SIXTH FRAMEWORK PROGRAMME
PRIORITY IST-2002-2.3.1.8
Networked Audiovisual Systems

Contract for:

SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

Annex I - "Description of Work"

Project acronym: Uni-Verse
Project full title: A Distributed Interactive Audio-Visual Virtual Reality System
Proposal/Contract no.: 002228

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Operative commencement date of contract: Feb 1, 2004

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1. Project summary

The goal is to create an open source Internet platform for multi-user, interactive, distributed, high-quality 3D graphics and audio for home, public and personal use. The platform will support high-quality 3D-graphics as well as high-quality 3D-audio and acoustic simulation.

The foundation of the platform is a lightweight, low latency, general-purpose network protocol for 3D data, which lets multiple applications act together as one large system by sharing data over the network. If one application makes a change to the data the change is distributed instantly to all interested clients. Therefore rendering engines, tools, simulation engines and other components can be separate applications working together over a network to form an application. The platform will be scalable from simple PDA's to large immersive environments.

The core of the project is to integrate state-of-the-art technology from different partners using this protocol. This will form a consistent and useable system with unique dynamic properties

The components we intend to develop include an advanced 3D graphics engine, a unique 3D audio acoustics simulator, tools and visual scripting and computing engine as well as integrating new and existing tools. We also intend to build and research new opportunities given this highly dynamic collaborative system such as dynamic mesh generation, adaptive global illumination solutions, distributed computing.

Our research will be focused on integration as well as development in the respective fields. We will also research the scalability of the system for future wide spread use.

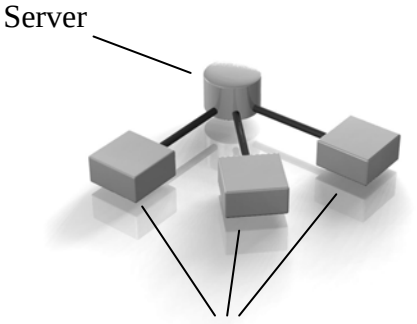
The platform will be tested in two application areas, architecture and digital media.

We believe that such a platform could have an impact on the interactive media industry as well as design, arts, education and simulation.

2. Project objectives

Our intention is to create an open source IP-based platform for multi-user, interactive, distributed, high-quality 3D graphics and audio for home, public and personal use. The platform will support high-quality 3D-graphics as well as high-quality 3D-audio and acoustic simulation. The goal is to create a platform that can unify the technology found in virtual reality, games, and networking to form a delivery platform for a new form of content. Media has benefited enormously by content delivery standards such as 35mm film, PAL/NTSC, FM radio, and HTML. Today we see a game market with huge potential held back by the lack of content standard and closed hardware platforms. If this technology could be made standardized we would be able to create development pipelines, tools and education that would increase overall quality and experience, drastically reduce the development cost of content and open up for a wide range of applications. With most households having computers and with the advent of cheap 3D hardware and broadband Internet connections we believe that the time has come. This platform must be open to allow any content provider to create content, any hardware vendor to create new hardware and any tool/technology vendor to add software.

The foundation of the platform is an IP network protocol for integrated dynamic 3D-graphics and 3D-audio content. This lightweight, low latency network protocol will be based on an existing protocol known as Verse [17][23] developed by one of the partners. This protocol lets multiple components act together as one large application by sharing data over a network. If one application makes a change to the data the change is distributed instantly to all interested clients. This simple network protocol allows anyone to write components and applications that are compatible. The protocol is usually configured with a central server that acts as a hub passing of messages to the clients. Clients no longer needs to access data through load/save features since all communication is done instantly using the protocol. This also adds redundancy since all clients and the server have a copy of the data. No data is lost if one component crashes. The data format used by the protocol is an easy-to-use, non-application specific format, but with advanced features as subdivision surfaces geometry, shader trees, high dynamic range and 3D textures.

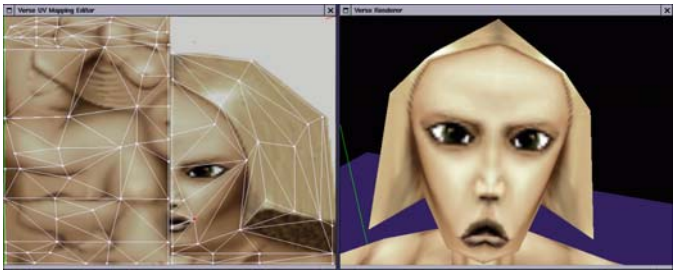


Tools, rendering engines, services and other clients

We have gathered researchers and experts in relevant fields like 3D graphics, interaction, gaming, 3D tools, 3D audio, Virtual Reality, display systems, 3D processing and hand-held devices to come together under the umbrella of this idea of a common network protocol for information exchange. One partner in the project is the Blender Foundation bringing in a community of open source developers. Blender is by far the largest open source 3D creation tool, with a registered user-base of over 250,000 users worldwide (march 2002). All software developed in the project will be open source but other companies may develop modules for Uni-Verse, which are proprietary.

The 35mm film specification doesn't produce films or in itself have a value, but enables independent entities to create cameras and projectors that are compatible giving rise to a multi

billion € industry. In the same way a networking protocol is useless unless we create applications that utilize it. In fact the protocol has deliberately been created to have a low profile and not govern and limit the applications using it. This forms the objective of the Uni-Verse project to integrate components to create an open source platform for multi-user, interactive, distributed, high-quality 3D graphics and audio for home, public and personal use.



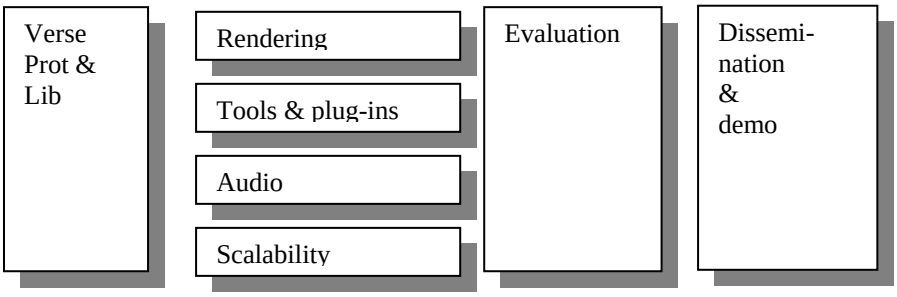
Two applications using the same data

Each component consists of independent clients connected by the Verse protocol. Each of these components contains **innovative methods** and research topics and will be designed to meet and extend the state of the art:

Graphics will be provided by a *rendering client*, which already exists in prototype form, featuring Subdivision surfaces, Texture compositing, Programmable shades, displacement mapping, dynamic lighting and shadows. The current early version will be extended to make use of the new hardware exposed by OpenGL 2.0 released late this summer. This Rendering engine will be written to be portable for multiple operating systems and run on standard PCs and high-end workstations and Caves.

In order to facilitate mobile phones, PDAs and other hand-held devices with limited hardware resources we will also develop a *low-end rendering client*. We believe that 3D will be important in the future applications for portable devises, such as location specific information and path finding.

The goal of the *audio client* is to provide real-time acoustic simulation and rendering. The idea is to enable concurrent architectural and acoustical design in a distributed manner. The client will combine physical and perceptual modelling in a novel way to achieve a high performance level. The main research questions in this area are: 1) automatic geometry simplification of complex architectural models to make them suitable for acoustic simulation, 2) audio culling, i.e. finding the most relevant sound sources contributing to the overall soundscape in a virtual acoustic environment, 3) relation of perceptual and physical acoustic parameters for efficient acoustic rendering.



A special *script client* with a run-time environment built in will be developed in the project. This client connects plug-in modules in dataflow fashion. This can be used to create data relations, events, animations and other interactivity. In this is environment you can for instance relate a door's angle to a button, a train to a specific path or an avatar's animation to a specific user action. By creating flow graphs with components, a non-programming user can easily create advanced behaviour and logic. This environment will have a simple API so that anyone can write additional plug-ins. The environment will not have a graphical user interface

but will communicate with a separate user interface client using the network protocol. This will enable remote processing and allow more flexibility.

For this scripting environment we will develop a number of plug-ins, for mathematics, logic, event handling, graphics processing and animation. Some of them will be basic but there will also be some more advanced plug-in such as the radiosity plug-in described below. We will also create plug-ins for dynamic mesh systems like L-systems for dynamic generation of biological entities like trees, vegetation and dynamically generated animals.

The simulation of light is very important for the visual appearance in virtual environments. This system will include a *progressive radiosity module*, which gives a high degree of realism. The radiosity module will provide a physical based distribution of light radiation in a 3D scene. This is done by considering the 'interaction' of light between surfaces of objects and light sources in the 3D scene. Using this method will create realistic lighting and will also create correct soft shadows of the objects, which will look far more realistic than the hard-edged shadows produced by other rendering systems. Especially in closed environments, like interiors of buildings, this method will create very realistic images

A number of *tools* will be developed to be able to edit and create the data in real-time. Since all tools are connected by the protocol there is no need to create one large application in order to get integration. Therefore the tools will be divided in multiple smaller components. This approach is more flexible since the user can choose the tools they want to use for different tasks. Tools can also be made cleaner and with more focused design and interface with a smaller scope inviting to more innovative and experimental solutions.

Additionally to the tools we will create a *plug-in* for a selected graphics application. This will allow the selected application to connect to the network and share data. This would for instance enable multiple users to be able to draw, edit and interact with the same data and in real time see the other users actions in a familiar interface.

Special consideration will be taken to *scalalability* and we have a workpackage dedicated to write variations of the network server that contain data reduction and zoning algorithms to cope with very large data sets or limited clients. Since our network protocol can be run in any configuration we believe that many innovative solutions to scalability issues can be reached.

To truly appreciate the new possibilities of this approach let us explore some **examples** of how such a system could be used:

Imagine an **architectural** office being able to run a project where multiple architects can use plug-ins to their 3D software to connect to a server and being able to modify the model simultaneously. Since the data on the server is stored in a common data format each architect can use his or her 3D application of choice. An on-site manger or customer can at any time use a secure login to connect to the server to review the work and give feed back. And as they do they can see the model change instantly in real-time as the architects responds to the feedback. The manager or customer doesn't have to use a complicated CAD application but can use simple rendering client on a PC or PDA, or an advanced VR set-up such as a CAVE. This example is also relevant to areas such as engineering, planning and construction where the entire chain of management, designer/engineer manufacturing, testing and installation easily can communicate and make changes and get approval for changes.

Another area is **on-line gaming**. A game development company could set up pay-per-play servers and invite players to participate in online gaming. They could choose to use standard Uni-verse tools, animation engines, logic engines and server configurations, but would also be able to write any components themselves. This would obviously be reducing costs dramatically while still retaining flexibility. A project can also be managed remotely and large teams of different talents could cooperate virtually without the need to relocate to a single office. Since the game logic would be on the server side there is no possibility of piracy and the game designers can at any time change the game in any way while it is running to be able to keep the game up to date. Users would not be limited by hardware platforms, as they would be able to participate in the game from any platform that has a rendering client. Porting therefore becomes a non-issue.

In the area of hand held and portable devices a new class of applications can be created where a users connected client can have a 3D representation of his/her surrounding area that updates in real-time to reflect the changes in the area, like the position of people, cars, trains and busses. The client would use position technology to constantly notify the service provider of its position while constantly getting information form other users. Obviously the service provider could give the user privacy settings. This type of systems would also be very useful for security, information and educational applications.

The main **deliverable** of the project will be a tested and verified prototype of the Uni-Verse system consisting of the following components

- An open specification of the protocol and libraries, which implements it.
- Uni-Verse server
- Visual and Audio Rendering clients for workstations, and immersive environments.
- Visual and Audio Rendering for thin clients such as PDAs and mobile phones
- Modelling tools
- A plug-in for an existing geometric modelling tool
- A progressive radiosity module
- A scripting client, which facilitate development of interactive applications without programming.
- A client for dynamic mesh generation, L-systems etc.
- Tools for administration of Uni-Verse systems
- Alternative server implementation for large data sets and thin clients

Some of the software developed in the project. e.g. for acoustic rendering and data reduction will moreover be generally applicable.

The Uni-Verse system will be a unique system that can be used for a wide variety of applications. In the project we will use the game and digital media industry as well as architectural offices and the building industry as test cases and two demonstrators will be developed in the project.

Comparing with state of the art

Comparable systems can be divided into a number of classes:

File formats
Many File formats to store and distribute have been proposed, but they only allow distributing finished work for a single user to view. A connected system on the other hand can download data that is continuously changing and can also contribute changes that other users can experience in real-time. In a world where collaboration, multi-user and real-time capabilities are important a file format quickly becomes very limited even if multiple applications can read and write it. (Examples are: VRML, MPEG4, Cult3D and XML)

Game engines/VR systems
There are multiple commercial and non-commercial engines available offering a more or less complete 3D networking solution. They are all however designed to be implementation specific. They are made by a single entity that creates all components and does only invite for limited modification by third party. They are also not compatible with each other and are specially tuned for a very limited type of application. There is today a lack of real dynamic content such as artificial life systems, dynamic motion etc., because of the limitations and lack of standardizations of the protocol's and systems used. The graphic data is often completely static and located at the client. (Examples are: the Quake, Unreal and LithTech engine, DIVE [24], Ygdrasil [25]).

Hardware APIs
There are a number of interfaces made to talk to various hardware such as 3D rendering and audio hardware. They do however not let multiple applications communicate and share data. (Examples are: OpenGL, Direct X, X, OpenGL ES, AudioWorks and OpenAL).

Libraries
Libraries contain functionality that can be included into a software development project to add a specific technology, such as rendering, physics or input. Our project will create a new library containing networking. That will make it possible to interact with other applications using the same library. No library exists that is designed to create network interoperability between interactive media applications (Examples are: Renderware, Havoc, Performer, OpenScene graph, and VR-juggler [26]).

Sound simulation systems
In today's acoustic simulations tools like ODEON and CATT Acoustics you use an already reduced geometry or reduce the geometry by hand. To our knowledge no tool exists that directly can use the architectural model and automatically reduce the geometry so it can be used for acoustic simulation. Acoustic simulation in a completely dynamic world is also a completely new concept and is one of the research undertakings in this project. For games audio culling is a most important aspect of the Uni-Verse system and to our knowledge no game system supports this today. By examining some of the most spread research oriented VR systems it becomes evident that the VR related research has mostly been concerned with the visual part of the immersive experience ignoring the importance of high quality 3D audio. For example, one of the widely spread systems is DIVE [24] and it has only ordinary stereo sound. Ygdrasil [25] is using the Bergen sound system that does not even simulate directional sound at all. VR Juggler [26], one of the most recent systems, depends on OpenAL or AudioWorks and can simulate directional sound but has no acoustic simulation. The same is true for CyberStage [27][28], which is the German National Research Center for Information Technology (GMD) Cave like VR environment.

Light simulation
Light simulation using the radiosity method, is well known since its introduction in 1984. Up to now it is mainly used for computing single images since a huge computing power is necessary to solve large equation systems, which describe the light distribution. Improvements of the algorithms for radiosity and the availability of powerful hardware however, seem to enable the development of real-time radiosity. There are some projects working on basic real-time radiosity implementations, but to our knowledge there is no development of a distributed VR system using a real-time radiosity lighting simulation

The Uni-Verse system is different from all other systems we know of since it is based on a low-level lightweight protocol, which allows distribution of completely dynamic content with arbitrarily fine granularity.

As far as we know, there is no framework, which is capable of encoding all these different kinds of data (geometry, appearance, audio, animation and textual content) in one protocol with totally dynamic content.

