account for the environment's aural signature, binaural effects, the influence of the presence of virtual objects and materials as sound reflectors. For these purposes we will provide the Augmented Audio SE (see Section 5).

2.1.3 - Game Social Platform

We utilize social platforms for the Pervasive Games Platform in two ways - one is intended for game developers and the other one for players. For both we take advantage of the Social Network SE [10] in combination with the Identity Management GE [11] from FI-WARE.

The developer portal is a useful place for game developers to find answers or help each other. It provides a starting point to get in contact with the capabilities of the Pervasive Games Platform and to receive information beyond the pure documentation, such as a Wiki including a FAQ section and a forum. Users can rate each other's entries, like tutorials or published games, and send messages using that developer portal. A news section and an optional mailing list will be used to inform about changes and announce new features and Specific Enablers of the Pervasive Games Platform. Standard software will be used for this.

Within the player social platform a dedicated area for each game will be provided including a forum to answer questions of players and to provide support. Ideally, more experienced players will help new players. The Leaderboard SE [12] seamlessly integrates into this platform, showing overall high scores for individual games or levels. Some games may require a group of players, like collaborative or competitive games. Therefore, the Spatial Matchmaking SE [13] connects to the social platform and helps to find nearby teammates.

2.1.4 - Games Content

This component of the platform is designed to provide services to manage the actual content of games. It allows the synchronization of UI and game states between players and devices and offers an efficient API for scene interactions and rendering. Therefore, we take advantage of several Generic Enablers alongside with Specific Enablers for game-domain specific purposes. The storage of game content, such as level data, avatars and assets, will be handled by the Object Storage GE [14] to provide a distributed, robust and scalable storage solution.

The Synchronization GE [15] can be used to create new types of multi-user applications shared between multiple devices and can be combined with the Game Synchronization SE [8] for taking charge of specific

synchronization of game states. These Enablers rely on the technologies of the Advanced Middleware GE [16] to update game settings and 3D-scenes in multiplayer scenarios across different platforms.

Moreover, the Networked Virtual Character SE (see Section 5) interacts with the Synchronization GE [15] by exchanging motion data of virtual characters and applying the changes to the scenes. Those services may also rely on Cloud Physics Processing (see Section 5) to computationally intense parts to be streamed to a mobile device and the Virtual Characters GE [17] in order to provide animated and controllable characters to interact with the scene.

2.1.5 - Games with Things

The Games with Things feature set acts as a bridge between the Pervasive Games Platform and the Internet of Things. This enables games to handle both worlds - the virtual and real world, with both affecting each other. For this purpose the Configuration Management GE [18] will be utilized. Furthermore, we take advantage of the Complex Event Processing GE [19] to simplify the logic required to talk to a set of things, but also to allow them to act as a group and generate events more complex than they can as individual Things.

2.2 - Specific Enablers

We will provide the following list of Specific Enablers through the Pervasive Games Platform.

- Reality Mixer - Reflection Mapping SE [20] (Release 09/13)
- Reality Mixer - Camera Artifact Rendering SE [9] (Release 09/13)
- Reality Mixer - Simulation Continuum SE (see Section 5)
- Reality Mixer - Augmented Audio SE (see Section 5)
- Augmented Reality - Marker Tracking SE [21] (Release 09/13)
- Augmented Reality - Fast Feature Tracking SE [5] (Release 09/13)
- Augmented Reality - Skeletal Tracking SE (see Section 5)
- Augmented Reality - Image Marker Tracking SE (see Section 5)
- Leaderboard SE [12] (Release 09/13)
- Game Synchronization SE [8] (Release 09/13)
- Game Server SE (see Section 5)
- Networked Virtual Character SE (see Section 5)
- Cloud Physics Processing SE (see Section 5)
- Spatial Matchmaking SE [13] (Release 09/13)

We will utilize the following list of common Specific Enablers for the Pervasive Games Platform.

