VirtualLife Virtual World Platform: Peer-to-Peer, Security and Rule of Law

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Abstract: This paper addresses the purposes, design decisions and innovative features produced while developing a peer-to-peer virtual world platform within the FP7 VirtualLife project. VirtualLife project aims to create a safe, democratic and legally ruled collaboration environment to be used for business, education and entertainment. The novelty of the platform is mainly in the issues of security and trust and in the implementation of an in-world legal framework, which is real world law compliant. Nevertheless, the research has also been focused on other technical aspects such as network, scripting and real-time 3D engine issues.

Keywords: Virtual world, peer-to-peer, security, legally ruled collaboration, virtual law.

1 INTRODUCTION – VIRTUALLIFE: THE EVOLUTION OF 3D VIRTUAL WORLDS

The paper presents early results obtained while developing a virtual world (VW) platform which is designed under the following requirements: (1) the use of a peer-to-peer communication architecture, (2) security and trusted transactions, and (3) legally ruled collaboration. The work is being done as part of the EU FP7-ICT-2007-1 VirtualLife¹ project. The project aims to produce a prototype of a virtual world platform which is innovate from the administrative, security and data protection perspectives, an evolution of 3D virtual worlds towards a stronger digital trustworthiness.

The main innovative features to be promoted and exploited in a commercial way are a novel editable and enforceable virtual constitution, an enhanced security framework, and a peer-to-peer network architecture.

Security and trust contribute to legal values such as equality, avatar integrity, honour, reputation, privacy, free movement, freedom of thought, freedom of association, sanctity of property, etc. which are listed in the code of conduct within the virtual constitution. The rule of law is a legal principle. In VirtualLife, we treat it as a paradigm, a purpose. It results in legally-ruled collaboration in a virtual world of VirtualLife.

Currently, VirtualLife is targeted at scenarios focused on distance learning, such as a university virtual campus. 3D virtual world platforms are able to enhance Web 2.0 experiences of students and teachers by using a rich collaboration environment. Whereas the 2D environment of Web 2.0 provides the information as content, 3D virtual worlds allow using the interaction as content. Students perform certain activities in the immersive 3D environment for which they obtain instant feedback.

2 ABOUT VIRTUALLIFE

VirtualLife constitutes a new form of civil organisation, realized by the creation of secure and ruled places within a virtual world, where important transactions can occur (where transactions are those that normally occur in real life). The virtual world is treated not as a game but as an extension of the real world. VirtualLife enables everyone to create his own virtual world and store it on his own computer.

VirtualLife offers a customizable platform for private companies and public institutions interested in building a virtual world for both intranet and public use.

Figure 1: Peer-based connection model of a virtual zone

Each virtual world in VirtualLife consists of a peer-to-peer network with nodes connected using a secure protocol. Control in each world (referred to as a zone) is managed by a zone server (Z-server). A collection of zones forms a nation, consisting of a network of virtual zone servers. The use of Z-
servers gives the end-user the full control over the fundamental components of the virtual zone and the persistence and protection of his critical data (see Figure 1). The concepts of nodes, the virtual zone and virtual nation are essential ones.

2.1 Virtual zone server overview

The virtual reality engine of VirtualLife is designed to be a non-centralized mechanism that functions across a number of machines connected by a network. However, to maintain the goals of security, integrity and persistency, it is imperative that at least one of these machines have an extended role to perform these functions. We refer to this machine as the Z-Server. Anyway, while performing some server-like functions, the communication system within a virtual zone is primarily peer-based (see Figure 1).

The Z-Server has the following roles within a virtual zone:

- Node authentication and authorization: it serves as the entry point to the virtual zone for a node, and validates the authorization of that node within the zone. Note that this process serves to authenticate only the node, and not the user of that node;
- Persistency: it serves as a central point where the state of the virtual zone is regularly saved.

The Z-Server contains the following primary modules:

1) Authentication and authorization protocols;
2) The virtual reality engine. It takes care of the following:
   i) maintains a current module of the virtual zone in terms of entities that are in the world;
   ii) handles persistency, i.e. committing entities to disk;
   iii) handles authorization activities – only permissible actions can be performed by designated users;
3) Handling communication between avatars, e.g. public chat;
4) Handling requests for resources that reside in other zones.

2.2 Virtual nation overview

A virtual nation is a set of users sharing the same purpose and values. The virtual nation introduces concepts of the real world such as constitution, government, monetary system, register office in a real world (see Figure 2). The virtual nation defines a secure and trusted infrastructure to share information and interact with the rest of the community.