3. Participants list

List of Participants

Partic.Role*	Partic. no.	Participant name	Participant short name	Country	Date enter project**	Date exit project**
CO	1	Kungl Tekniska Högskolan	KTH	S	1	39
CR	2	Interactive Institute	II	S	1	39
CR	3	Helsinki University of Technology	HUT	FIN	1	39
CR	4	Fraunhofer-Institut für Graphische Daten-verarbeitung	FHG/IGD	D	1	39
CR	5	Minusplus Epitesz Kft.	Minusplus	HU	1	39
CR	6	Paregos Mediadesign AB	Paregos	S	1	39
CR	7	Stichting Blender Foundation	Blender	NL	1	39

*CO = Coordinator
CR = Contractor

4. Relevance to the objectives of the specific programme and/or thematic priority

In the discussion of the scientific and technological objectives of the Information society technologies in 'Integrating and strengthening the European Research Area' (2002-2006) it is stated that:

> *Although substantial advances have been achieved, we are still far from taking full advantage of the potential of knowledge-based services in real life. Products and services are still hard to use and out of reach for many people, and the 'digital divide' is widening within Europe and across the world. Research will focus on the future generation of technologies in which computers and networks will be integrated into the everyday environment, rendering accessible a multitude of services and applications through easy-to-use human interfaces. This vision of 'ambient intelligence' places the user, the individual, at the centre of future developments for an inclusive knowledge-based society for all.*

The Uni-Verse system utilizes 3-dimensional virtual reality worlds and high quality audio which is a natural and *easy-to-use human interface.* The communication protocol is lightweight and can connect devices of almost any form which making it possible to *be integrated into the everyday environment.* The protocol is also highly general making is suitable for *accessing a multitude of services and applications.*

> *Research will focus on new computational models, including computing and information GRIDs, peer-to-peer technologies and the associated middleware to make use of large scale highly distributed computing and storage resources and to develop scalable, dependable and secure platforms. It will include novel collaborative tools and programming methods supporting interoperability of applications and new generations of simulation, visualisation and datamining tools.*

The architecture of the protocol makes it possible to construct hierarchical servers, which can be considered as *large scale highly distributed storage resource* for 3D information. The Uni-Verse system is ideal for building *collaborative tools,* as it is distributed, interactive and has advanced audio properties. The protocol is designed for data interchange between applications, existing and newly developed, i.e. to support *interoperability of applications.*

> *Research will also address the enabling technologies for personalised access to networked audio-visual systems and applications as well as cross-media service platforms and networks, trusted digital TV architectures and appliances able to process, encode, store, sense and display hybrid 3D multimedia signals and objects.*

The protocol used in Uni-Verse is an enabling technology for access to networked audio-visual systems and applications. The Uni-Verse system is able to *process, encode and store and display 3D multimedia* in form of geometrical objects, sound sources as well as acoustic information.

The overall objectives of the IST programme in FP6 is defined as follows in the '2003-2004 Workprogramme':

The objectives of IST in FP6 are therefore to ensure European leadership in the generic and applied technologies at the heart of the knowledge economy. It aims to increase innovation and competitiveness in European businesses and industry and to contribute to greater benefits for all European citizens
The focus of IST in FP6 is on the future generation of technologies in which computers and networks will be integrated into the everyday environment, rendering accessible a multitude of services and applications through easy-to-use human interfaces. This vision of "ambient intelligence" places the user, the individual, at the centre of future developments for an inclusive knowledge-based society for all.
This research effort will therefore ***reinforce and complement the eEurope 2005 objectives*** *and look beyond them to the 2010 goals of the Union of bringing IST applications and services to everyone, every home, every school and to all businesses*

The proposal fits well into this broad mission, as a Distributed Interactive Audio-Visual Virtual Reality System is a *generic technology*. The system has the potential to contribute to *greater benefits* for many *European citizens* as it can be used in several areas, which will be widely spread in the future.

Uni-Verse is indeed a *future technology* and it *integrates computers and networks* in a way which makes it possible to *integrate into the everyday environment*. The system can be implemented on various communication devices from future immersive devices for homes to more simple devices like PDAs and other equipment with limited functionality. On top of Uni-Verse it is possible to build a *multitude of services* and the high-quality Virtual Reality and Audio interface makes it the most natural and *easy-to-use human interface*.

Uni-Verse also fits in well with the goal of enabling sustainable growth and improving competitiveness of large and small business. The basis of the Uni-Verse system will be open source, which makes it possible for both large and small business to utilize it's potential. The implementation in Uni-Verse is highly *innovative* and has great potential to increase the *competitiveness* in the European industry in fast growing sectors such as games, digital media, education, collaborative systems, tele-presence etc.

The proposal makes a significant contribution to the strategic objective 2.3.1.8 Networked Audiovisual systems and home platforms. This objective targets:

To develop end-to-end networked audio-visual systems and applications, and open trusted and interoperable multimedia user platforms and devices, notably for broadcasting and in-home platforms with full interactivity capacity

This fits very well with the goal of the Uni-Verse project to build a *networked audio-visual system* in the form of a distributed interactive virtual reality platform with high-quality audio, which can be used in many ways including by the entertainment industry as a distribution platform *for in-home platforms with full interactive capacity.* The protocol, which the system relies on and the libraries, which implements it, will be *open* source, which lowers the threshold for European industries including SMEs to utilize the technology.

The strategic objective especially focused on 1-3 below:

1. Trusted free choice environments for more intuitive access and interaction with hybrid 3D multimedia signals and objects. Rich media objects representation, identification, location and description.

Uni-verse is a *multimedia* system, which handles synthetic VR-environments as well as real-time audio. The system is *objec*t oriented in the sense that geometric objects can be given arbitrary properties by the application developer and that method calls can be defined to operate on the objects. The flexibility of the system allows more or less complex access mechanism to be implemented.

2. Seamlessly co-operating IP (Internet Protocol) audiovisual (AV) networks, storage, new middleware protocols and architectures for real-time and consistent multimedia routing, storing and distribution, load and balancing control mechanisms, P2P, datacasting and streaming of audio-visual rich media. Adaptive Quality of Services for scalable audio-visual flows on heterogeneous networks, AV internetworking, network traffic engineering, interactive AV service management, and simulation.

Uni-Verse is based on the *Internet Protocol* Verse developed by the partner the Interactive Institute. The protocol will be extended with *streaming audio*. The Verse protocol allows building system with either a client-server or a *point-to-point* architecture. The protocol propagates changes in any of the participating systems in *real-time* to all connected systems. The smart protocol implements simple features *for adaptive quality of services*. The system can be viewed as a new *distribution* media for advanced interactive *multi-media* applications.

3. Home server portals, interoperability between home networking technologies and their integration with global networks, as a means for access to, and generation of combined applications and services. AV portals with storage, management and repackaging appliances, including extended home distribution. Advanced retrieval methods and business models to support access to streamed and stored audiovisual media from anywhere in the home and car environment from any device.

The Uni-Verse system is scalable on a wide variety of communication devices from simple PDAs to state-of-the-art immersive environments as today's CAVEs and future *home portals.* It fulfils the vision of access to audiovisual media *from anywhere and from any device*. The use of distribution from an central server where the logic is located with no persistent data stored in the client home portal also means a *new business model* for distribution of digital content and games which reduces the risk of illegal copying etc.

5. Potential impact

Reinforcing competitiveness

The European interactive media have grown to become a large multi billion € industry. But as the technology has become more sophisticated and the content has become larger the cost of developing new content has raised dramatically, some thing that has hampered innovation. Also all hardware and operating system platforms are controlled by US or Japanese interests. Having a European software platform would enable European interests to collaborate and prevaile as a new dominant force in the field of interactive media by shifting focus to a software platform that can run on any hardware or operating system.

Although Virtual reality methods are today used successfully in many industries in Europe to replace real prototype testing in the design process such as in the car and aircraft industry, most industries, especially small companies (SMEs) can not afford the investments, which up to now have been required for using the more advanced form of VR This is now changing rapidly with the decreasing prices on personal computers and workstations. What in the past required expensive supercomputers is now possible to run on a PC. This means that VR and mixed reality environments in different forms will be more frequently used both in industry, in cultural contexts and at home. Today's areas of VR (in manufacturing and design) will grow dramatically but new collaborative areas like e-commerce, games and entertainment, virtual communities and e-learning, art and cultural events will be even more important. The reason is of course that VR and mixed reality environments offers a very natural human-computer interface, as we are so familiar with the real 3-dimensional world. Soon the lack of software platforms, both easy to use and of high quality performance will be a larger obstacle to wide adoption of VR.

An open source high quality digital media platform for immersive environments would be a major break-through in the field. The availability of such a platform will have a major impact on the research and development in this field and new areas yet unexplored will begin to explore the possibilities of VR and mixed reality. New types of applications based on this technology will reach the market and the cultural stage as a result of this research.

In order to make Uni-verse successful we believe that it has to be open source. This means that anyone can use the Verse protocol and libraries to network enable his or her applications. Verse does not require the applications that use the protocol to be open source, they can be whatever license the author chooses and therefore we hope to attract users who are open source hobbyists and research/educational institutions as well as commercial companies. With this project we plan to make most of applications that we create open source since it would be very helpful for developers both commercial and not to have a wide range of example source code to learn from. Releasing the software as open source will help to disseminate the software to a broad range of developers and users and it will help to establish a de facto-standard for transmitting 3D graphics and audio. It will also help to stimulate the further development process by getting new ideas for applications from developers using Uni-Verse

The proposed platform developed by the Uni-Verse project offers a new way of designing collaborative networked audio-visual VR and mixed reality environments with high quality multi-modal data for PDA, desktop and CAVEs with less programming efforts. This approach addresses several of the fundamental problems with most of today's existing systems which cannot be used in a collaborative way in everyday contexts, are hard to program and which suffer from insufficient quality on the visual side but even more so on the audio side. The

reduced programming effort through the architecture, modularity and open source libraries leads to shorter time to market, which makes the European industry more competitive. It also opens the possibility for small SMEs to play a role in the growing market as will be shown already within the project.

Using the Uni-Verse platform for digital media i.e. games opens new business models for distribution of content. The content including game logic can reside on a central server, making pay-per-view possible. It also reduces the risk for illegal copying dramatically.

At the moment there exists no competing product comparable to the planned Uni-Verse software. The system developed in this project would be possible to apply to many application areas as design, architecture and landscape planning, games, entertainment and collaborative systems. The market value of such a system, which will be unique in the world, would also be substantial.

The market value for design in digital media is growing with 52 % and the value today is more than 200 million Euro. *Source: SG Coven mars 2001.*

Collaborative solutions, such as communities, are becoming more and more widespread in different Internet based communication-, learning- and e-commerce-systems. An e-commerce site that offers the user collaborative solutions receives more loyal clients. The difference reported is up to nine times more visits. *Source: http://www.ecommercetimes.com.*

The majority of the current computer-based games on the market are made in 3D. Games like "Half-life" and "Quake" are often played in groups, sometimes utilizing the Internet for connectivity. The new type of 3D games, Massive Multiplayer Online Games (MMORG), is aiming to take this a step further by allowing thousands of players concurrently play and exist in a virtual persistent world. The complexity to create these games and especially to make them more interactive, by trying to implement artificial life and collaborative systems into them, is very high. This market is expanding extremely within the game business, and when looking at a study of who plays online, the figures shows interesting changes from the common normally young and male game-community. An IDSA study conducted by the Online Research Division of The NPD Group in 1998 shows this profile. *Source:* http://www.idsa.com/releases/online98.html:

- Female gamers are more likely to play online (53 percent) than male gamers (46 percent).
- Seventy-nine percent of online game players are between the ages of 25-55, with 60 percent of these in the 25-44 year old demographic so highly prized by advertisers and marketers.
- More people over 55 (5 percent) play games online than do those under 18 (2 percent).

These new types of games open up a new market for European companies, this market is especially valuable since it contains a different and new community of gamers with greater purchasing power. A large problem when creating these new types of games (MMORG) with very big and complex virtual persistent worlds is that there are no 3D-plattforms that offers and provides functionality for the kind of collaborative systems and dynamic content (artificial life and geometric evolving and deforming system) that are necessary for making these complex games dynamic and collaborative. Uni-Verse is offering exactly this kind of modular, scaleable and complex functionality. *Source:* http://www.gamasutra.com

The system will allow European game developers to diversify the market appeal of massively-multiplayer game products by catering for many tastes within a single product. Object-oriented and spatialised game logic customised to multiple delivery devices will increase market access to product, and also allow the incorporation of niche e-commerce products for value-added experiences within a game.

A project like this could not be carried out in one single country. The task requires a multi-disciplinary group of experts, which cannot be found in one European country alone. For dissemination and exploitation the market would also be too small. The Uni-Verse effort needs the strength of the European Community to become a success.

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Contribution to Employment

The contribution to the employment in Europe will be:

- The Uni-Verse project can form the basis for a new generation of collaborative applications for professionals, making the European industry more competitive, as well as for innovative games, entertainment and community building.
- Once the system has been successfully developed the commercialisation will create additional employment. Already today a start-up company has been set up in Sweden to work with Verse technology. The open specification and open-source libraries will make it possible to spread the technology to all over Europe.
- The modular and open source approach makes it attractive for SMEs to produce separate modules for different applications. This makes it easier for small companies to enter the market and to contribute to the development of the Uni-Verse platform.
- The proposed software can directly be used at the architect's offices and town and landscape planners as well as game and community developers making them more productive and competitive.
- The development of the system will employ around 10 scientists on a European level working on a leading edge technological development. The interchange of knowledge will contribute to the training and education of these scientists and the staff and students working with them.

Environment

The proposed research will have impact on the environment in the following ways:

- Collaborative VR environments based on Uni-Verse can be used to replace physical meetings with electronic meetings of a new quality level and will thus decrease the need for expensive and polluting travel by car and by air.
- Using the audio and acoustic properties of the proposed software in the planning process of towns and landscapes will reduce noise and make a better acoustic environment.
- Using VR can help protect natural areas and monuments, by offering tours of interactive VR simulations instead of access to the protected areas, which often are very sensitive for the wear and tear by tourists and visitors.

Quality of life, health and safety, including working conditions

The proposed research will have impact on quality of life in the following ways:

- High quality collaborative audio-visual virtual environments will have a major impact on the digital media industry which will give European citizens a richer life for example to

visit places and have experiences otherwise infeasible. This is especially important for the elderly and handicapped, which often have difficulties to travel.

- The high quality of the audio and visual aspects of Uni-Verse will improve the ergonomics of using virtual environments. This is also especially important for the elderly and persons with impaired hearing or vision.
- Virtual Reality in the form of Uni-Verse will be used to design workspaces such as production lines etc. in a more ergonomic form avoiding mistakes leading to industrial injuries.
- The use of audio-visual VR in the planning of workspaces will give a more ergonomic and user-friendly work environment including a better acoustic environment. This is also especially important for elderly and handicapped
- The use of networked audio-visual VR and mixed reality in the planning of townscapes and landscapes and for traffic environment simulations will make it easier to eliminate planning mistakes. This will raise quality of life and reduce the risk for accidents.

Exploitation and Dissemination of Results, IPR

Working with open source community requires new ways of thinking. It is not sufficient to just 'go open source' to become a success or an accepted standard. The Uni-verse project will work towards this along four lines:

1. solid academic development and dissemination
2. close industry collaboration and partnership program
3. open source dialogue, development and dissemination
4. public demonstrators in two business areas, architecture and on-line gaming

1) will be done through the strong academic partners in the consortium
2 and 3) will be organised through the industry partners themselves, through the well developed industry partner programs of the academic partners but above all through the partner Blender Foundation. Blender is the largest open source 3D modelling tool today. Already at an early stage a Unit-verse server will be set up and the community will be invited to test and participate in the development. This will indeed generate a lot of attention for the project and the results developed and will also produce valuable input for the project both in forms of comments, bug reports etc. Although we don't rely on volunteers in this project it is highly likely that the community will develop additional tool and functionality, which will leverage the investment by the Commission even further.