- Social Network SE [10] (Release 09/13)

2.3 - Generic Enablers

We will take advantage of the following Generic Enablers from FI-WARE within the Pervasive Games Platform. The specifications of some of them are in a very early stage. Thus, the actual functionality or the identifier may differ once the specification of the respective GEs is finalized.

- Identity Management GE [11]
- Advanced Middleware GE [16]
- Synchronization GE [15]
- Object Storage GE [14]
- 3D User Interface (3D-UI) GE [4]
- Augmented Reality GE [22]
- Virtual Characters GE [17]
- Data Center Resource Management GE [23]
- Complex Event Processing GE [19]

- Configuration Management GE [18]
- POI Data Provider GE [6]
- GIS Data Provider GE [7]

2.4 - External Game Development Tools

One goal of the Pervasive Games Platform is to connect to existing game development tools created by European companies that have been proven in the field and supported by large communities. In the first platform release, we provide connections to:

- Unity3D from **Unity Technologies** (Denmark)
- SmartFoxServer, by **gotoAndPlay()** (Italy)

This list will be expanded over the course of the next year. We are currently evaluating the work of **GameAnalytics** (Germany), for instance.

2.4.1 - Unity3D

Unity3D [24] is a Game Development IDE, that provides a feature-rich Game Engine as well as a production environment for the creation of game scenes and the management of game assets. Unity3D supports JavaScript and C# code. Code and content of the Pervasive Games Platform relevant to Unity3D is distributed in form of unity packages - containers that facilitate the import and export operation between unity users.

The unity assets store is a marketplace for unity packages. Our packages will be uploaded and be available to the whole Unity community. We think this is a powerful distribution mechanism with a large pool of potential users.

2.4.2 - SmartFoxServer

SmartFoxServer [25] is a multi-platform server-client solution for multiplayer games and applications. It provides a rich set of features and extensive documentation, and comes with free and commercial licensing options. In particular, SFS provides functionality to create lobbies where players can chat, create instances of a game and start a playing session.

The server supports extensions for a variety of tasks while utilizing JavaScript and Python as programming languages. The Pervasive Game Platform will provide a number of server extensions to integrate both Specific Enablers and Generic Enablers from the Future Internet technology. SFS instances will run at least in the Zurich experimentation site.

3 - PERVASIVE GAMES PLATFORM - RELEASE 09/13

The first release of the Pervasive Games Platform will focus on Tier 1 gaming scenarios. For tracking, mostly existing image or marker based approaches are used. Supported applications mainly consist of two types that will run on most devices. We concentrate in particular on mobile devices with portability in mind. For these requirements, two foundation technologies suit best: HTML5 and Unity.

Install-free HTML5 web applications. Many mobile devices support nowadays WebGL and therefore, hardware accelerated 2D and 3D graphics. For many users, a dedicated software installation can mean too much effort, but in our case it is enough to just go to a website.

Unity 3D based games for high performance and quick development. For gamers that are willing to install the Unity player software, games can be a bit more sophisticated. For game development and content creation a useful tool exists that is already used by many game developers. A game can be easily deployed to multiple operating systems.

The following Specific Enablers are included in the September release of the Pervasive Games Platform and provide the technological foundation for our gaming scenarios.

3.1 - Reality Mixer - Reflection Mapping

3.1.1 - What you get

All visual oriented Specific Enablers of the Reality Mixer group measure camera properties and adapt the virtual objects to visually fit to the camera image background. The Reflection Mapping SE utilizes a light probe to extract a sphere map from the camera image, which contains the environmental lighting conditions. This sphere map will be used to apply an appropriate lighting model to rendered virtual objects. Thus, the additional virtual objects are incorporated into the resulting image in a very seamless fashion leading to a more realistic experience of mixed reality applications.

3.1.2 - Why to get it

This enables a new level of realism in augmented reality applications. It may be used directly with a diffuse light probe to match the appearance of matt surfaces on virtual characters and vehicles. Furthermore, developers may experiment with mapping different materials to application objects, such as marble or crystal.

