

# Networked Virtual Environments

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## INTRODUCTION

The inherent need of humans to communicate acted as the moving force for the formation, expansion and wide adoption of the Internet. The need for communication and collaboration from distance resulted in the evolution of the primitive services originally offered (i.e., e-mail) to advanced applications, which offer a high sense of realism to the user, forming a reality, the so-called virtual reality. Even though virtual environments were first introduced as stand alone applications, which could run on a single computer, the promising functionalities of this new form of representation and interaction as well as the familiarity of the users with it drew increased research interest. This fact resulted in virtual reality to be viewed as the solution for achieving communication and collaboration between scattered users, in various areas of interest, such as entertainment, learning, training, etc. This led to the creation of Networked Virtual Environments (NVEs). In particular, NVEs were first introduced in the 1980's and the first areas that exploited the newborn technology were military and entertainment applications. In particular, the U.S Department of Defense played an important role to the direction of applications, protocols and architectures for this promising technology. In the 1990's, where academic networks became a reality, NVEs drew increased academic research interest and a variety of applications and platforms were developed. In particular, the academic community has reinvented, extended, and documented what the Department of Defense has done. The evolution and the results extracted by research on this field were widely adopted from multiple areas of interest, with main representative the entertainment area.

Since 2000, where virtual reality technology, processing power of computers and the network were significantly improved, a wide variety of systems, protocols and applications were developed. In particular, the familiarization the end users with the Internet and the promising advantages and opportunities of Virtual Reality contributed to currently view NVEs as an effective tool for supporting communication

and collaboration of scattered users. Currently, the application areas of NVEs have been widely expanded and their use can be found at military and industrial team training, collaborative design and engineering, multiplayer games (Zyda, 2005), mobile entertainment, virtual shopping malls, online tradeshows and conferences, remote customer support, distance learning and training, science, arts, industry, etc. Summarizing, NVEs nowadays tend to consist a powerful tool for communication and collaboration, with applications ranging from entertainment and teleshopping to engineering and medicine. To this direction, in the recent years important active research on this topic in both academic and industrial research is taking place.

## BACKGROUND

NVE is a twofold term. Even though the "Virtual Environments" part prevails, the "networked" substance changes the meaning and nature of these environments. Regarding the Virtual Environment, it can be considered as a simulation generated by a computer, which can simulate either an imaginary or real world. Even though Virtual Environments can be two-dimensional, the term is mainly related to three-dimensional environments that aim at providing to the users a high sense of realism by incorporating realistic 3D graphics and stereo sound, to create an immersive experience. As far as it concerns the "networked" part of the term, this dimension is mainly related to the support of multiple concurrent users, scattered around the globe, even though NVEs can be single user applications. A definition provided by Singhal and Zyda (1999) states that "NVEs are software systems that can support multiple users, which can interact both with each other and with the environment in real time and aim at providing to the users a high-sense of realism by incorporating 3D graphics and multimedia."

The concept of a NVE is simple. Two or more users can view the Virtual Environment (VE) on their computer, having their own local copy of the virtual world. For achieving

high-sense of realism and maintaining consistency, when a user performs actions on one computer, these actions are propagated through the network to other participating computers for keeping all copies of the VE synchronized. The participants constitute active parts of the VE, usually represented by human-like entities, called avatars for enhancing the awareness (Joslin, Pandzic & Thalmann, 2003).

As mentioned earlier, the network constitutes the core of NVEs. However, NVEs can be further categorized by their architectural model or the nature, in terms of the kind of application they plan to support (Macedonia, 1997). In particular, regarding the architectural model, the most popular category of NVEs are the Distributed Virtual Environments (DVEs), where active parts of the virtual environment are scattered to different computers, which are connected through the network. Accordingly, in respect to the nature of these environments, one of the major categories are the Collaborative Virtual Environments (CVEs), where the users have the ability to meet and interact with others, with agents and the objects of the virtual environment.

## **MAIN ISSUES AND CONCEPTS IN NVES**

A NVE constitutes a computer system, which generates virtual worlds, where the users can interact both with the system and the other connected users in real time. The users are connected to the Internet and working on different computers, access the same virtual scene. The simulation of the virtual scenes is realized through distributed and heterogeneous computational resources. The evolution of the software applications and services in combination to the melioration of the network allows for the development of networked applications, which are characterized by the enhancement and combination of many advanced features. For NVEs in particular, where the achievement of high realism constitutes a key concept, the realistic and detailed representation of the provided information is of high importance. Therefore, the potentialities that technology presents in combination to the increased needs of the users result in NVEs to adopt rich representation for the information in terms of graphics and media.

Despite the fairly simple concept, the design of NVE systems involves a complex interaction of several domains of Computer Science. In particular the interacting domains are the following: (a) networking, which is related to the transmission of various types of data with different requirements in terms of latency, bitrate, and so forth, (b) simulation, which is related to the virtual environment and involves visual database management and rendering techniques with real time optimizations, (c) human-computer interaction, which is related to the support of various types of devices, (d) virtual human simulation, which is related to the avatar's

realistic representation in terms of facial expressions, motions, and so forth, and (e) artificial intelligence involving decision making processes and autonomous behaviors (Joslin et al., 2003).

This section will present the basic issues related to NVEs, in terms of the basic features they need to support, the components necessary, in terms of the hardware needed for their operation and interaction with the users, the most common architectures adopted for supporting such environments, the technologies and protocols for their development as well as the issues and factors that should be taken into account for assuring a good performance.

## **Basic Characteristics**

As mentioned above, NVEs can represent either a real or imaginary world. Thus, the structure, the space, the objects and the functionalities provided in such an environment may significantly vary in respect to the concept they aim to support. However, for achieving a high sense of realism, NVEs are characterized by some common features. In particular, these environments should provide: (a) a shared sense of space, in terms of creating the illusion to the users that they are being located in the same place, (b) a shared sense of presence, which is mainly related to the virtual representation of the users that is commonly realized through human-like personas called avatars as well as to the visibility of others participants entering or leaving the environment, (c) a shared sense of time, in terms of being able to see other participants' actions when they occur, (d) a way to communicate, which can be achieved through gestures, typed text and voice and finally (e) a way to share, in terms of being able to interact realistically not only with other participants but also with the virtual environment itself (Singhal & Zyda, 1999). The support of the above-mentioned characteristics is critical for the successful simulation of reality and vital for the effective communication and collaboration of the participating users.

## **Basic Components**

In terms of the hardware needed for NVEs, four components are found necessary for the correct and successful operation of these environments. In particular the components needed are: (a) graphics engines and displays, which constitute the cornerstone of the user interface and the users' "window" to the environment, (b) communication and control devices (e.g., keyboard, mouse, joystick, dataglove, head mounted display, motion detectors in full-body immersive environments), which allow and support the manipulation of the objects of the environment as well as the navigation and interaction of the user with the environment, (c) processing systems for computing and determining the transmission of the events that take place within a virtual environment and

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