The idea of a real-time protocol is new and implies many interesting scientific and technological benefits where only some is full understood today. This work will lead to many new insights on different application areas and applications. The scientific and research work will be disseminated using ordinary academic channels as education, seminars, project work, publication in journals and conferences etc.

A board of advisors will be created within the framework of the project. The members will be representatives from companies especially SMEs and from the open source community with experience from designing products based on 3D graphics and games and communication services. Many of them haven't succeeded the way they hoped for. One of the major reasons is that the platforms that are ready to use today do not offer modular and scaleable functionality. The services and products have limited functionality and the cost to ad functionality is immense. The board will give the project most valuable end-user input and advice about how Uni-Verse should work.

5.1 Contribution to standards

The Uni-Verse project is a research project, which will produce a prototype platform, where the base software and most clients will be open-source and possible to use freely for the European IT and media industry. In the future the real-time protocol Verse [17] can be made into a standard or affect coming standards. The MP3 standard was developed at the Fraunhofer Society by the Fraunhofer Institute for Integrated Circuits, but there is a close collaboration between all Fraunhofer Institutes. The Fraunhofer Society was also highly active in the formulation of the MPEG4 standard.

The Uni-Verse system also has the potential to become a de facto standard in the open source world. The Blender Foundation will actively work to make this happen. The collaboration with Nevrax, who will include modules from Uni-Verse into their open source multi player on line game engine, also helps to make Uni-Verse used in the open source community.

6. Project management and exploitation/dissemination plans

6.1 Project management

The project will have a management structure commensurate with the complexity of the task and the number of partners. The main aim of the management is to ensure that the consortium is working as a team in the spirit of co-operation, co-ordination and commonly understood procedures.
The coordinator of the project will also act as the technical manger for the project ensuring efficient coordination of both administrative and technical matters. Respective workpackage leaders will be responsible for deliverables from the individual workpackages.

Management Structure

Coordinator: The coordinator Gert Svensson has about 13 years experience in research management while working for the Center for Parallel Computers at KTH. He was also heavily involved in the PDC Technology Transfer Node (PDCTTN) where he initiated and supervised several of the activities.

Assistant coordinator: Professor Peter Becker at the Interactive Institute will act as Assisting coordinator and will assist the coordinator with the practical management of the project. He has extensive experience as manager of large-scale R&D projects in interactive media

Project Coordination Committee (PCC): The Project Coordination committee will consist of one representative of each consortium partner, who shall be a person empowered to transact legal and administrative agreements on behalf of the partner. This representative will be nominated by the partner and will be the primary point of contact between the partner and the Project Coordinator.

The purpose of the PCC is to:

- make the Consortium Agreement
- make rules for publications and press contacts
- to monitor and control progress
- to manage resources
- amend the work-plan if necessary
- to resolve conflict.

If necessary also negotiate the following conditions with the European Commission:

- The terms in the contract
- The cost or time schedule
- The termination data of the contract

The Chairman of the PCC shall be the Project Coordinator. PCC meetings will be held every six months either in conjunction with a technical meeting or as teleconferences. Special meetings may be called by the Project Coordinator, or at the request of the partners. When a Partner Representative cannot attend a PCC meeting, he/she may give power to another Partner Representative to represent him/her. The PCC operation shall be by reference to a written agenda distributed before the meeting. Additional issues may be raised only by

agreement. The project shall proceed according to the time schedule and outputs are as listed in its workplan. Only the PCC has the authority to alter the workplan in any significant degree. Each project output (e.g., deliverables, and periodic reports) to be delivered to the Commission of the European Community (CEC) shall be approved by the PCC. Formal procedures and rules, such as voting mechanisms and conflict resolution procedures, shall be defined in the Consortium Agreement.

Coordinator: The Coordinator will have the overall responsibility for the organization, planning and control of the project. He/she will report to the PCC, and will ensure the punctual delivery of reports and other deliverables. If there is some delay in the delivery he/she will immediately contact the partner who will either attempt to re-solve the problem or convene a PCC committee meeting (see under resolution of conflict). The Coordinator will collect and monitor and integrate financial and administrative data from the Partners and will prepare the data for submission to the Commission. Each Partner Representative shall provide the Coordinator, once every six months, with a statement of all expenses incurred and resources used on the project (Cost Statement) together with report on the progress of the work. The Coordinator will integrate these statements into a Progress Report to be delivered to the commission
For communication inside as well as outside the consortium a Web-site will be set up. The Web page will consist of two parts: One part will be information on progress to the general public; the other will provide information to consortium partners only. The access to the second part will be restricted to consortium partners. Information released to the public will need to be approved by the PCC.
The coordinator will also be responsible for facilitating the communication between partners by implementing facilities such as

- mailing lists
- tele- computer and video conferencing etc.
- working papers using MS office tools
- project management facilities using MS Project

WP Leader: The management responsibility for each WP is attributed to one of the partner see table. The WP Leader is responsible for the work done by all participants in his WP. He establishes, in co-ordination with the participating partners and other WP leaders, the detailed schedule of his WP. He presents the WP progress when required by the PCC and at the external reviews. He organizes the production and internal review of the WP deliverables. Each WP Leader shall provide a written technical progress report each month to the Project Coordinator, based on the reports submitted by the concerned Task Leaders. He will also submit to the Coordinator a three-monthly Control Report, summarizing advancement and status of work for the period.

Task leader*:* The persons responsible for the daily technical management of the work associated to a particular task. The task leader report to the respective WP leader and they should make sure that the proper deliverables are ready to be reviewed in time for the corresponding milestone. Each WP leader will nominate the Task leaders in respective workpackages.

Exploitation Manager: The exploitation management is handled by Ton Roosendaal at the Blender Foundation. He has vast experience of exploitations and dissemination issues both from the commercial and the open source worlds. The Exploitation Manager is responsible for Exploitation, Dissemination and he will co-ordinate issues related to exploitation,

dissemination and Intellectual Property Rights between the different partners. He is also responsible for the exploitation plan, which should be finished in draft form to the Mid-term assessment

Mid-term Assessment: A mid-term assessment will be carried out by the PCC. Aim of this is to determine if the project aims can be fulfilled within the duration of the project. A report to the Commission of the European Community will be made on the outcome of this meeting.

Quality Assurance: Quality Assurance of project outputs is a very important concern of the PCC, which will guarantee a consistent quality for all project results by evaluating them following a procedure, which will be outlined in a reference document for the project.

Resolution of Conflict: Should any significant delay in supplying deliverables or a potential conflict arise, then a PCC meeting will be convened in order to resolve the conflict. All partners accept that decisions taken in the PCC is binding and cannot be overruled.

Table: Workpackage leaders

Work-package No	Workpackage title	Lead partner	WP Leader
WP1	Management	KTH	Gert Svensson
WP2	System Specification	II	Peter Becker
WP3	Protocol/API extension	KTH	Eskil Steenberg
WP4	Rendering clients	FHG/ IGD	Volker Luckas
WP5	Tools development	II	Martin Schlingmann
WP6	Scalability	FHG/ IGD	Volker Luckas
WP7	Acoustic rendering and simulation	HUT	Lauri Savioja
WP8	Evaluation/Validation	Paregos	Niklas Forslund
WP9	Dissemination	Blender	Ton Roosendaal

6.2 Plan for using and disseminating of knowledge

The standard rules of Intelectual Property Rights (IPR) in EC funded project will be used. This means that the copyright belongs to the partners developing that particular part of the system. The modular approach of the system makes it in most cases possible to identify one single IPR owner. In some cases it might however be necessary with joint IPR ownership. This will also be addressed by the consortium agreement. It might be the case that certain parts of the system will be protected by patents or other means at the discretion of IPR owner.

Access rights to the other participants for their execution of the project will be granted when necessary.

Important preexisting knowledge exists in the project:

Eskil Steenberg together with Emil Brink developed the Verse protocol then at the Interactive Institute now at Kungl. Tekniska Högskolan.

The audio system will be based on previous work at Helsinki University of Technology and the Interactive Institute.

The data reduction system and radiosity module will be based on previous work at the Fraunhofer Gesellschaft.

For licensing of software several “standard” licenses are commonly used in the open source community for example:

- GNU GPL The most far going open sources license. Derivative work has to be open as well. Stipulates that proprietary code making use of code with GNU GPL license will also be GNU GPL open sourced. Many commercial companies have decided not to use software with this kind of license.

- BSD Derivate work can be commercial and no restrictions on mixing with proprietary code.

The Verse protocol and its future development in this project will be licensed with a BSD license. Furthermore the specification of the protocol is open and freely available. This choice is taken to make it possible for the protocol to be an open standard possible to adopt by all.

Dual Licensing is also increasingly common. This implies that you issue the software both with a GPL and a commercial license. The demand in GPL to publish all changes to the code makes many commercial enterprises choose the commercial license, which could be based on per case agreement. This makes it possibly to benefit from the open source model and still get some revenue from the commercial side. The Dual Licensing model will be considered in the Uni-Verse project.

The planned plug-in to the commercial 3D-modelling software package might not be open source and might be sold commercially. This will be decided by the PCC and can be part of a dialogue with the software vendor for we, which we choose to implement the plug-in.

A unified and clear policy on licensing will be worked out, coordinated by the PCC.

For more information on dissemination see the description of WP9 in the Workplan section.

6.3 Raising public participation and awareness

An important factor in making Uni-Verse an accepted standard is to raise the awareness of the project also among non-specialists. This will be done by actively working with the press during the lifetime of the project. As soon as the project gets started a press release will spread by the partners in different countries.

Awarness in the large open source community will address by the Blender foundation by using the existing channels of the foundation like:

- The Annual Blender conference
The first technical conference on Blender was a huge success, attracting over 100 people from all over Europe

- General user community portal
Discussion forums, galleries and editorial content (articles) about the project. This serves communication between end-users, developers and the Foundation organisation in general.

- Partnership Program and portal
Companies and industry partners typically need a different approach to communicate with them, and get them involved with the project. A Partnership Program offers custom services for companies to help them integrate or bundle the technology in their product offering. It includes a commercial offering for (online or onsite) support, PR coordination, and communication channels with other Partners. The Partnership program also include a web-portal where companies can market products and services Partners are being classified in the following areas:
- Publishing and magazines
- Software and hardware industry
- Content/Entertainment studios

- Marketing
To build interest in the project, it is important to involve industrial and educational channels. This means actively promoting the Partnership Program, providing material for magazines to write articles, and work with Publishers to bring out books.

Several of the partners have large Virtual Reality facilities like Caves etc, which attracts a lot of visitors from the public. By providing demonstrations of Uni-Verse technology this can help to disseminate information about the project to the public.

Synergies with education

The research project will have direct impact on the education of students at KTH and HUT. Students will become aware of the application of virtual reality in several areas of application. The possibility of projects or diploma-theses on a topic, which combines science and practical use, increases the value of the education. Already an innovative master's degree education has been started by the National College of Radio, Film Television and Theatre in co-operation with the Interactive Institute and KTH.

7. Workplan –for full duration of the project

7.1 Introduction- general description and milestones

The work in order to achieve the objective namely to develop, test and evaluate the Uni-Verse system is divided into 9 workpackages. The first workpackage ensures that the consortium works efficiently and that information is available to all partners. This is achieved by Internet, tele- and computer conferencing and regular meetings.

The first 12 months the focus will be to create a working system where necessary components are present. It will also give is a better idea of problem areas and how to use the system in an optimal way.

When this is completed we have the intention of setting up a public server and allow project participants and the general public to take part in the development. This will also give use experience in running the system and maintaining it. Having such an open approach will also help us get a good foothold in the open source community.

WP2 is concerned with the specification of the systems capabilities. Here the partners representing end users from architecture and digital media industry will have considerable input to ensure that the end product satisfies users needs. The WP is also concerned with choosing appropriate developer tools. Due to the modular approach different modules can be developed in different languages and with different tools.

WP3 –WP7 constitutes the actual research and development in the project and each workpackage develops some functionality in the system, which is combined into a complete system. To be able to divide the work in this way the specification phase is extremely import so interfaces between different modules are well defined WP3 is the implementation of the protocol and API for the scripting environment.

Workpackage 8 will be concerned with the evaluation of the systems developed in Workpackages 3-7. The main evaluation criterion will be the usefulness of the system as base system for game and entertainment industry and as a tool at the architect offices. There will also be a continuous evaluation by open source community especially through the Blender foundation.

Workpackage 9 finally will be concerned with the dissemination of the results. Apart from the obvious presentations at conferences and dissemination via Internet the workpackage leader Blender has strong and valuable customer contacts and excellent visibility on the digital media market including games, entertainment as well in the open source world.

The project plan is outlined in the Gantt chart in 7.2. Crucial for the development of the Uni-Verse system is the specification of the system capabilities, the selection of the developer tools. Another crucial time is the completion of WP3-WP6 so the evaluation can start.

Background

System architecture of the Uni-verse project

The typical system is built on the client/server paradigm with a centralised server, which stores the state of the simulated world. Clients can choose to subscribe to selected parts of the data but also dynamically create and modify data by sending changes to the server. The server will notify the changes to all subscribers of the changed data. Client integrity is guarantied by the architecture as all communication goes through the server.

The server itself does not in general perform any data processing except the storing and retrieving of data. The clients do all data processing. Commonly used system services is implemented in special clients called servlets, which are executed on the server side, for example game engines, and physics engines. This architecture makes the protocol clean and efficient and facilitates extension of the system without affecting the protocol.

Existing software

The idea of the Verse protocol has been verified in real applications. Verse has recently been re-implemented to go from a test version over to a more mission ready implementation. This has generated a number of Verse-enabled applications, among them an Open GL rendering engine (known as Quel Solaar) a modelling tool (known as Loq Airou) a colour correction tool (known as Nill Salentinn) and a few smaller tools. This will obviously help but more important a number of help libraries to store, modify and render Verse data has been written and can greatly reduce the time needed to create new applications and tools.

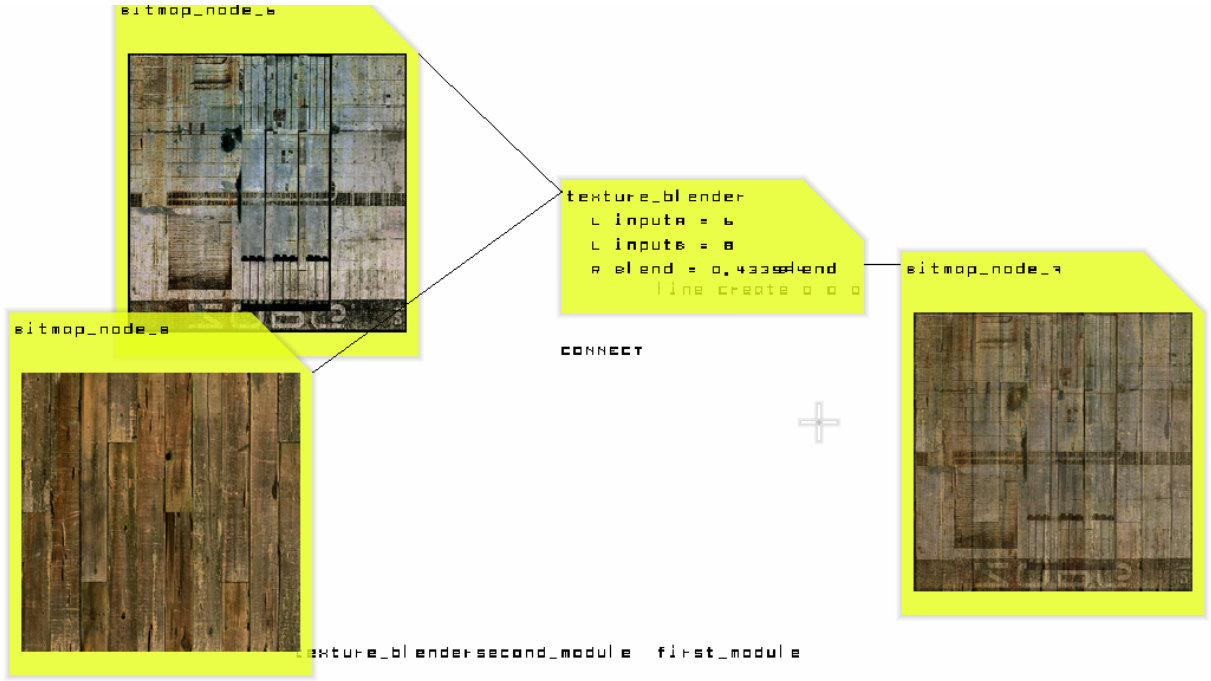
WP3 Protocol extension and API

Network protocol Verse

The network protocol of the Uni-verse system will be an extended version of the real-time network protocol Verse developed by partner II [17][23]. This protocol is highly innovative in itself having a different approach to information exchange than most currently used VR systems which usually exchange data by transferring files in various different exchange formats. The ability to have multiple clients interacting with the same data in real-time opens up for a range of new uses and features. The current protocol allows many advanced graphical properties such as high dynamic range textures, Loop [20] and Catmull-Clark [21] subdivision surfaces, programmable shader trees, displacement mapping, and dynamic surface properties. The protocol also has a number of features useful for interaction such as language independent scripting, tags and dynamic remote call procedures.