3.1.3 - Documentation

- Technical Documentation of the Reflection Mapping SE [20]
- Developer Guide of the Reflection Mapping SE [26]

3.2 - Reality Mixer - Camera Artifact Rendering

3.2.1 - What you get

This SE helps to render plausible virtual objects on top of a camera image. It consists of two steps which are executed on the client side, e.g. a mobile device. First, some camera parameters are estimated, such as noise, motion and white balance. This can be based on images or other sensor information of the device. The second step is to apply those parameters as a post processing fragment shader pass to the rendered virtual objects.

3.2.2 - Why to get it

This SE helps making the virtual objects more believable and fit seamlessly to the camera image in the background. When the camera imperfections such as color casts, motion blur or noise are not taken into

account, the virtual objects will stand out and not look like belonging to the scene. This SE estimates such parameters from the life image and other sensors and applies a post processing step to the virtual objects.

3.2.3 - Documentation

- Technical Documentation of the Camera Artifact Rendering SE [9]
- Developer Guide of the Camera Artifact Rendering SE [27]

3.3 - Leaderboard

3.3.1 - What you get

The leaderboard is a high score list for a game. You can submit an integer score together with the player information, usually after a game is over. To compare the score with the score of other players, you can retrieve an ordered list of scores and respective players. For large lists you can also only get a part of the list. In addition you can query the position of a player on the high score list. Multiple scores can be used, such as 'collected items', 'time' and 'overall score'.

3.3.2 - Why to get it

A simple interface makes it convenient to use. Internally, the Identity Management GE will be used. With a leaderboard the players can be motivated to improve their skills and competitively compare their results with the results of their friends.

3.3.3 - Documentation

- Technical Documentation of the Leaderboard SE [12]
- Tutorials and Example Code for the Leaderboard SE [28]

3.4 - Augmented Reality - Fast Feature Tracking

3.4.1 - What you get

All Specific Enablers of the Augmented Reality group provide various tracking methods to enable augmented reality applications. The Fast Feature Tracking SE learns targets by color, then matches the center of the color area (for example a colored football) in the camera image to retrieve the relative camera pose information. This extends an application with the capabilities to apply the matching transformation to 3D-scene content and render them onto respective targets.

3.4.2 - Why to get it

With the Fast Feature Tracking SE you will be able to easily create applications with basic markerless augmented reality functionality. With this Specific Enabler you can learn the color of targets on the fly in an application and then track the center and size of the target for camera relative placement of animated interactive graphics such as virtual characters or vehicles.

3.4.3 - Documentation

- Technical Documentation of the Fast Feature Tracking SE [5]

3.5 - Augmented Reality - Marker Tracking

3.5.1 - What you get

All Specific Enablers of the Augmented Reality group provide various tracking methods to enable augmented reality applications. The Marker Tracking SE utilizes AR markers to retrieve camera pose information through XML3D/Xflow. This extends XML3D with the capabilities to apply the matching transformation to 3D-

scene content and render them onto respective markers in a web-based environment. The Marker Tracking SE follows the declarative approach of XML3D and is real-time capable.

3.5.2 - Why to get it

With the Marker Tracking SE you will be able to easily create web applications with basic augmented reality functionality. The Specific Enabler nicely captures all the necessary computations into Xflow operators of XML3D. Thus, you can create AR application without being an expert in computer vision. Basic knowledge in web technologies is sufficient to produce great applications using XML3D together with the Marker Tracking SE.

3.5.3 - Documentation

- Technical Documentation of the Marker Tracking SE [21]

3.6 - Game Synchronization

3.6.1 - What you get

This enabler provides functionality to synchronize the game world. We consider the following taxonomy. For the connection of the parties, we consider Peer-to-peer (p2p) and Server-to-Client (s2c). This enabler serves different networking models, such as:

- RTS-lockstep (p2p) - [*September 2013*].
- Authoritarian Client (p2p), also known as 'Host' model - [*November 2013*].
- Authoritarian Server (s2c) - [*November 2013*].