A virtual nation is defined by:

- The list of virtual zones belonging to it;
- The allowed avatars (virtual citizens), authorized by a certificate generated by the virtual nation;
- The constitution (that will be mapped onto a set of technologically implemented laws);
- The timing reference.

2.3 The peer-to-peer communication prototype

The connection model (see Figure 3) is implemented in the communication module of the virtual reality engine.
Each Node can have multiple connections to any other node in the zone.

Transfer of messages and data across the connected machines is done in a peer-to-peer way.

2.4 Avatar identity card

Each avatar has an identity card, which contains information about both his virtual and real life identities (see Figure 4).

Figure 4: Virtual identity card

The ID card includes simple indicators of trust. A red bar means that the avatar is a guest and has not proved his identity; a yellow bar – the avatar has an identity, but it has not been verified by any certification authority; and a green bar – the avatar’s identity has been verified by a certification authority.

Each avatar also has an economical, social and civic reputation, whose indicators are handled by a sophisticated reputation system, depending on the avatar’s behaviour.

A virtual identity can use a number of different key pairs, issued by different certification authorities. Different certified key pairs have a different level of trust. There is no chance of having the same key pair as that of another user, unless the key pair has been stolen.

3 INTERACTIVE OBJECTS IN A VIRTUAL CAMPUS SCENARIO

At present VirtualLife is targeted at learning support scenarios (see Figures 5 and 6). A professor avatar gives a lesson whereas student avatars listen. Avatars can interact with each other and with objects in the world. An interactive object is shown in Figure 5.

Figure 5: A geometric interactive model operated by a 3D widget in the context of a virtual lesson

Figure 6: Pointing to a stellated dodecahedron

4 INNOVATIVE FEATURES

Besides the virtual constitution, security (integrating public key infrastructure, PKI) and P2P, there are other technical innovations with regard to network, system architecture, real-time 3D engine, scripting and searching.

4.1 The Virtual Legal Framework

It seems that currently the only sources of rules in a virtual world are the end-user licence agreement (EULA) and the terms of service (also called terms of use). The EULA is not enough for many reasons, in particular:

- It only partially governs the relationship between the provider and a user but not between users.
It is in most cases unilateral (it protects the provider’s interests but not those of the user).

When the user enters a virtual world, he automatically becomes part of a community. This means that he interacts with other users. These interactions are, in most cases, peaceful but are also likely to produce conflicts. When a conflict takes place, the need for resolution arises.

Present virtual worlds try to prevent conflicts through the rules of conduct contained in the terms of service. But still, this regulation is not enough. The existence of rules does not prevent a user from adopting a bad behaviour towards another user. When a user feels that an injustice has occurred, the only way through which the user can seek justice is to report the abuse to the virtual world creators that can decide to ban or punish the griever (the term to refer to someone acting “illegally” in a virtual world). In some cases the virtual world creators invest in specific techniques to keep the virtual world “under surveillance”. For instance, this is the purpose of the peacekeepers in Active Worlds.

Thus an innovative feature in VirtualLife is a legal framework that is compliant with real world law. The framework is a three-tier system. Moreover, the system contains an in-world dispute resolution mechanism and a voting system.

1) In order to become a citizen, the user can be asked by the Virtual Nation to certify his real identity, in other words, the virtual identity of the user is bound to his real one (a certification authority guarantees this correspondence).

2) As soon as the user becomes a citizen of a Virtual Nation, he must accept the laws in force in that specific nation, specified within the Virtual Nation Constitution.

3) There will be two different constitutions. First, a Supreme Constitution that will be made of fixed rules (that cannot be changed by the user). Second, the Virtual Nation Constitution (one for each Nation) which will be made of modifiable laws that can be changed by virtual citizens, thanks to a voting system which is in force in each Nation. The Supreme Constitution is a kind of EULA with a great innovation: the fact that the user of a Virtual Nation as well as the administrator of a Virtual Nation have to accept it. Therefore it does not protect the administrator’s rights but binds him in the same way as it binds the user.

4) The constitution also contains a list of templates of contracts that can be used to regulate “business” relationships between users.

5) Each Virtual Nation should have an arbitration service, i.e. a dispute resolution ruled by the Nation with a Mediator Board made of virtual citizens

4.2 Security

Security is very important in on-line systems in particular for the protection of users and contents. In the analysis of competitors’ virtual worlds, the authors did not find specific and well defined mechanisms which guarantee security when joining the community. Most of the platforms are focused on implementing a strong authentication system based on username and password. Some integrate the common login process with hardware or standalone devices in order to improve security.