Verse is based on the idea that interoperability is important in order to fully utilize the possibilities of 3D graphics. We believe that interoperability is needed between different applications as well as between content creators and content consumers. Verse is therefore a lightweight open protocol that allows several applications to share data in real-time. The protocol allows several applications to create local copies of the shared data and if an application wants to make changes they are distributed to all the other applications so that all copies of the data are synchronized. This means that all applications can act together as one single application since the changes from one is distributed to the others in real-time. An example of this can be to have two 3D tools modifying the same data at the same time. This allows a user to use many applications, or many users to collaborate. A large project can also be split into many applications that can communicate through the Verse protocol. The protocol is accessed by a simple API called VLL (verse low-level library) and any application

written for this API will automatically work together with any application written for the same API.



We have found that the way to approach development changes when Verse is used. Since all applications connected to a Verse environment act as one there is less need to write large complicated system, that have many features, but rather you can write multiple smaller and cleaner applications that are more specialized. A normal 3D application usually have a number of editors and windows for various purposes, but with Verse all these applications can be independent applications, written by different persons or organizations making it easy to rewrite components and to add new without the need to study and have access to the old parts. Also the actual creation of the content is different since the world can be edited at any point. Normally we have an authoring phase followed by publication. With Verse we can dynamically author the content at the same it is being consumed. This allows the authors to be much more flexible and answer to the needs of the users faster and to reduce the risks of authoring large sets of data that are not of interest to the consumers. The protocol is built to be point to point, but is usually configured in a server client solution where the server acts as a hub to allow several clients to share the same data. In this case the hub also stores a local copy of the data to allow the users to subscribe to data-changes and to keep the data persistent

Even though this is the simplest approach many other configurations can be made such as hierarchical server clusters or peer-to-peer configurations. We also see the possibility of proxy clients that can reduce the complexity of the data to allow very low-end systems to participate in the environments. This makes us confident that Verse can be used with virtually unlimited number of users and data, and makes it very scalable. We believe that rewriting the server hub to be hierarchical is simple and since it does not affect the protocol and thus the other clients can be done with little impact when the need for a more scalable approach arises.

A Verse client can run on practically anything making it possible to experience worlds in anything from high-end systems with CAVEs and head mounted displays to a PC, a game console with network connection or even a PDA or mobile phone. Existing applications can also be Verse enabled by plug-ins. Verse clients are also analogous to service providers. This makes it possible to have many more not so obvious clients, like different types of tracers like

GPS, BlueTooth, video and radar or other input devises like weather stations, databases, home electronics or any device capable of a IP connection. This makes it possible to build worlds that are connected to, or mirror events in the real world. A sailing simulator may feature weather that matches the currently conditions of the seas making it possible for the participants to listen to real weather rapports on the radio to be able to take decisions. A server providing a city map may feature real-time update of the position of busses, trains and other trackable objects.

Verse data

The 3D graphics data is designed around the philosophy of "perfect data", it means that the data doesn't describe how to render the graphics, but more how the graphics should look. Then it is up to client to do a "best effort render" of the data. The idea is to create a data set that is as easy as possible to use independently of the application. The data is divided in seven different node types: Object, Geometry, Material, Bitmap, Text, Physic and Curve. The 3D geometry data is based around a single primitive: subdivided polygons. A subdivided polygon is basically a normal polygon, but it can be subdivided to create a 3rd degree curved surface. This means that you may display the graphics as simple, planar, polygons, but you can also subdivide them to increase the smoothness of the surfaces. It is also compatible with a lot of existing 3D software, since you can convert polygons, B-splines, patches and NURBs into subdivision surfaces without loss of precision. The data set has many features such as an advanced shader tree for surface properties such as colour, texture, lighting and displacement, High dynamic range textures, animation curves, generic surface properties for storing UV, colour, selection and other data. A system wide tag system lets users store additional custom data in nodes. The physic node allows clients to do client side simulation of things such as cloth, hair, smoke and fire. The text node lets each object be associated with scripts; these scripts can be read and executed by a client, which run on the server side. This is a very flexible way of doing scripting since scripting engines can be written by any one for any language making Verse language independent. In addition to the text node and tags the object node can have generic method calls that can be passed between clients.

The existing real-time protocol allows sharing of geometrical and graphical oriented data but has to be extended to handle 3D-audio, acoustics.

Scripting Tool Environment

This tool consists of two separate clients. One is a plug-in architecture that will allow people to write independent capabilities and unify them together in a dataflow fashion. It acts much like an operating system executing plug-ins and piping the data between them. One of the clients is a so-called "back-end" client without any graphical user interface. The user works with a graphical user interface of the second client: a front-end client to contact the back-end using the Verse networking protocol. The back-end will send a list of its plug-ins to the front-end, and the user can configure how the different capabilities should be executed, on what data and send it back to the back-end. All computation will be made by the back-end client.

The front-end of the scripting tool will give the user a schematic view of the data stored in the Uni-verse environment and allow the user to manage the data and be able to link data to different functionality in the back-end. For example you can connect two points on a characters arm to a distance measuring function to measure the distance between the two points. Then the output of this computation can be connected to a deformer function deforming the muscles of the arm depending on the distance of the two points. Whenever the two points are moved the back-end will re-compute this dependency and deform the muscles accordingly. This type of relations are typical of how this framework can be used to make the

3D environment come alive, and as more functionality is added the users can find new ways to configure and use the capabilities in complex networks of dependencies.

We believe that this architecture will be a very useful component in the project because it provides a platform to create persistent scripted events and to make the world come alive. To have a plug-in interface where users easily can implement simple functionality will make it easier to create custom functionality in 3D worlds.

This front/back-end approach has many interesting benefits: it allows multiple users to collaborate, you can have many front-end implementations, a thin client can control the large computing power of a back-end machine, new plug-ins can be added on the back-end without modifying the front-end and so on. The API and the base implementation for the plug-in system will be developed in this workpackage but the plug-ins themselves will be developed in other workpackages. The scripting environment will provide an easier method, in a higher-level API, to add functionality than VLL and will give the user the possibility to utilize his/her addition in a multitude of configurations.

WP4 Rendering Clients

There already exists an OpenGL based rendering implementation for Verse. This is in the form of a library that can be used in any application that may need the capability to render. This lib is also implemented in an end user client called "Quel Solaar". During the course of the project we aim to keep this implementation fresh by adding new functionality. The main Scope is to port the renderer over to Open GL 2.0 that will be released late summer 2003. The main responsibility for this will be taken by Eskil Steenberg who is an OpenGL 2.0 participant and who have been taking an active part in the design of OpenGL 2.0. This rendering engine has a wide range of features such as progressive Subdivision surfaces, Programmable shading, shadows, animation and displacement mapping that are all highly state of the art. This rendering engine will be ideal for laptop, and desktop computers but will also scale up to multi display systems like CAVEs and other display devices. However in order to be able to make use of the latest 3D hardware this implementation will not be able to scale down to the smallest calls of devises such as PDAs and mobile phones. We believe that this hand held market will play a major role in the future of personal computing and that user will want to be able to experience the same content on these small devises as their larger more powerful hardware. There is a wide area of application for 3D graphics on mobile devices, such as location-specific information services, path finding, architectural applications and also entertainment, like virtual chat rooms or online games. Many actual mobile devices have the ability to communicate via wireless networks. Therefore we see it as essential that we are able to prove that a Verse end user client can be implemented on such hardware in order to solidify the system as an alternative for all types of devises.

In order to facilitate mobile phones, PDAs and other hand-held devices with limited hardware resources, we will develop a low-end rendering client.

The low-end renderer is similar to the high-end renderer but does not optimize for high quality, but rather for small memory footprint and less CPU power. The renderer will use OpenGL ES, which is the new smaller version of OpenGL designed especially for embedded systems and will make our implementation portable to many hand held devices. OpenGL ES will support software implementation as well as the emerging devices with 3D hardware. The OpenGL ES standard is currently in its final stages of ratification.

The client will use exactly the same protocol and data as all other verse clients and will therefore fit well in to the rest of the system. It also provides us with a simple design where content creators do not have to create special type content for the hand held clients.

The protocol is optimized for maximum efficiency regardless of the bandwidth, and will work well for light clients. However, there may be cases where hand held devices need to participate in sessions containing very large data sets, and this may cause problems. To solve this, rather than designing a special client or transfer protocol we have chosen to create a proxy server that reduces the complexity of the data transfer in the protocol, and allows clients to participate in the session with lower resolution data. The advantage of this solution is that the client is not bound to the proxy and can also connect directly to the server, it is also conceivable to have several different types of proxy servers for different uses.

Like the high-end client the low-end client should have an interface for sending input back to the server using the method call system. This interface should be modified for the kind of interface you might find in a hand held device such as touch screen and will also have support for tracking, such as GPS. This will allow us to create location-based applications where the actions in reality can be mirrored in the virtual world. This is very useful in a number of applications such as Maps, information, games and local awareness.

WP5 Tools development

To be able to properly build and maintain the servers and content the project will require a number of tools. Although the Blender community has shown a great interest in providing such tools we must se too that some basic tools are available.

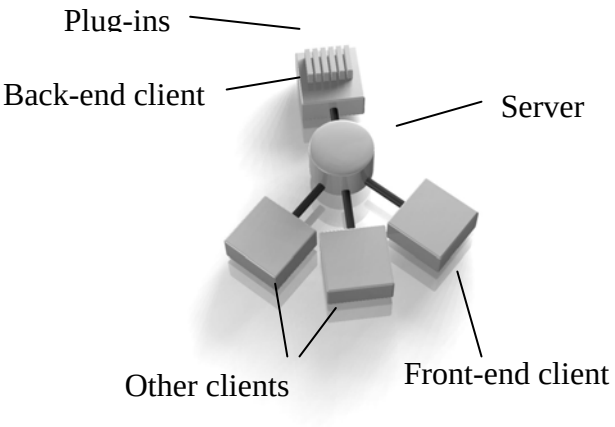
Among the tools needed we will create a few basic tools such as back-up tools, data management, modelling, texturing and animation tools. Some of this will be provided through the Blender effort and some will be created by writing plug-ins for existing commercial and open source plug-ins. An advantage of writing plug-ins for existing tools apart for time saving is that users of those applications can use the plug-in to be able to use the application collaboratively. This can attract new users to the system.

Since many of these tools are smaller programming projects we expect to be able to post some of them as assignments for students in various classes at the Royal institute of Technology in Sweden and elsewhere.

Tools may not be the most exciting of all components in a project like this but we have come to the conclusion that many earlier projects have failed because proper tools where not provided. If tools and interfaces are not provided researchers and developers will have to spend too much time dealing with practical issues and are not able to reach their full potential. And as we hope to see the platform have a long life after this project and to become a platform that will attract researchers form the entire European community it is crucial that the system is easy to manage. We also believe that once networking is achieved tools can benefit from this. If a tool can be so well integrated with other tools each tool can become more specialized. Where as in existing applications one often tries to cover an entire field, with the help of networking you can instead create multiple smaller tool where each and every one is specialized for a specific task.

Scripting libraries

Once the workflow scripting tool framework and API is written we will write a standard set of plug-ins for it. These plug-ins will serve as a basic toolbox of functionality and will also be use full as example code for programmers who wants to write more complex plug-ins. In this standard lib, a number of mathematical functions will be found as well as simple geometry, image and signal processing functionality. In this tool kit there will also be basic event handling that is use full for game and VR programming (such as connecting a button to a door). The development of the workflow scripting tool will also need an array of plug-ins in order to test the API. Once this tool kit is implemented many simple actions will be easy to set up and run using the scripting tool framework making it possible to use the scripting tool as process engine that can handle many of the tasks needed when developing applications. But perhaps the best thing is that it provides the users with an easy non-programming interface to access the power in the Uni-Verse system.



Real-Time Radiosity Light Simulation

Normally in computer graphics light simulation computes how each light interacts with each surface, but in reality each surface also reflects light that hits surrounding surfaces. This means that each lit surface in it self becomes a light source. Simulating this (what is usually known as “Global illumination”) is considerably more complex but also provides a much better end-result and has so far not been possible in real-time. However some have suggested that a static lighting solution can be provided by pre-computing the global illumination and then “baking” the light in to the model using textures or vertex lighting. Since this is not very practical for our very dynamic system we will attempt to create a simulator that continuously adapts the light as the environment changes. If a user makes a change to the world he/she doesn’t have to re calculate the light model because the light engine will notice the change and make the appropriate lighting calculations for the area that has changed. This light simulator will be on a best effort principle and may be able to adapt to minor changes in real time but may also refine complex areas indefinitely making it very flexible and usable for both small and large scenes. This capability will likely be implemented as a plug-in for the scripting environment for maximum flexibility.

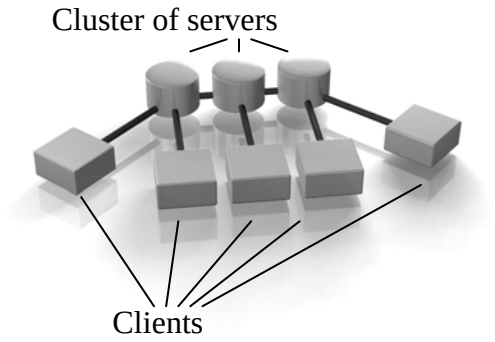
Dynamic Meshes Generation

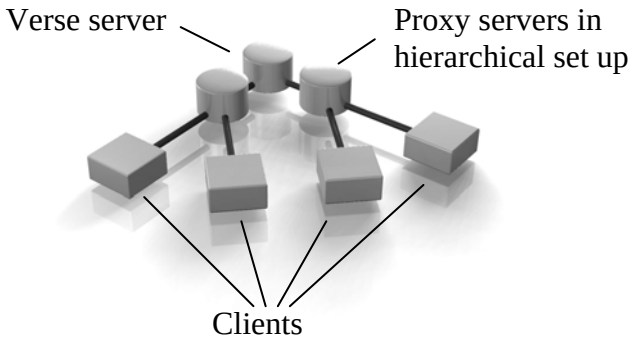
Since Uni-verse will have completely dynamic data many technologies previously not possible in networked environments will be possible. One of these is a technology that can dynamically generate geometry such as trees, terrain and ecological systems. Instead of just using static mesh data we can generate objects depending on environment over time. This means trees that grow over time, terrain where vegetation and paths are created over time depending on where users are most active. These tools would help users to quickly create rich environments that are alive and adaptive. There are many technologies such as L-systems, terrain and texture generation previously created but having the ability to do this in a dynamic world opens up for some amazing new possibilities. This type of capabilities would also be very useful to implement as plug-ins for the scripting environment.