The RTS-lockstep is intended for games with a large game state that would be hard to synchronize over the network. This is indeed the case of RTS games with many units. In the peer-to-peer scenario, after a hand shaking phase (see the use of SmartFoxServer) the network is only used to transfer the players' input, and the game simulation is done locally on each client. Both Authoritarian solutions are intended for games where the game-state has a manageable size, and can be transferred over the network. The authority (either a client or a dedicated server) will act as authority and simulate the game, sending the updated game-state to the clients. Clients send back the player input.

3.6.2 - Why to get it

Synchronization of game content is often game specific. As a developer, one has to choose the networking model, and often invest resources in crafting something that fits the particular needs. The choice of using this enabler depends on the complexity and requirement of your game, as well as your resources.

With this enabler, we focused on two classic paradigms, peer-to-peer and server-to-client, with the intent to build a base for developers to build upon. This enabler provides a working base that can be extended to the specific needs without having to start from scratch.

3.6.3 - Documentation

- Technical Documentation of the Game Synchronization SE [8]
- Tutorials and Example Code for the Game Synchronization SE [29]

3.7 - Spatial Matchmaking

3.7.1 - What you get

Connecting to others in your vicinity is often a challenge in cities and around the country. This enabler focuses on enabling people with matched interests to connect when they are close to one another. Moreover, it opens up new possibilities for interacting with digital content among like-minded people.

3.7.2 - Why to get it

This SE matches clients allowing the developer to connect clients without programming a server back end. Application users will then be able to connect without having to exchange connection information. In particular game developers, who want to connect nearby gamers, will benefit from this Specific Enabler.

3.7.3 - Documentation

- Technical Documentation of the Spatial Matchmaking SE [13]
- Developer Guide of the Spatial Matchmaking SE [30]

4 - INTERACTION AND COOPERATION WITH OTHERS FICONTENT PLATFORMS

With regard to the effort in platform development, there is an overlap between the Social Connected TV (WP2), Smart City (WP3) and Pervasive Games (WP4) Platform. In particular relevant for city-wide games, for instance, might be the cooperation with work package 3. We address these synergies in various fashions:

Common Specific Enablers. First of all, we promoted certain Specific Enabler, such as the Social Network SE [10], as Common Specific Enabler of FIcontent due to the fact, that multiple platforms take advantage of them. For example, the social platform module of the Pervasive Games Platform utilizes the Social Network SE as well as the Smart City Platform (WP3) as described in D3.2. Thereby, both benefit from the user interaction abilities of the Social Network SE including sharing of contents such as media, status, and comments.

Technology Transfer. Moreover, we develop groups of Specific Enablers within WP4, such as the Augmented Reality SEs and Reality Mixer SEs, dedicated for gaming in the first place, but probably useful as well for advanced interaction techniques in the context of Smart City Services. Hence, we will push selected pieces of technology from WP4 either directly to WP3 or even promote certain SEs as Common Specific Enablers too. Our Augmented Reality group of SEs contains promising candidates for the latter approach. Therefore, we cooperate with WP3 on the requirements for these SEs and align the development of feature with gaming scenarios in mind as well as POI use cases, for instance.

FI-PPP Architecture Board. In addition, we maintain a strong connection between the technical work package WP6 and partners of the Pervasive Games Platform to strengthen in particular the link between the technology providers and game-domain related parties, and through WP6 to the whole FI-PPP in general due to the active engagement of WP6 in the FI-PPP Architecture Board.

Finally, few partners, which are driving the technological platform development and being involved in multiple work packages, act as bridge with regard to common requirements and sharing efforts between those work packages.

5 - PERVASIVE GAMES PLATFORM - UPCOMING RELEASES

For the upcoming releases of the Pervasive Games Platform we will shift our focus to Tier 2 and Tier 3 gaming scenarios. Therefore, we will extend the portfolio of Specific Enablers of the Pervasive Games Platform and add dedicated Enablers to handle these scenarios. Moreover, we will improve our existing Specific Enablers with additional features, performance improvements and alternative implementations. We may introduce new Enablers based on existing ones to provide a more advanced feature set.