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Some mechanisms have been considered in order to assure the users, even in a weak way, that the world is secure and reliable. Current virtual worlds usually introduce moderators in order to supervise avatars’ in-world behaviour and user generated content. Moderators and system administrators are able to suspend or ban accounts depending on the severity of the offence that the related avatar has been accused of.

Innovative features in VirtualLife are the following:

1) Identities are harder to steal, as the PKI key-pairs of the user are not stored online but on the client side. This means that losing a password will not allow anyone to access an account from anywhere else.

2) True identification of communication partners.

3) VirtualLife outsources some state processing to other nodes, but only ones that the outsourcing party trusts.

4) No technical means is implemented to remove inappropriate content. It will be handled by a moderating process.

5) No tools for detecting cheating. In MMORPGs (massively multiplayer online role-playing game) servers need clients to behave well. In VirtualLife trust relations are more equal and aim towards rationality. Here the design philosophy with respect to trust is that a user must prove something to be trusted. Every party is in charge of verifying the actions related to its data and rights. The machine of a client, zone or nation is considered to be a tool of its user and the others do not have to communicate with someone who does not play by the rules.

4.3 Network

Most of the existing virtual worlds are based on client-server architecture. The main computational work is up to the server which is in charge of maintaining persistency and integrity for the whole system.

Some platforms have implemented a network of server clusters along with an instancing mechanism in order to improve the load balancing among nodes, and thus enhanced real-time integrity. This is true in particular for MMORPG platforms, in which quick responsiveness is an important issue, especially during quests and adventures.

Innovative features in network topology in VirtualLife are:

1) Streams for distinguishing between messages of different services
2) Equality between nodes. Every node is a service provider with some services. Nations, zones and clients have a different set of services that overlap to some degree.

4.4 Real-time 3D engine

The virtual reality engine of VirtualLife competes with a number of MMORPG platforms. Criteria to compare are online architecture, the number of users supported and graphics rendering. Commercial platforms make use of a variation of client-server architectures. For example, Second Life uses a single server per region, while systems such as There, OLIVE and RealXtend use a number of special purpose servers for communications, databases, authentication and simulation.

The main innovative feature of the virtual reality engine of VirtualLife is the P2P based communication scheme. Existing commercial platforms rely heavily on large central servers for processing. VirtualLife aims to reduce this dependency by spreading the load between different clients. The purpose is to have the following advantages:

1) A good scalability ratio with respect to the number of concurrent users, as a result of a carefully designed communication system using P2P connections

2) The “server” module for a VirtualLife implementation need not be a powerful machine with large bandwidth. This is because world processing (logical, animation, integrity, reckoning, etc.) is shared across peers.

3) The peer-based scheme supports redundancy of data, as well as redundancy of communications for better fault tolerance than a centrally located server.

4) Competitive graphics quality, despite the challenges resulting from peer-based communication architecture. The goal is to obtain higher responsiveness and integrity levels, when compared to the existing systems.

4.5 Scripting language

Scripting allows users to create interactive objects (e.g. vehicles, automatic doors, teaching tools, etc.). In some virtual world platforms the scripts execute on the client program and are used just to improve GUI. In most cases the script engine runs on the server node of the system network.

A proprietary language can be used (like LSL in Second Life) or a standard one (e.g. Python, Lua, EcmaScript). A custom language can better suit the virtual world programmer’s needs, but it can be less reliable and more difficult to master.

VirtualLife scripting is on both server side (to define the behaviour of interactive entities and to implement some “virtual laws”) and client side (to personalize the GUI and to create building tools). The language used is Lua, augmented with libraries (e.g. to manipulate vectors and quaternions) and object-oriented binding which allows the script to access VirtualLife entities (e.g. the zone).

5 FOCUS ON VIRTUALLIFE LEGAL FRAMEWORK

A VirtualLife legal framework was elaborated in project deliverables (see Figure 7). Further the elaboration was in the form of the technical specification of Virtual Nation laws which comprises the editor of rules.

![Figure 7: VirtualLife legal framework, see Spindler, G. et al.: D7.1 VirtualLife deliverable (2008)](image)

A virtual world is quite different from a standard video game, where there is a story, a final purpose, and the system only allows for a limited (more or less limited) set of actions. In a virtual world there is not a determined purpose, there is not a game over, people move their avatar and establish their second life, driven by different motivation and with different purposes. Thus the rules of play should be replaced by a sophisticated legal framework, which is considered to be essential in order to guarantee the existence of a secure and safe virtual world. In VirtualLife the legal system takes into account both real life values and virtual world laws.