Verse performance

Verse is a very lightweight protocol built on top of UDP/IP. Since clients handle computation, logic, rendering and simulations, Verse takes up almost no processing power. The main performance concern when designing Verse has been to create a low latency protocol for good network responsiveness. To do this we have invented a robust event compression algorithm that handles even the most difficult network conditions. A Verse connection does not take up any processing power or network bandwidth as long as no data is sent. The bandwidth requirements are completely dependent on the data sent over the protocol as the Verse protocol can handle very large data sets: roughly half a billion objects containing about 4 billion vertexes each. Once the data the client chooses to subscribe to has been transferred only changes are sent. To give a good estimate we can consider that a object movement command uses 17 bytes of data, if we would have ten movements per second (a relatively high estimate) a packet containing 29 command plus 4 bytes of Verse header and 8 bytes of UDP header would land at 505 bytes. A one Megabit user would using this metric be able to receive information on 717 constantly moving objects.

However Verse is only a point-to-point protocol, and the amount of bandwidth used up by a Verse connection is determined by how much data the clients choose to send. If we have a set up that requires huge data sets, too large for the clients to download, or a server with too many clients for a single server machine to handle, or participating clients with extremely limited resources (such as hand held devices) we may run in to problems using a simple "dumb hub" server passing data between clients. Even though the simple server has very good performance characteristics we must plan ahead for future extreme set-ups. Therefore we plan to write and investigate other server solutions that may contain clustering, server-tree configurations, zoning and proxy servers. A client that connects to a server starts by asking for a description of the world, but this description does not have to be exactly the same for all clients. A server may give only a partial view depending on position in the world, or data with reduced complexity. Just like a web server doesn't have to deliver the same web pages to all users, it can also generate dynamic pages for each users needs. This provides us with greater server side flexibility and we are not looked in to just one configuration. We feel that this is a very interesting area of research and would like to investigate it further to see of we can create versions of servers that include features such as complexity reduction and zoning. A huge advantage with this approach is that even though the server architecture can change radically it still communicates with clients using the same protocol, therefore clients doesn't have to be adjusted depending on server set-up.





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Data reduction
Based on experience from partner FHG/IGD. A common representation of geometric models in the area of computer graphics are triangle meshes. There are some well-known techniques, which make it easy to obtain very large triangle meshes. Two examples are 3D surface extraction from volume data and 3D scanning. With these techniques is possible to create triangle meshes, which easily exceed the resources of an average computer graphics workstation. Polygonal models, that are not completely represented with triangles have to be triangulated before the simplification.
We will develop software, which will help the user in the follow areas of 3D mesh processing: The main purpose of the software is to simplify large triangle meshes with properties like surface properties (e.g. reflection), colour and texture

- The simplification algorithm is based on an error metric to keep the appearance of the 3D models as accurately as possible to the original 3D model.
- Develop algorithms that simplify with an error metric that does not preserve visual but acoustic features.
- It will be possible to simplify very large triangle meshes, even if the size of the meshes exceeds the memory of the computer where the simplification has to be done.
- To archive the highest possible speed for simplifying, the software will be able to utilize parallel hardware if available. This can be a single computer with multiple processors or a cluster of several computers.

The simplification software will be developed as a module. So it can be integrated into different environments for 3D geometry editing or creating, acoustic simulations of advanced server implementations.

WP7 Acoustic rendering and simulation

This project is based on experience from previous acoustic simulation and 3D-audio projects of the partners KTH, II, HUT, [5][19]. The novelty lies in the combination of existing methods in new ways and the integration of them into a multimodal immersive environment platform.

Simulation of acoustics based on geometry is a difficult task. There is not a single simulation method that will work well for all types of environments. A ray-based method is a good candidate to implement in the type of system that we have in mind. It can perform the simulation in real-time and works satisfactory in most closed spaces. On the other hand the lower frequency range in small spaces where the room modes are dominating the method will not give an accurate result. A wave based method would have given a better result in this case but it is computationally too demanding to use in a real-time system at all audible frequencies.

In this project we have three research topics, and in addition we are going to implement a platform to enable the research. In the following the research questions and the implementation are shortly described.

Geometry reduction for acoustic rendering
The major unsolved problem in audiovisual rendering is the integration of 3D-audio and graphics, i.e. how to reuse the data from 3D graphical models in acoustic simulation. The model utilized for visual rendering is typically much too complex and detailed for modelling

of acoustics and sound rendering. In other words a lot of computational power is wasted if detailed model are applied for sound. That is the reason why in this project one main research topic is that how we can utilize complex geometries for sound rendering by reducing the model complexity. Such a reduction is also motivated from a perception point of view since the effect of small details in geometry are not audible. Our approach to solve the problem is to develop an algorithm for the reduction of geometric complexity for acoustic rendering based on graphical geometry data. The algorithm will be based on experience from partner FHG/IGD. Geometry data will be optimised using a progressive data structure containing a very coarse representation of the geometry and all information necessary to refine it step by step allowing access of the data an arbitrary resolution. This mechanism will make it possible to use the same the 3D model in a very low resolution suitable for acoustic simulation and in a high resolution suitable for displaying it in a CAVE. This will also open up for a future exploration of a mechanism for frequency dependent resolution of the acoustic model, which can be useful for modelling of acoustic diffraction and diffusion.

Audio culling

The culling of sound sources is very simplistic in most current VR systems, where a simple geometric shape is used to describe the spread of the sound. This is not sufficient in a high quality 3D audio system as it is a too blunt instrument to describe the spread of sound. Culling of audible sound source and acoustically significant geometry is fundamentally different from the visual counterpart. The difference is that reflection and diffraction of the sound have to be considered to estimate the audibility of sound sources. This area of real-time acoustic simulation has not been deeply penetrated. One of the few interesting works in this direction is the Beam-tracing method [18]. We will develop an acoustic culling module based on this work.

Relation of perceptual and physical attributes

Nowadays there are two main principles for acoustic rendering, the physical and perceptual ones. (see e.g. MPEG-4 AABIFS [22]). In real-time physical modelling of room acoustics, the most practical algorithm is the image-source method. It provides accurate information of the early reflections of sound. But to produce convincing acoustic rendering a realistic model for higher order reflections and late reverberation is needed as well. All this data can be obtained from a room model consisting of geometry and material data. Although it is possible to compute and render these physical attributes it is computationally expensive. The typical sound cards used at home utilize the perceptual approach in acoustic rendering. For this reason we are going to study the relation between the perceptual and physical attributes. Our objective is to find a procedure to obtain the perceptual attributes directly from the physical model of a room. By this technique creation of realistic VR sound would be much easier since no specific acoustic modelling is needed. Naturally, this aims in quite a coarse approximation applicable, e.g., in the game industry, instead of making authentic simulation as required in design of concert halls.

Implementation

Finally, we will develop a multi-platform sound rendering software that renders efficiently the audible sources provided by acoustics modelling and source/reflection culling produces. The rendering software consists of two parts: acoustics modelling client and sound rendering client. The clients can be run either separately or in the same computer. We will not develop any new modelling algorithms or software, but instead we will integrate existing algorithms and software together to serve for our purposes. The implementation of sound rendering part has to be done to some extend, so that we can verify the performance of polygon reduction and sound source culling algorithms. The sound-rendering platform can be based on two

different approaches. First one relies on individual rendering of each sound sources and reflections. In this approach, typically a few dozen of sources or perceptually important reflections can be rendered in real-time and the late reverberation part is handled with statistical computationally efficient algorithm. The other approach is to utilize perceptually-based rendering technology in which the rendered impulse response is fixed, but its parameters are based on perceptual attributes. These attributes can be defined without the room geometry, but in this project we will develop an algorithm that produces these rendering parameters according to the acoustics modelling and source/reflection culling produces. The latter rendering strategy is attractive since in this case the actual rendering can be performed with available sound rendering technology, e.g., OpenAL and EAX, which are hardware supported by most soundboards. Our approach will be a hybrid model combining both rendering strategies in a novel way.

WP8 Evaluation/Validation

The system will be tested and evaluated in the digital media industry by a implementing a simple game but with advanced technical features as dynamic mesh generation and allowing a large number of players. The idea for the game will be done in collaboration between Paregos and the Game studio of the Interactive Institute. The implementation will be done mainly by II. The result will be evaluated by Paregos, II together with the Game company Nevrax.

The architect company Minusplus will provide test examples from different building project. The Minusplus architect office is currently planning a theatre in Budapest.
This would be an ideal test case requiring both architectural and acoustic simulation.

We will set up a public server and allow project participants and the Blender foundation open source community to take part in the development. This will give user experience in running the system and maintaining it.

WP9 Dissemination

The unique architecture of the proposed system makes it possible to use the system directly, with limited programming effort by combining a set of clients with a server, in several areas like:

- Architects
- Acoustic consultants
- Town and Landscape planners
- Designers and CAD/CAE using companies.

On top of the base system applications can be developed by some simplified programming effort in areas like:

- Game companies
- Entertainment companies
- Collaborative software development companies
- CAD/CAE development companies
- E-commerce companies

The consortium partners have strong links to the following organizations:

- Eurographics
- Reality Centres Special Interest Group,
- Architects' Council of Europe
- UIA - Union Internationale des Architectes
- International Game Developers Association
- Audio Engineering Society
- International Computer Music Association
- International Community for Auditory Displays
- The National Swedish Association of Architects
- The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
- SIGRAD The Swedish Association for Computer Graphics

The dissemination and exploitation work will be lead by Ton Roosendaal from the Blender Foundation. He has vast experience from exploitation both in the commercial world and the open source community. He will lead the work with the exploitation plan which will exists in draft form till the mid-term review.

The development of audio and acoustic simulation will be possible to apply also in other environments than Uni-Verse. This will also be disseminated in academic channels but also at professional societies as Audio Engineering Society and International Community for Auditory Displays

A small company has already been set-up in Sweden to commercialise tools built on the Verse protocol and libraries. We will closely collaborate with this company to gain maximum dissemination and exploitation.

The Interactive Institute's research-studio Zero-Game is working closely with the French Game development company Nevrax (www.nevrax.com), which provides a new open-source Massively Multiplayer Online engine, called Nel. The Zero-Game studio is currently using the Nel platform for test and implementations of research results and themes. Within this project a test implementation, documentation and release of new dynamic content (described in B1) modules for the Nel platform. A test-game is planned to be released, utilizing Uni-Verse in the researched and implemented areas. In addition to this the dynamic content, open-source, modules can then be freely downloaded and used by anyone. The Zero-Game studio will use its position and contacts within the game developer community to disseminate and exploit Uni-Verse, as well as hold workshops and seminars for the developer community and on university level. Especially the studio will arrange a short course for game developers with Uni-Verse technology.

KTH PDC will use its contacts with media, end-users and research organizations from the Technology Transfer Node (TTN) project including the Media Sectors Group.

The specification for the Verse protocol will continue to be open and most of the software developed will be open –source which means that any European industry can use the software to develop tool and applications. The software will be placed at the web-site http://sourceforge.net/, easily accessible for everyone and providing a platform for developers to make additions and corrections and hosting a growing community of users.

Table 1 **Partners and their role in dissemination**

Partner	Disseminating Role
KTH	Students with project assignments and diploma work Clients of the 6-sided CAVE; Articles and conferences Through The National Swedish Association of Architects, The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, Reality Center Special Interest Group Contacts from the EC TTN project especially the Media sector group
Interactive Institute	Students with project assignments and diploma work Articles and conferences Use in projects and exhibits Audio Engineering Society, International Computer Music Conference International Community for Auditory Displays.
HUT	Students with project assignments and diploma work Articles and conferences; Audio Engineering Society International Community for Auditory Displays.
Fraunhofer IGD	Students with project assignments and diploma work Articles and conferences Clients of the 5-sided CAVE Standardization bodies
Minusplus	To clients Through Architects' Council of Europe Students with project assignments and diploma work Conferences
Paregos	Dissemination WP leader Clients and through network of collaborating companies. Conferences and through examination students
Blender Foundation	Dissemination in the open source community Working will volunteers On the Blender Web-page and Blender conference

Risk analysis

The Uni-Verse project deals to a large extent to integrate parts developed at different leading European research laboratories like the communication protocol, audio simulation, light simulation, data reduction etc As in all integration work a risk exist that unforeseen problems will arise which makes it hard to fit components together. The risk is minimized by making the design as modular as possible. If some component would have some problem this would still not jeopardise the entire project. The situation is also the same with some research issues in individual task like audio culling etc. that has to be resolved. The highly qualified original developers of all the components are also partners in the project, which should guarantee that the integration work would be successful.

The protocol in the project allows any part of the scene to change dynamically at any point. This may put extreme requirements on the audio and light simulation, which normally does some pre-calculations. This is indeed one of the interesting research topics of the project. However, it might also be necessary to limit the dynamic properties of the models to make this work in practice. The result will still be highly innovative and would be a significant advance of technology.

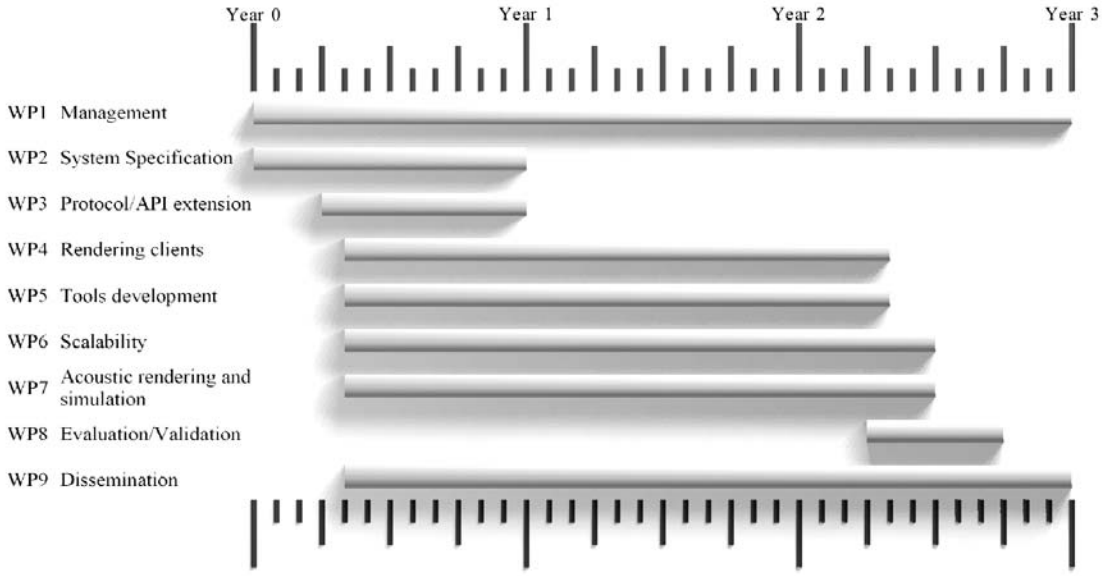
Acoustic and light simulation are computing intensive tasks. Large scenes may be impossible to render in real-time depending of the available computing resources. The high rate of development in processing speed will make this technology even more useful in the future.

OVERVIEW OF MILESTONES			
Milestone No	**Due date**	**Brief description of Milestones objectives**	**Decision criteria for assessment**
M1.1.	Month 3	Web page	Web-page published
M2.1.	Month 12	Final specification	Report agreed among the partners
M3.1.	Month 12	Tested protocol	Works according to D 2.2
M4.1.	Month 12	Simple client	Works according to D 2.2
M4.2.	Month 28	Slim rendering client	Works according to D 2.3
M5.1.	Month 14	Geometry modeller plug-in	Works according to D 2.3
M5.2.	Month 28	Radiosity module	Works according to D 2.3
M6.1	Month 14	Geometry reduction library	Works according to D 2.3
M7.1	Month 36	Implemented and tested audio system	Works according to D 2.3
M8.1	Month 38	Evaluation in architecture	Works according to D 2.3
M8.2.	Month 33	Evaluation in digital media	Works according to D 2.3
M9.1	Month 24	Conference paper	Paper accepted
M9.2	Month 36	Course for game developers	Course successful and evaluated
M9.3	Month 39	Final Report	Report published on the web

Note: Month 1 denotes the start of the project

7.2 Planning and timetable

GANTT CHART



7.3 Graphical presentation of Workpackages

The interaction between the different tasks is shown in the Diagram below.