The following Specific Enablers are planned for upcoming releases of the Pervasive Games Platform and will provide the technological foundation for our Tier 2 and Tier 3 gaming scenarios.

5.1 - Game Server

This enabler is planned as simplified abstraction to the SmartFoxServer service. This is a platform for networked games available for most of the existing game engine platforms. It gives developers the tools to create and run multiplayer games, both in terms of game modules, server hosting, and analysis tools.

5.2 - Reality Mixer - Simulation Continuum

Augmented reality experiences further take place with virtual objects placed in the real world. Virtual objects under a physically accurate simulation thus far have no physical effect on real objects and conversely rigid and soft body dynamics captured from real objects have no physically simulated effect in virtual objects. This enabler includes development of methods for achieving a simulation continuum between real and virtual objects.

5.3 - Cloud Physics Processing

Physics simulations can be demanding in terms of computation power, memory and power consumption. On mobile devices only simple simulations are feasible. With this SE we will offload the computation to a server. This is especially useful when multiple co-located mobile devices send input to a single simulation and receive the results streamed by the server.

5.4 - Reality Mixer - Augmented Audio

Sound effects add another level of immersion to games. By taking the acoustic properties of the environment into account, the sound will feel more integrated and less artificial. Especially reflections (echo) are important. Without a direct line of sight, the spectrum of the sound is attenuated non-linearly. With binaural sound we might even add a convincing sense of direction of the sounds.

5.5 - Augmented Reality - Skeletal Tracking

For Tier 1 game scenarios it is useful to track the position and orientation of a toy. This SE goes one step further by recovering the pose of the toy such as the angles of arms and legs with respect to the body or the head rotation. This can be used to react on the physical pose or for better visual augmentations on the toy itself. Maybe, the same technology can even be used to get information on the pose of other players.

5.6 - Networked Virtual Character

The animation of virtual characters is a usual task in game development. Regardless of the way how to animate the virtual character, it might be desired to synchronize the sequence of motions across multiple clients. Therefore, we provide the Networked Virtual Character to utilize the Synchronization GE for that purpose and thereby support a variety of cross-platform clients.

5.7 - Augmented Reality - Image Marker Tracking

All Specific Enablers of the Augmented Reality group provide various tracking methods to enable augmented reality applications. The Image Marker Tracking SE utilizes natural features of suitable images as markers to

retrieve camera pose information through XML3D/Xflow. This extends XML3D with the capabilities to apply the matching transformation to 3D-scene content and render them onto respective marker images in a web-based environment.

6 - DEPLOYMENT OF THE PERVASIVE GAMES PLATFORM

The figure below illustrates where the Enablers are located, i.e. where they are installed and running. On the left side the cloud services are listed that mostly have a RESTful API to be used by clients or other services. The right side shows Enablers that are running purely on the client side. The center contains Enablers that simplify the interface and need to run code both on the client and server side.