5.1 From norms in law to norms in artifact

A Virtual Nation Constitution contains special provisions as regards, for example, the protection of objects used in that Virtual Nation under copyright law or the authentication procedure required to become a member of that nation. Distinct virtual nations, e.g. a virtual campus and a virtual mall, should be governed by different rules.

As one can note, the Supreme Constitution is placed in the level of contract law. This contributes to law enforcement. A user of VirtualLife software is not ruled exclusively by the sources above, but also by the user’s national law.

The editor of rules comprised in the VirtualLife platform is a tool to compose laws. The rule concept is approached considering (Vázquez-Salceda et al., 2008). A sample toy rule ‘Keep off the grass’ is transformed into ‘The subject – avatar – is forbidden the action – walking on the grass’. Other examples of rules:

- An avatar is forbidden to touch objects not owned by him or a certain group
An avatar not belonging to a given group is forbidden to a given area of the zone
An avatar is forbidden to create more than a given number of objects during a given time interval
An avatar is forbidden to use a given dictionary of words (slang) while chatting with other avatars
An avatar of age is forbidden to chat with avatars under age
An avatar is forbidden to execute authorized scripts in a certain area

If an avatar violates a rule (e.g., walks on the grass), his reputation is decreased. Rule enforcement is implemented by triggers. They trigger the changes of the virtual word states and thus invoke avatar script programs.

One can note that we follow a legal informatics approach “From norms in law to norms in artifact”. The approach contributes to bridge between law and informatics. The artifacts can be of different kinds. Additionally to embedded systems, the artifacts comprise software systems like virtual world platforms and virtual nations.

5.2 Values protected by VirtualLife laws

VirtualLife laws – like laws in general – identify purposes and protected values. These are the values of a Virtual Nation (VN). Each user has an obligation to respect these values. The values shall be enforced by code – a set of technologically implemented rules and laws.

The purpose of a virtual nation is described in the beginning of the Virtual Nation’s constitution. For example, in the case of a virtual campus scenario, the purposes in short can be formulated as teaching and learning.

Examples of values, which are immanent in a real-world constitution of a state, are democracy, human life, sanctity of property, legal certainty, etc. In legal theory, the norm is a basic element of the law. Values can be worded explicitly, but mainly they are implicit. For example, the Code of Conduct within the Supreme Constitution identifies equality (non-discrimination), avatars integrity, honour, reputation, privacy, free movement, freedom of thought, sanctity of property, etc. Such explicit representation contributes to detect infringements of the VN laws by the users.

A pursued goal can be treated as a value. A primary goal is nearly all MMORPGs is the development of the player’s character. VirtualLife also pursues other higher level values. Interaction is treated as a true value, too.

Value-based interaction is a distinct feature of VirtualLife.

5.3 The law of avatars

After addressing the law of humans above, we further focus on the law of artificial agents. We call this kind of ruling “virtual law”. It aims at legally ruled behaviour of avatars.

A novel idea is that the behaviour of artificial agents (avatars, too) shall be governed by law. An example of a norm is that an avatar is forbidden to commit a (virtual) crime over another avatar. For example, an avatar is forbidden to harm (kill, hit) another avatar. Thus we approach a code of avatars that is concerned by Koster (2000).

Our idea also accords with the concept of legally ruled interaction of artificial agents in multi-agent systems (MAS), see e.g. (Vázquez-Salceda et al., 2008). Law governed interaction is addressed by Naftaly Minsky (2005). Our research identifies certain problems, e.g., how to enforce the law or artificial agents.

Designers of actions over avatars have to care that such actions do not infringe the so-called “virtual rights” of other avatars. For example, the physical integrity of the body of another avatar shall be preserved when my avatar takes an action – walks, moves, flies, etc.

Virtual laws accord with the concept of a community of programs by Lyubimskii (2009). He came to the conclusion that programs should interact similarly to humans: “the structure of the community of programs and the means of their interaction are largely similar to the structure and means of interaction in human society”. Hence similar laws should rule the interaction of programs.

6 CONCLUSIONS

Virtual worlds are likely to become a widespread extension of our real lives, thus legal and security virtual features need to be improved in order to guarantee safe and reliable virtual infrastructure. VirtualLife project intercepts this need; in fact it combines a virtual legal system, a strong security infrastructure and a scalable peer-to-peer communication architecture, to provide a secure, massively multitudes and cross-platform 3D environment suitable for education, e-commerce, business and entertainment.

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