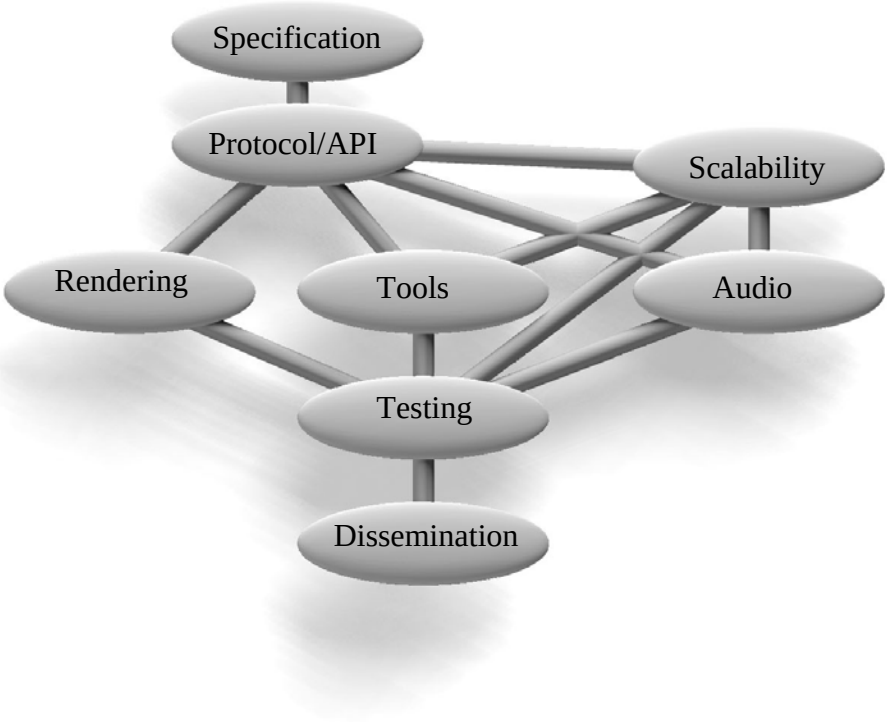


Fig 5: *Interaction of Tasks*

7.4 Workpackages list

Work package list (full duration of project)

Work-package No	Workpackage title	Lead contractor	Person-months	Start month	End month	Deliv-erable No
WP1	Management	KTH	14	1	39	D1.1-D1.2
WP2	System Specification	II	19	1	12	D2.1-D2.3
WP3	Protocol/API extension	KTH	21	3	12	D3.1-D3.4
WP4	Rendering clients	FHG/ IGD	32	4	28	D4.1-D4.3
WP5	Tools development	II	78	4	28	D5.1-D5.5
WP6	Scalability	FHG/ IGD	30	4	30	D6.1-D6.2
WP7	Acoustic rendering and simulation	HUT	68	4	36	D7.1-D7.6
WP8	Evaluation/Validation	Paregos	24	27	38	D8.1-D8.4
WP9	Dissemination	Blender	21	4	39	D9.1-D9.7
	TOTAL		307			

7.5 Deliverables list

7.5 Deliverables list

Deliverable No	Deliverable name	WP no	Lead participant	Estimated person-months	Nature	Dissemination level	Delivery date Month
D1.1.	Web-page	1	KTH	2	O	PU	3
D1.2	Project presentation	1	KTH	1	R	PU	6
D2.1.	Report on selected developer tools	2	II	3	R	CO	3
D2.2.	Report on system capabilities	2	II	12	R	CO	4
D2.3.	Final specification	2	II	4	R	CO	12
D3.1.	Improved Protocol	3	KTH	3	P	PU	5
D3.2.	Security Implementation	3	KTH	5	P	PU	8
D3.3	Scripting API implementation	3	Blender	10	P	PU	8
D3.4.	Tested Protocol	3	Blender	3	P	PU	12
D4.1.	Simple rendering client	4	KTH	3	P	PU	12
D4.2	High-performance rendering client	4	KTH	11	P	PU	28
D4.3.	Slim rendering client	4	FHG/IGD	18	P	PU	28
D5.1.	3D geometry modeller plug-in	5	KTH	15	P	CO	18
D5.2	Scripting tool plug-ins	5	Blender	20	P	PU	18
D5.3	Administrations tools	5	KTH	17	P	PU	18
D5.4	Dynamic mesh generation module	5	II	14	P	PU	28
D5.5.	Radiosity module	5	FHG/IGD	12	P	PU	28
D6.1.	Geometry reductions library	6	FHG/IGD	20	R	PU	14
D6.2.	Alternative server implementation	6	FHG/IGD	10	P	PU	30
D7.1	Specification of acoustic simulation	7	HUT	4	R	CO	7
D7.2	Geometry reduction module	7	HUT	12	P	PU	19
D7.3	Audio culling module	7	II	15	P	PU	19
D7.4	Sound rendering module	7	HUT	20	P	PU	24
D7.5	Perceptual based module	7	II	14	P	PU	36
D7.6	Final report of acoustics	7	HUT	3	R	PU	36
D8.1	General evaluation report	8	Paregos	4	R	CO	36
D8.2	Evaluation in architecture	8	Minusplus	8	R	CO	38
D8.3	Evaluation in digital media	8	Paregos	8	R	CO	33
D8.4	Documentation	8	KTH	4	R	PU	36
D9.1	Exploitation plan	9	Blender	2	R	CO	12

D9.2	Dissemination plan	9	Blender	2	R	CO	12
D9.3	Journal/magazine articles	9	KTH	2	O	PU	24
D9.4	Conference papers and exhibition at conferences	9	KTH	4	O	PU	36
D9.5	Result Web-page	9	KTH	3	O	PU	39
D9.6	Course for game developers	9	II	5	O	PU	36
D9.7	Uni-Verse final report	9	KTH	3	R	PU	39
			TOTAL	296			

Note: Month 1 denotes the start of the project

7.6 Workpackages Descriptions

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Management**		WP No: **1**
Starting date: month **1** Duration: **39** months		Total Effort in Man-months: **14**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	**WP Leader, coordinator**	**11**
II	Participant	**3**
HUT	Participant	**0**
FHG/IGD	Participant	**0**
MINUSPLUS	Participant	**0**
PAREGOS	Participant	**0**
BLENDER	Participant	**0**

Objectives
The objective is the management of the project in order to guarantee the efficient functioning, to manage problems that may arise and to ensure the timely completion of deliverables and milestones.

Description of work / tasks

WP 1.1. Coordination of activities
The over-all management of the project will be assured by the project coordinator. The coordinator will be assisted by a project coordination committee, which will consist of hone representative from each partner. The main tasks will be the coordination of activities in the project, and the dissemination of information to consortium partners. The coordinator will also ensure the timely completion of deliverables.
WP 1.2. Project coordination meetings
Meetings of the project coordination committee will be convened at regular intervals in order to monitor progress. If difficulties arise ad hoc meetings will be convened with the parties concerned.
WP 1.3. Web page
WP 1.4 Update of web-page
A web page will be established and maintained for the purpose of disseminating information within the consortium and to potential users.
Deliverables
D1.1 Web page (Month 3)
D1.2 Project presentation
Milestones and criteria
M1.1 Web page; Web-page published (Month 3)
Interrelation with other workpackages
All workpackages

WORKPACKAGE DESCRIPTION		
Workpackage Title: **System Specification**		WP No: **2**
Starting date: month **1**. Duration: **12** months		Total Effort in Man-months: **19**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	Participant	**4**
II	**Workpackage leader, Participant**	**4**
HUT	Participant	**3**
FHG/IGD	Participant	**4**
MINUSPLUS	Participant	**1**
PAREGOS	Participant	**1**
BLENDER	Participant	**2**

Objectives
The objective is to make a careful choice between existing development tools and systems. The selected software should be platform and operating system independent. The second task is to specify the system capabilities.

Description of work / tasks
The work will comprise the following tasks:

WP 2.1. Selection of developer tools
The developer tools have to be selected carefully. Ii is necessary to verify existing software on the market as well as applications or modules available from the project partners. The advantages and disadvantages are compared to each other referring to the criteria and the desired features mentioned above. A central issue of the selection process is to guarantee an efficient software development process as well as a minimisation of costs. Ideally the required software is already available and used by the project partners involved.

WP 2.2. Specification of system capabilities
In all large research and development projects it is important to have a common understanding of each other and of the problem to be addressed. The subtask deals with this both in a technical but also in a more social way. To get the common understanding and define interfaces between parts, which are to be developed, two workshops will be held with duration of 2-3 days each with some month in between.

WP 2.3. Improvement of specification
The specification will be gradually improved and updated during the development work.
Each WP leader will be responsible to update the specification for his parts.

Deliverables
The deliverables of WP 2 are:
D 2.1. Report on selected developer tools (month 3)
D 2.2. Report on system capabilities (month 4)
D 2.3 Final specification (month 12)

Milestone
M2.1 Final specification ; Report agreed among the partners (month 12)

Interrelation with other workpackages
Basic task for all subsequent workpackages. Provides necessary information for WP3-WP7.

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Protocol/API extension**		WP No: **3**
Starting date: month .**3** Duration: **9** months		Total Effort in Man-months: **21**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	**Workpackage leader, Participant**	**12**
II	Participant	**1**
HUT	Participant	**1**
FHG/IGD	Participant	**1**
MINUSPLUS	Participant	**0**
PAREGOS	Participant	**0**
BLENDER	Participant	**6**

Objectives
The current version of the real-time protocol developed by partner II [17] is event-based for graphics and animation. This WP will extend the protocol enabling high quality sound and acoustics modelling, animation and skeleton representation. To facilitate the integration of audio and acoustic simulation in the Uni-Verse system the protocol will be extended to enable the description of virtual sound sources, their behaviour and the acoustic properties of the modelled environment that interacts with the sound sources. Added to existing support for security encrypted login will be implemented. Evaluation and testing of protocol extension will be undertaken according to current software design practices. Delivered as Open Source. In this work package will also deliver the API for the scripting environment. Since the scripting environment is plug-in based this is important for other workpackages that will use it by writing plug-ins.

Description of work / tasks
The work will comprise the following tasks:
WP 3.1 Protocol improvement
Initially a transform and an animation system for efficient low bandwidth communication of 3D motion data will be implemented. Adding audio support.
WP 3.2 Security
Implementation of an authentication mechanism.
WP 3.3 Scripting environment API
Implementation of the Basic API for writing processing plug-ins for the scripting environment
WP3.4 Testing
Testing of the protocol extensions and their implementation. Corrections, bug fixes etc.
Deliverables
The deliverables of WP 3 are:
D 3.1. Implementation of the improved protocol (Month 5)
D 3.2 Security implementation (Month 8)
D 3.3 Implementation of the scripting API (Month 8)
D 3.4 Tested implementation of protocol (Month 12)
Milestone
M 3.1 Tested implementation of protocol; Works according to D 2.2 (Month 12)
Interrelation with other workpackages
Basic task for all subsequent workpackages. Provides input to WP4 -WP7.

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Rendering Clients development**		WP No: **4**
Starting date: month **.4**	Duration: **24** months	Total Effort in Man-months: **32**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	Participant	**14**
II	Participant	**0**
HUT	Participant	**0**
FHG/IGD	**Workpackage leader, Participant**	**18**
MINUSPLUS	Participant	**0**
PAREGOS	Participant	**0**
BLENDER	Participant	**0**

Objectives
Existing rendering clients will be adapted to various hardware platforms, such as CAVEs and PDAs, complementing existing desktop renderer.

Description of work / tasks
The work will comprise the following tasks:

WP 4.1 High-performance Rendering client
Adaptation and testing of rendering clients for PC, Workstations and Immersive Environments

WP 4.2 Slim Rendering client
Development and testing of rendering client for mobile phones and PDAs based on OpenGL ES.

Deliverables
The deliverables of WP 4 are:

D 4.1 Simple client (first release of High-Performance Rendering client)(Month 12)
D 4.2 High-Performance Rendering clients (Month 24)
D 4.3 Slim Rendering Client (Month 28)

Milestones
M 4.1 Simple client released. (Month 12)
M 4.2 Slim rendering client; works according D 2.3 (Month 28)

Interrelation with other workpackages
This WP will be crucial for supplying WP7 and WP8 with rendering tools for testing and evaluation

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Tools and Clients development**		WP No: **5**
Starting date: month **.4** Duration: **24** months		Total Effort in Man-months: **78**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	Participant	**21**
II	**Workpackage leader, Participant**	**28**
HUT	Participant	**0**
FHG/IGD	Participant	**12**
MINUSPLUS	Participant	**0**
PAREGOS	Participant	**0**
BLENDER	Participant	**17**

Objectives
Basic content authoring tools for the Uni-Verse system. Integration of 3D graphics and audio results in new demands on content authoring tools. Our approach to this is to develop plug-ins to existing 3D-modelling applications, thereby empowering a large base of current developers of 3D and VR content. A plug-in to a third-party 3D-geometry modeller and an audio editor will be implemented. A high level language scripting environment will be developed in aiding application designers in creating interactive immersive experiences with reduced development and programming effort

Description of work / tasks
The work will comprise the following tasks:
WP 5.1. 3D modeller plug-in
A plug-in to an existing 3D-geometry modeller selected in WP2 will be developed, implemented and tested.
WP 5.2 Scripting tool plug-ins
Writing a standard set off plug-ins and functionality for the scripting environment
WP5.3 Administration tools
Various smaller tools for administration and maintenance
WP 5.4 Dynamic mesh generation module
Algorithms for dynamic mesh generation and modification
WP5.5 Radiosity module
Module for progressive light simulation

Deliverables
The deliverables of WP 5 are:
D 5.1 3D geometry modeller plug-in (Month 14) (may not be open source)
D 5.2 Scripting tool standard library (Month 14)
D5.3 administration tools (Month 14)
D5.4 Dynamic mesh generation module (Month 28)
D5.5 Radiosity module (Month 28)

Milestones
M 5.1 3D modelling plug-in; works according D 2.3 (Month 13)
M 5.2 Radiosity module; works according D 2.3 (Month 28)

Interrelation with other workpackages
This WP will be crucial for supplying all other workpackages with authoring tools for testing and especially for evaluation WP 8.

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Scalability and data reduction**		WP No: **6**
Starting date: month **4** Duration: **26** months		Total Effort in Man-months: **30**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	Participant	**4**
II	Participant	**2**
HUT	Participant	**2**
FHG/IGD	**Workpackage leader, Participant**	**22**
MINUSPLUS	Participant	**0**
PAREGOS	Participant	**0**
BLENDER	Participant	**0**

Objectives
The Objective of this WP is to develop research scalability issues. This WP will also work on issues regarding server side scalability in the form of Proxies and clustering. In this development geometry compression will be used and this technology will also be used in the Acoustic simulation work.

Description of work / tasks
The work will comprise the following tasks:

WP 6.1. Data reduction
A software module will be implemented for simplifying geometric data with textures and appearance information. The simplification will create a progressive data structure that can be saved to special file format.

WP 6.2. Alternative server implementation
We will investigate other server solutions to expand scalability using multiple computers and data reduction algorithms, to cope with very large data set and thin clients.

Deliverables
The deliverables of WP 4 are:
D 6.1. Geometry reduction library (Month 14)
D 6.2. Alternative server implementation. (Month 30)

Milestone
M 6.1. Geometry reduction library Works according D 2.3 (Month 14)

Interrelation with other workpackages
Depends on the protocol from WP3. Will be utilized in WP7 and WP8.