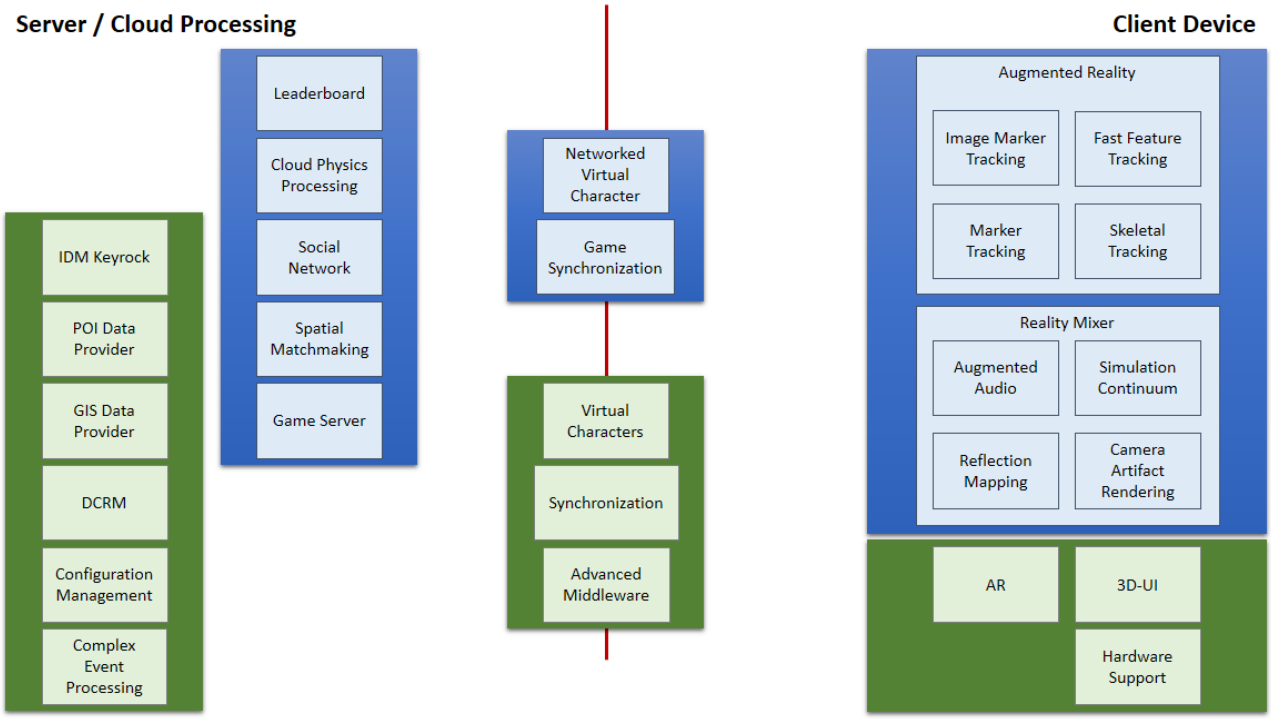

Figure 3 Deployment sites of Enablers of the Pervasive Games Platform

6.1 - Client Side Enablers

Some Specific Enablers of the Game Platform are purely located on the client side. They consist of libraries, installation packages or standalone applications. Download links will be provided via the FIcontent catalogue ('where to get') but the files will be hosted usually by each responsible partner to allow for easy updates. Such Enablers are:

- Reality Mixer - Reflection Mapping SE (see Section 3.1)
- Reality Mixer - Simulation Continuum SE (see Section 5)
- Reality Mixer - Augmented Audio SE (see Section 5)
- Reality Mixer - Camera Artifact Rendering SE (see Section 3.2)
- Augmented Reality - Skeletal Tracking SE (see Section 5)
- Augmented Reality - Image Marker Tracking SE (see Section 5)
- Augmented Reality - Fast Feature Tracking SE (see Section 3.4)
- Augmented Reality - Marker Tracking SE (see Section 3.5)
- 3D User Interface GE [4]
- Augmented Reality GE [22]

6.2 - Server Side Enablers with a Shared Instance

Some Specific Enablers and Generic Enablers that have either little performance requirements and are used by several games or SEs and GEs, which are intended to share data among several games, will use single instances. They will be deployed once and used by a number of games. These Enablers are:

- Identity Management GE [11]

- Social Network SE [31]
- Spatial Matchmaking SE (see Section 3.7)
- Configuration Management GE [18]
- Data Center Resource Management GE [23]
- Complex Event Processing GE [19]

6.3 - Server Side Enablers with one Instance per Game

Some Specific Enablers are cloud services and have to be deployed per game by the game developer. Thanks to the Thales PaaS this will be as simple as a few clicks in the administration panel. Usually, such instances also require database access. These databases can be setup with the same interface and are also created per game. These Enablers are:

- Leaderboard SE (see Section 3.3)
- Cloud Physics Processing SE (see Section 5)
- Game Server SE (see Section 5)
- POI Data Provider GE [6]
- GIS Data Provider GE [7]

For most Cloud Based (server side) enablers we will use the XIFI FI-LAB testbed infrastructure and the PaaS from Thales. The latter will greatly simplify deployment and administration by automatic scaling and health monitoring. Three notable exceptions exist where dedicated servers might be used at the respective test sites:

- latency-critical message handling for multi user games such as racing or first person shooter type games
- ethical requirements to store private data within the same country as the test site
- GPU computing power for high performance physical simulations if not available on cloud servers

For these cases, the experimentation sites provide a server infrastructure, supporting local experiments during the two experimentation cycles.

6.4 - Enablers on Both Client and Server Side

Some Enablers are located at the interface between client and server and, therefore, consist of both a server side cloud service as well as a library part which is used on the client. The enablers are:

- Advanced Middleware GE [16]
- Synchronization GE [15]
- Virtual Character GE [32]
- Game Synchronization SE (see Section 3.6)
- Networked Virtual Character SE (see Section 5)

6.5 - Infrastructure used in the 1st Experimentation Cycle

The Pervasive Games Platform is deployed on two of FIcontent's six experimentation sites: Barcelona and Zurich. The following sections briefly describe the available infrastructure at both experimentation sites, which are described in more detail in deliverables of WP7 (see D7.1.2, D7.5.1, D7.6.1).

6.5.1 - Technical Infrastructure in Barcelona

Regarding the technical infrastructure used in the Barcelona Experimentation site, i2Cat has connected different venues to run the FIcontent experiments: PMT in Castelldefels [33], Citilab in Cornellà [34], Neapolis in Vilanova [35] and Fabra & Coats in Barcelona [36] as main hub of activities.