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Acoustic rendering and simulation**		WP NO: **7**
Starting date: month **4**. Duration: **32** months		Total Effort in Man-months: **68**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	Participant	**2**
II	Participant	**32**
HUT	**Workpackage leader, Participant**	**32**
FHG/IGD	Participant	**2**
MINUSPLUS	Participant	**0**
PAREGOS	Participant	**0**
BLENDER	Participant	**0**

Objectives

The objective of this workpackage is to implement and integrate three **modules** based on complementing simulation methods. The modules are: the **Geometry reduction** for acoustic rendering, the **Audio culling** module and the **Perceptual based** module based on previous work by HUT [5], II [19] and work described in [6]. In addition, a **Sound-rendering module** will be developed and it will handle all the signal processing needed by the acoustic simulation modules. It will be based on the participants' previous works [5] [19]. The main system architectural advantage of having a separate sound-rendering module is to isolate and hide the loudspeaker/headphone configuration from the acoustic simulation modules.

Description of work / tasks

- WP 7.1 Specification of the **Acoustics simulation modules**
- WP 7.2 Development of the **Geometry reduction** module
- WP 7.3 Development of the **Audio culling** module
- WP 7.4 Development of the **Sound rendering module** based on work described in [5, 19]
- WP 7.5 Development of the **Perceptual based method** based on work described in [6]
- WP 7.6 Validation of all the components

The work in this workpackage is large part based on previous work by the participants. It however contains unsolved research issues in the areas of geometry reduction, audio culling and combining physical based and perceptual based simulations methods.

Deliverables

The deliverables of WP 7 are:

D 7.1. Specifications for Acoustics simulation and rendering modules (month 7)
D 7.2. Geometry reduction module (month 19)
D 7.3. Audio culling module (month 19)
D 7.4. Sound rendering module (month 24)
D 7.5. Perceptual based acoustic simulation module (month 36)
D 7.6. Final report of WP 7 (month 36)

Milestones and criteria

M 7.1 Implemented and tested 3D-audio subsystem. Works according to **D 2.3** (month 36)

Interrelation with other workpackages

The Sound-rendering module will depend on the audio protocol in **WP 3 D 3.1**
Data reduction developed in WP 6 will be used for simplification of geometry.

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Evaluation/ Validation**		WP No: **8**
Starting date: month **27**	Duration: **9** months	Total Effort in Man-months: **24**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	Participant	**5**
II	Participant	**5**
HUT	Participant	**2**
FHG/IGD	Participant	**2**
MINUSPLUS	Participant	**4**
PAREGOS	**Workpackage leader**;Participant	**3**
BLENDER	Participant	**3**

Objectives
The objective of the WP is the assessment that the Uni-Verse system developed in the previous workpackages meets the requirements and specifications stated in WP2. To assess the accomplishment of these requirements, an evaluation of the developments of different WPs (3-6) will be done, as a validation of the results of the project. Validation will be done for both of the sectors, architecture and the digital media industry because there are different requirements and then validation criteria.

Description of work / tasks
The work will comprise the following tasks:

WP 8.1. General validation
General testing and evaluation that the criteria in D2.3 is met

WP 8.2. Evaluation in architecture
Testing and evaluation with the architecture end-users

WP 8.3. Evaluation in digital media
Testing and evaluation with the digital media end-user

WP 8.4 Documentation
Documenting the system

Deliverables
The deliverables of WP 7 are:
D 8.1. Uni-Verse evaluation report (month 36)
D 8.2. Report on evaluation in architecture (month 38)
D 8.3. Report on evaluation in digital media (month 33)
D 8.4. Documentation (month 36)

Milestones and criteria
M 8.1. Evaluation in architecture completed/ Requirements in system specification met (month 38)
M 8.2. Evaluation in digital media/ Requirements in system specification met (month 33)

Interrelation with other workpackages
Relies on input from WP 2 (System specification). Validates the results of WP3 – WP7. Provides necessary information for WP 9 (Dissemination).

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Dissemination**		WP No: **9**
Starting date: month **4**.	Duration: **36** months	Total Effort in Man-months: **21**
Member involved	Task description / Contribution of Member	Effort man-months
KTH	Participant	**3**
II	Participant	**3**
HUT	Participant	**3**
FHG/IGD	Participant	**3**
MINUSPLUS	Participant	**2**
PAREGOS	Participant	**2**
BLENDER	**Workpackage leader; Participant**	**5**

Objectives
Dissemination and exploitation of Uni-Verse Market research, presentation and marketing plans.

Description of work / tasks
All partners will participate in this work package

Existing international networks of the project partners and associated end-user groups will be used for dissemination:

- Blender user group and conference
- Eurographics
- Reality Centres Special Interest Group,
- Architects' Council of Europe
- UIA – Union Internationale des Architectes
- International Game Developers Association
- Audio Engineering Society
- International Community for Auditory Displays

WP 9.1 Information will be made available through participation at conferences, seminars and journal articles. Several members participate in graduate and postgraduate courses.
WP 9.2 Short course for game developers

Deliverables
D 9.1. Exploitation plan (month 12)
D 9.2. Dissemination plan (month 12)
D 9.3. Journal/magazine articles (month 24)
D 9.4. Conference papers and exhibition at seminar/conferences (month 36)
D 9.5. Result web-page (month 39)
D 9.6 Short course for game developers (month 36)
D 9.7 Final Report (month 39)
Milestones and criteria
M 9.1 Conference paper /Paper accepted (month 24)
M 9.2 Short course for game developers: course successfully performed and evaluated (month 36)
M 9.3 Final Report, Report published on the web (month 39)
Interrelation with other work packages
Results of all previous work packages required.

8. The consortium and project resources

8.1 Effort for the full duration of the project

STREP Project Effort Form

Project acronym

Uni-Verse	KTH	II	HUT	FGD	MINUS-PLUS	PAREGOS	BLENDER	TOTAL PARTNERS
Research/innovation activities								
WP2 System Specification	4	4	3	4	1	1	2	19
WP3 Protocol/API extension	12	1	1	1	0	0	6	21
WP4 Rendering clients	14	0	0	18	0	0	0	32
WP5 Tools development	21	28	0	12	0	0	17	78
WP6 Scalability	4	2	2	22	0	0	0	30
WP7 Acoustic	2	32	32	2	0	0	0	68
WP8 Evaluation/Validation	5	5	2	2	4	3	3	24
WP9 Dissemination	3	3	3	3	2	2	5	21
Total research/innovation	65	75	43	64	7	6	33	293
Management activities								
WP1 Management	11	3	0	0	0	0	0	14
Total management	11	3	0	0	0	0	0	14
TOTAL ACTIVITIES	76	78	43	64	7	6	33	307

8.2 Overall budget for the full duration of the project

8.3 Management level description of resources and budget

The consortium consists of highly qualified partners, spread throughout Europe, **which have considerable expertise in 3D graphics, virtual reality, network protocols, 3D authoring tools, audio, and acoustics** together with end users representing **digital media, games and architecture.**

The project task requires a multi-disciplinary group of experts, which cannot be found in one European country alone. The consortium consists of four of Europe's most advanced research groups in VR and acoustic simulation. The Uni-Verse consortium relies on the expertise in VR from the Royal Institute of Technology, KTH and the Interactive Institute, II, in Stockholm, Sweden, from Helsinki University of Technology, HUT, in Finland, and Fraunhofer IGD in Germany. Several of these partners have in-house access to advanced immersive VR facilities in forms of Caves [2] with 4, 5 or 6 sides, some equipped with advanced audio systems. On the audio and acoustics side the expertise is mainly coming from the Interactive Institute in Stockholm, Sweden, from Helsinki University of Technology and Fraunhofer IGD with expertise in audio and video streaming and compression.

The Blender foundation adds an open source community to the consortium, enabling both a developer dialog and important dissemination channels.

The end-users representing different application areas will take part in the design and specification phase, testing and evaluation Paregos is contributing with excellent experience in digital media like game and virtual community development as well as offering test cases. Minusplus is a leading Hungarian architecture office with good experience in use of digital media. The consortium with the most experienced experts in Europe is spread over 5 countries giving a good basis for dissemination. All partners will take part in the dissemination of the ideas and the results of the project.

The partners Interactive Institute, Paregos, Minusplus architects and the Blender foundation are all SMEs. The use of open source in the project is especially attractive for SMEs. The modular designs with many separate modules working together as one large system also make it possible for a small company to produce tools for a specific purpose. A course for game developers (especially SMEs) will be arranged by the Zero game studio as main responsible partner.

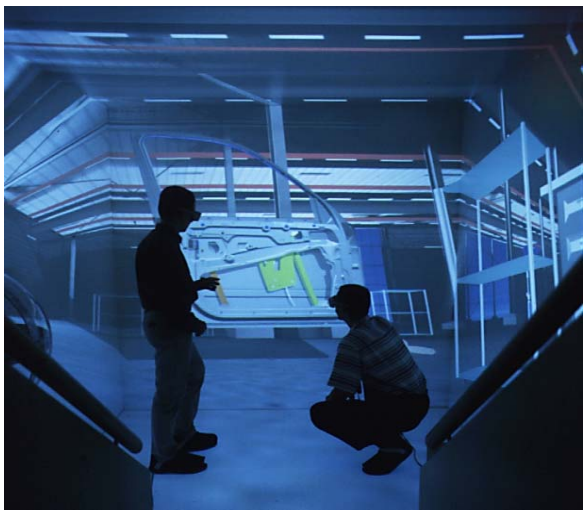


Fig 3: *Five-sided CAVE*

The partner Interactive Institute has access to a state-of-the-art real-time optical 12-camera motion capture studio. The studio has the ability to capture motion in real-time and the eagle-cameras can operate on selectable frame-rate from 1 to 2000 Hz, the motion-data can later or in real-time be streamed and applied to 3D models. The Interactive Institute also has a state of the art sound studio.

Fig 4: *Body & facial Motion Capture set-up at II*

Partners with additional cost model

The Royal Institute of Technology, KTH and Helsinki University of Technology, HUT are universities using the additional cost model. This means that the commission doesn't cover costs for staff, which already have other funding. This kind of costs and corresponding man months are not mentioned in the normal budget and work plans.

Below are however such costs and efforts estimated:

KTH

WP	*Personal Costs*	*Position*	*Amount (h/month)*	*Price per month*
WP1	Mrs. Lina-Beth Norrström	Secretary	8	236
WP1	Mrs. Chistina Billing Ericson	Head financial officer	2	59
WP1	Prof. Lennart Johnsson	Professor	1	147
WP6	Prof. Lennart Johnsson	Professor	1	147
WP9	Prof. Lennart Johnsson	Professor	2	294
WP9	Prof. Nils Ehnlund	Professor	1	88
Total				**677**

HUT

WP	*Person*	*Position*	*Amount (h/month)*	*Cost per month*
WP2	Prof. Lauri Savioja	Professor	2	112
WP2	Dr. Tapio Lokki	Researcher	4	152
WP3	Dr. Tapio Lokki	Researcher	4	152
WP7	Prof. Lauri Savioja	Professor	2	112
WP7	Dr. Tapio Lokki	Researcher	4	152
WP7	Mrs. Sirpa Penttinen	Secretary	1	30
WP7	Mr. Seppo Äyräväinen	Laboratory Manager	2	68
WP9	Prof. Lauri Savioja	Professor	1	56
WP9	Dr. Tapio Lokki	Researcher	1	38
	Floor rents			
WP7	EVE (our CAVE-like system)		5% (8 h/month)	96
Total				**969**

Free contribution in each work package:

	KTH	HUT	
WP1	3.3		
WP2		1.5	
WP3		1	
WP4			
WP5			
WP6	0.3		
WP7		2.25	
WP8			
WP9	0.9	0.5	
Total	4.5	5.25	9.75

The commission contributes to the salary + social fees and also to direct costs of the project. In addition 20 % is granted to cover indirect costs. A simple calculation shows that this total funding is not sufficient to cover infrastructure such as rent (which is not eligible to charge but in any case has to be paid), heat, electricity, administration, library etc. Which all amount to about 60-80 % on top of the amount funded by the commission

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CONSORTIUM OVERVIEW						
Participant		**Organization Name**	**Country**	**Nr. of Empl.**	**Main Mission/ Business Activity/ Area of Activity**	**Role in Project**
Activity code	Nr.					
HES	1	Kungl Tekniska Högskolan KTH	S	3200	University and super computer center. Research group in VR including audio	Coordination, Specification Development of protocol, application clients, Provides a 6-sided Cave
REC	2	Interactive Institute II	S	165	Research institute VR, games and audio. Developer of real-time protocol	Specification Acoustic development, Games development
HES	3	Helsinki University of Technology HUT	FIN	3000	University, VR and acoustic research group	Specification, Acoustic development, Provides a 4-sided Cave
REC	4	Fraunhofer-Institut für Graphische Daten-verarbeitung FHG/IGD	D	180	VR-research group developed compression for audio and geometry experts in streaming technology	Specification Data reduction and streaming development, Making available a 5-Cave sided installation
IND	5	Minusplus Epitesz Kft. Minusplus	HU	10	Architect office with expertise in computer visualization	Specification Evaluation Dissemination
IND	6	Paregos Mediadesign AB Paregos	S	40	Digital design agency, Analyse, strategy and design for games, education- and marketing concepts in all digital media.	Specification Evaluation Dissemination
OTH3	7	Stichting Blender Foundation Blender	NL	3	Developer of the Blender 3D open source creation tool Software development	Specification Development Dissemination in the open source community

9. Ethical issues

Gender issues

All companies and universities involved in this project are equal-opportunity employers actively working to have more female employees in technical areas. At the universities involved there are plans to attract more females to technical educations. This has partly been successful and even more successful in the Ph.D. programs.

The technology developed in this project is mainly gender neutral. However the possibility to build multi-user high-quality applications based on Uni-Verse has the potential to attract also female users, which today are using computers less, compared to men both for recreation and communication applications.

Appendix A. Consortium description

A.1 Description of the participants

PARTICIPANT NUMBER 1:

KUNGLIGA TEKNISKA HÖGSKOLAN

Short description of the organization

The Royal Institute Of Technology, Kungliga Tekniska Högskolan, KTH, is the largest university of engineering in Sweden. The university has more than 10 000 undergraduate students, 1000 postgraduate students and a staff of 3200 people. KTH conducts excellent education and research of a broad spectrum - from natural sciences to all branches of technology. The department of Numerical Analysis and Computer Science is one of KTH's largest and houses a number of national centers of excellence including *The Center for Parallel Computers, PDC*, the major Swedish High-Performance Computing Center. In terms of hardware, the main resource of the center is a 200 node (300 processor) IBM Power Parallel RS6000/SP system In addition there are several Linux –clusters of different size. The visualization laboratory at the center houses the unique VR-cube, which was the world's first VR-facility with total immersion.

Experience and expertise

PDC has more than 10 years experience in high-performance computing and has been using high-performance VR since 1996. PDC also coordinated the Technology Transfer Node PDCTTN. PDC also developed a new audio system for the VR-cube and software for sound source modelling in immersive environments.

Short resume of the key persons

Associate director PDC, ***M.Sc. Gert Svensson***, coordinator of Uni-Verse project; one of the founders of PDC has more than 12 years experience in research management mostly in high-performance computing projects. He was heavily involved in the formation of the PDC EC-funded Technology Transfer Node (PDCTTN) and initiated and supervised several activities. He was project leader for the design and installation of the world's first 6-sided Cave .He is currently managing the VR-research at PDC. He has been involved in several European projects, including Virtual Reality projects such as 3demo and Virtualfires. He is currently acting as technical manager for the EC funded brain-imaging project Neurogenerator.