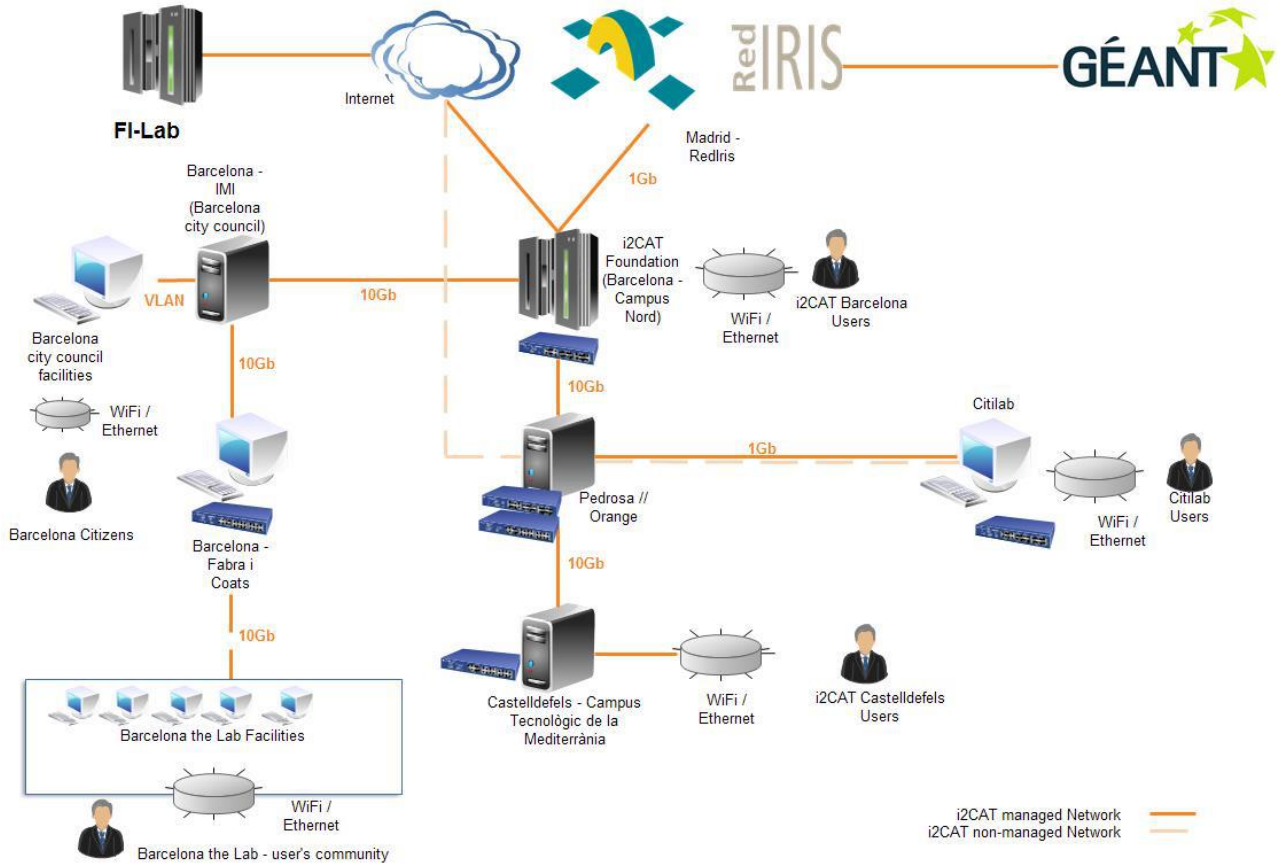

Figure 4 Barcelona: Technical Infrastructure

The connectivity of the Barcelona site to the external world, and to FI-Lab in particular, is provided by a 10GE link to FIRE facilities through I2CAT and Barcelona Municipality fiber optic network.

The Barcelona experimentation site can also count on an extensive hosting and networking infrastructure through MediaCAT's hardware facilities, fully owned and operated by I2CAT. Located in the C4 building of the Mediterranean Technology Park (Castelldefels, Barcelona), the MediaCAT CPD has 10 racks with 9 power lines (three triphasic lines) fully dedicated to hosting:

- 3 lines connected to the university's uninterruptible power system (backup electric generator).
- 3 lines per equipment distributed in the communication and services racks
- 3 lines dedicated to cluster servers and storage racks

MediaCAT's hosting capabilities are currently supported by:

- 90 hardware servers that host both services and virtual servers based on VMware or Xen.
- 14 Switches 10/1Gbps dedicated network
- 7 storage boxes.
- Different network testbeds including a Juniper MX480 router.
- Other equipment such as video conference, DWDM ...

6.5.2 - Technical Infrastructure in Zurich

The current technical infrastructure consists of a dozen of mobile devices, i.e. tablets and phones, as well as the infrastructure offered by ETH Zurich (wifi, rooms, open areas where to run experiments). At the moment Zurich is using the cloud hosting provided by FI-LAB which is sufficient for the current needs of the Pervasive Games Platform. Virtual servers can be rented from ETH on demand, allowing to reduce latency for some time critical synchronization of real time games.

7 - CONCLUSION

In this document, we have presented a technical description of the Pervasive Games Platform. First, we have presented the overall architecture of the platform, listing the groups of Specific Enablers and Generic Enablers that are involved, as well as how they interact with each other. In addition, we have indicated the external development tools that are currently integrated in the platform and how this integration works.

Second, we have presented the development roadmap, including a description of what will be available in the first platform release and in upcoming releases. This includes a high-level description of the Specific Enablers provided by the partners behind the Pervasive Games Platform. For a detailed description of Specific Enablers, please refer to FIcontent Wiki. Description of FI-WARE GEs is referred to the FI-WARE catalogue.

Finally, we have discussed the deployment of the platform and pointed out the diversity of environments hosting the utilized enablers between client devices and server instances together with technical infrastructure used for the first experimentation cycle in Barcelona and Zurich.

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