Eskil Steenberg, computer game developer and 3D artist with over 10 years of 3D Graphics experience. As an employee of the Interactive Institute (1999-2001) he specialized in real-time 3D and developed the Verse platform, as the main architect and group leader of the Verse-team. In January 2001 he headed a first public demonstration of the Verse platform jointly with Ericsson Telecom and Swedish Television at the NATPE conference, in Las Vegas. He is currently working as an independent contractor but will be an employee of KTH during the project. He has presented scientific papers on 3D graphics, e.g. at Eurographics 2001 [4].

PARTICIPANT NUMBER 2:

INTERACTIVE INSTITUTE

Short description of the organization

The Interactive Institute (II) is a five year old Swedish multidisciplinary research institute, already of some renown, active in the borderland between enterprise and art, technology and science, that strives for innovation within the field of digital media. The Institute carries out and publishes internationally recognized research and creates innovative concepts for new digital products and services. The Interactive Institute is currently represented in Stockholm, Gothenburg, Malmö, Umeå, in total nine cities, in twelve studios that co-operate but are independent.
II has initiated the Nordic Interactive, a research network, organizing a Nordic research school and NIC200X conferences. The institute is participating in several EU-projects, including Disappearing Computers as well as prize-winner at cultural events like Ars Electronica 2001 and exhibitors on the unofficial top-ten list at Expo2000 in Hanover. Part of many international academic collaborations, in US and Europe, also conference committees like UBICOMP2002 and UIST2002. The Interactive Institute is a wholly owned subsidiary company of the Swedish Foundation for Strategic Research. Http: //www.interactiveinstitute.se

Experience and expertise

The Interactive Institute is developing applications in mixed reality and VR environments, and doing specialized work in natural interfaces based on sensors, computer vision and video tracking as well as 3D audio technology [19] and advanced network protocols (Verse, {17]) for efficient real-time co-operation in graphic environments on scalable hardware platforms.

Short resume of the key persons

Peter Becker. M.Sc., in Mathematics and Physics. Senior researcher at the Interactive Institute, professor of Interactive Media at the National College of Film, Radio, Television and Theatre. Former head of the Multimedia Lab, College of Applied Engineering at KTH/ Royal Inst. of Technology. Extensive experience as manager of large scale R&D projects in interactive media. Experience as expert, evaluator and member of steering committee for some EU-projects.

Peter Lundén Lundén has been working as a researcher of Computer Music and Audio Technology at the Royal Institute of Technology, department of Speech, Music and Hearing between 1988 to 1999. Since 1999 he has done research about 3D-audio technology, developed a sound server and done acoustic modeling at the Interactive Institute. His open source sound server has been installed in the CAVE at Royal Institute of Technology (KTH) in Stockholm. His work has been presented at international conferences [19].

Craig Lindle Director for Zero-Game Studio (part of Interactive Institute). He has an extensive scientific research background specialising in the areas of knowledge base systems, artificial intelligence, and digital media systems. He has a PhD in computing science, and has worked as a technical researcher, a technical R&D project leader and a project manager for many research projects conducted in collaboration with industry partners. Most of his research

experience has been obtained with the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO). He is currently involved in research on generative techniques and believable agents in virtual environments. Craig Lindley has extensive international research publications in the areas of artificial intelligence and digital media systems. He also has experience in software engineering methodologies and real-time systems development.

Mirjam Eladhari, She has worked as a game programmer at Liquid Media in Stockholm, Sweden. The most recent title she worked on is Diamantmysteriet i Rosemond Valley (The Diamond Mystery in Rosemond Valley), a mystery game in real time 3D. Mirjam Eladhari has a BA with literary studies as a major and behavioural science as a minor. Her primary research interests are to explore the relationships between game play and the mechanics of interaction in virtual environments on one hand, and storytelling and worldbuilding on the other.

Martin Schlingmann He is specialized in software development, design and system architecture and has 10+ years of professional development and programming experience. Prior to his current work at the Interactive Institute as a technical researcher, Martin has held positions such as Technical Director, Tech lead, Senior Programmer and Competence Coach in the commercial programming and IT industry. Martin has a wide experience on a range of different platforms and technologies in several large- and small-scale projects, including projects across several countries and continents. In addition to commercial development, Martin has also been hired and giving lectures for both universities and the private industry. University-studies includes Graphical Engineering, Computer Science, Statistics, Technical English, Art and Architectural History/Theory. Martin’s primary research interests lies in the field and usage of distributed networking and generative media within games.

PARTICIPANT NUMBER 3:

HELSINKI UNIVERSITY OF TECHNOLOGY

HELSINKI UNIVERSITY OF TECHNOLOGY

Short description of the organization

Helsinki University of Technology (HUT) is the oldest and largest University of Technology in Finland. With twelve faculties, HUT provides higher education and promotes free research in technology. Through its education and research HUT is devoted to distribute the information for the benefit of the society. HUT has participated in 160 EU-projects within the Fourth and Fifth Framework Programs.

Telecommunications Software and Multimedia Laboratory (TML) belongs to the Computer Science Department at HUT. The laboratory was established in 1995 to meet the challenges of the new rapidly growing research area. The laboratory has 5 professorships, and their main areas are "Computer Networks", "Security", "Multimedia" and "Virtual Reality".
TML is also managing the Experimental Virtual Environment (EVE) at HUT. The system is a CAVE-like virtual reality installation in which users are surrounded by 3x3 m rear-projected screens. EVE is equipped with stereoscopic projection system utilizing shutter glasses, and with a head-tracking system as well as with a 3D-audio system capable of producing moving sound sources into three-dimensional space.

Experience and Expertise

TML is one of the pioneers of research on auralization and interactive real-time room acoustic rendering technologies. They have developed their own DIVA (Digital Interactive Virtual Acoustics) auralization system. Their advanced audio processing system is applicable also the Uni-Verse project. At the moment the EVE research group is involved also in another EU project called ALMA (Algorithms for the Modelling of Acoustic Interactions).

Short resume of the key persons

Professor Lauri Savioja, Dr. Sc. Tech., professor in Telecommunications Software and Multimedia Laboratory. He has been working for the university since 1991. He has over 40 journal and conference articles on virtual reality, the main focus being in the virtual acoustics, and room acoustic modelling. He is heading the EVE research group having 12 researchers and research assistants at the moment. The focus areas of the research group are virtual acoustics, applications of virtual reality, and human-computer interaction. He is responsible of teaching computer graphics and virtual reality in the university.

Dr. Tapio Lokki has studied electrical engineering and computer science at the HUT. He made his doctoral thesis in 2002 discussing room acoustic modelling and evaluation of the quality of acoustic simulation and auralization. Currently he has a position as a teaching researcher at the HUT.

PARTICIPANT NUMBER 4: FHG/IGD
Fraunhofer-Institut für Graphische Datenverarbeitung

Short description of the organization

The Fraunhofer IGD is one of 48 research institutes of the Fraunhofer Society and is closely connected with the GRIS Group of the Technical University of Darmstadt and the Computer Graphics Center (ZGDV). The Fraunhofer IGD does applied research with the aim of further developing the technology of computer graphics and of making the results of the new technology available for applications.

Experience and expertise

The Fraunhofer IGD is working on the following research areas:
Document imaging and industrial applications of prepress, printing, and publishing (Graphic Arts) are two major areas of research. From these areas bridges are built from computer graphics to applications in CAD/CAM/CIM, publishing, and electronic prepress. Scientific visualization for technology, science, and medicine is another focus, which plays an important role in many different contexts of realization. Visual communication fills the gap between imaging and telecommunication which-due to strong market growth-will play a leading role in the future. Of special interest here is the development of non-broadcast, high-definition applications. Another expanding area is graphical information systems, with the focus on spatial and geographic information systems.

Through the transfer of knowledge from research to practical applications the IGD contributes to the technological furtherance of European trade and industry. The IGD is involved in other CEC projects (e.g., DELTA, COMETT, ERASMUS, CTS2, RACE, ESPRIT), as project coordinator in some, and has produced significant results in these projects.

Short resume of the key persons

Dr.-Ing. Volker Luckas studied Computer Science and Mathematics with focus on optimization algorithms at the University of Technology in Darmstadt, Germany, where he received his MS (Dipl.-Inform.) in 1995. From 1995 till 2000, he has been a full-time researcher at the Fraunhofer Institute for Computer Graphics in Darmstadt. In 2000 he received his Ph.D. from the University of Technology in Darmstadt for his research about the element based, efficient and rapid creation of 3D visualizations and 3D animations. Since 2000, he is the head of the department "Animation and Image communication" (A3) at the Fraunhofer Institute for Computer Graphics in Darmstadt, Germany. Volker Luckas is also a professional member of the ACM and the ACM SIGGRAPH.
Dipl.-Inform.(FH) Ingo Soetebier studied Computer Science at Technical University of Applied Science Darmstadt with the focus on Computer Graphics and System Programming. He received his degree in Computer Science in 1998. Since 1996 he is working as a research assistant at the Fraunhofer Institute of Computer Graphics. In 1998 he also wrote his diploma thesis there and became a staff researcher in 1999 at the department for Animation and Image Communication. He was involved in the CASUS Project (Computer Animation of Simulation Traces) and in the MMDB Project (Multimedia Database) in the area of object-oriented databases.

PARTICIPANT NUMBER 5:

MINUSPLUS ARCHITECTS

Short description of the organization

Minusplus Architects is a modern Hungarian architect office formed by young architects, formerly students of Tamas Karacsony at BME – Budapest University of Technology and Economics. They had worked in collaboration with Karacsony Studio winning a competition in Csorna, HUNGARY /2001. After receiving M.Sc. in Architecture and Urbanism, at BME in 2002 they worked together with local and foreign offices in architectural and landscape urbanism competitions. They are currently working as an independent office, but during this project they will work together with Karacsony Studio in design, applied 3D graphics and modelling. Karacsony will act as a subcontractor to Minusplus.

The **Karacsony Studio** is a major architecture office in Hungary. The leading designer, *Tamas KARACSONY*, Doctor of Liberal Arts, unit director at the Public Building Design Department of the Faculty of Architecture at the Budapest University of Technology and Economics. The university is the most prestigious architecture school in Hungary, with traditions dating back to the end of the XIXth century. Tamas Karacsony is presidentory board member of the Hungarian Architects Association, received the Ybl Miklos prize in 1993, the most prestigious award in Hungarian Architecture, Szechenyi National Grant holder for outstanding cultural activity.

Experience and expertise

The Karacsony studio has more than 20 years experience in public, industrial and housing design, urban research and design. Both Minusplus and Karacsony studio uses computer modelling technologies and simulations as a major design tool.

Short resume of the key persons

Tamas Karacsony, owner and leading architect of the Karacsony Studio, emphasises on experimental design techniques, mostly collaborating with university students and young designers. Well known in Hungarian architecture scene, has many conceptual and built projects, involved in interior and furniture design, widely published and exhibited in Hungary and abroad. He will act a project leader for the Minusplus efforts in this project.

Minusplus Architects, the studio is focusing on experimental designing methods and techniques, accenting on human presence, distortive perception of senses and their reprojection to reality. The main aim is to work through a series of representation and experimentation schemes from modelling the basic conceptual aspects through redesigning and refining the process and the solution itself, in order to have a clear and most precise idea of the outcome of the final work. This is obtained through a wide research field: physical and virtual modelling in three dimensions, sound installations, animations, and interactive tools.

PARTICIPANT NUMBER 6:

PAREGOS MEDIADESIGN AB

Short description of the organization

Paregos is a digital communication agency established 1994 with 49 employees. The company has offices in three places in Sweden: Skellefteå, Umeå and Stockholm.

The operation consists of development and implementation of interactive digital communication often in association with gaming, training concepts and marketing solutions. The company has a significant experience in project management of major projects with many participants. Paregos routines for project management, quality assurance and reviews are much appreciated by the clients. Paregos is also well known for it's high-quality design, multimedia, dramaturgy, content and interactive pedagogic solutions.

Experience and expertise

Among Paregos clients can be mentioned Nike, Vodaphone, Skandia, Djuce, Zalto, MTV – Music Television Europe, Skandinaviska Enskilda Banken, SSAB, Tibnor, Unicef, Nokia, Telia, Renault, Ericsson, Swedish Television, Norstedts, Riksteatern, UR-Utbildningsradion and The Swedish Defense Agency.

The projects which Paregos has been responsible for are known for their well-defined goals and objectives, and the technical skill with which the web solutions are based. The target groups find Paregos solutions with the interactive pedagogy interesting and exciting. Paregos is professional in creating applications to satisfy the end user whether it is a game, training concepts or a marketing solution. Among Paregos work with 3D-technology can be mentioned

Paregos is also an award-winning ICT company. Here are some examples:
Webbspelen GoldenStar 2001 (The best Swedish Web Site, http://skyscraper.paregos.com/)
Excellent Swedish design 2000 (Diploma for the website: http://skyscraper.paregos.com/)
Guldklappan 2000 (First prize in the category Best Interactive Education and Grand Prix)
Prix Italia 1999 (The best-broadcast web site of advanced technologies: Mosquito)
Promax Berlin 1999 (The best-broadcast web site in Europe: Mosquito)

Short resume of the key persons

*Niklas Forslund***,** Creative Director (CD)
Founder of Paregos. Having completed more than 200 interactive projects. Has had the following roles in the company; Programmer, Project leader, Graphic designer, Producer, Account and Project Manager, CEO and Interaction designer.

PARTICIPANT 7

BLENDER FOUNDATION

Short description of the organization

The Blender Foundation is an independent organization (a Dutch "stichting"), acting as a non-profit public benefit corporation, with the following goals:

- To organize a fund raising campaign in order to finance the one time license fee to open the sources of the 3D technology (Blender) as being in development at the company Not a Number (NaN).
- To establish services for active users and developers of Blender
- To maintain and improve the current Blender product via a public accessible source code system under the GNU GPL license
- To establish funding or revenue mechanisms that serve the foundation's goals and cover the foundation's expenses

Foundation Office

The Foundation maintains a small office, with employees and volunteers, fulfilling regular tasks regarding development management and project coordination, general operations

Results so far

- The Foundation successfully completed the fund raising campaign in October 2002.
- The launch of the sources was done at the first Blender Conference in Amsterdam, three days of activities with over 100 participants from the EU and USA.
- Blender 2.26 was launched, the first full version entirely produced and improved by the open source community

Short resume of the key person:

In 1988, **Ton Roosendaal** co-founded the Dutch animation studio NeoGeo. NeoGeo quickly became the largest 3D animation house in the Netherlands. NeoGeo did award winning productions (European Corporate Video Awards 1993 & 1995) for electronics company Philips. Within NeoGeo, Ton was responsible for both art direction and internal software development. In 1995 a rewrite of the internal toolset began and was destined to become the 3D software tool Blender.

As a spin-off of NeoGeo, Ton founded a new company called Not a Number (NaN) in 1998, to further market and develop Blender. At the core of NaN was its desire to create and distribute a compact, cross platform 3D tool for free. NaN's business model was based at providing commercial products and services around Blender.

On the wings of a successful ’99 Siggraph presentation, NaN secured financing of 4.5 million EUR. This large in flow of cash resulted in the rapid expansion of NaN to 50 employees. By the end of 2000, the amount of registered Blender users surpassed 250,000.

Due to the difficult economic climate, the new investors decided shut down all NaN operations early 2002. The shutdown also included discontinuing the development of Blender.

In July 2002 Ton managed to get the NaN shareholders to agree on a unique Blender Foundation plan to attempt to open source Blender. With an enthusiastic group of volunteers, among them several ex-NaN employees, a fund raising campaign was launched to "Free Blender." To everyone's shock and surprise the campaign reached the 100,000 EUR goal in only seven short weeks. Blender development continues to this day driven by a team of far-flung dedicated volunteers from around the world led by Blender's original creator.

B3.1. A2 Sub-contracting

Minusplus architects often work together with Karacsony studio. In this project the major part of he work will be performed by staff of Minusplus, but subcontract Tamas Karacson as an experienced project leader and with many contacts for dissemination.

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