# Dynamically Generated Virtual-Reality Content for Online-Learning Laboratory

**Prof. Dr.-Ing. Andreas Christ**
*Dekan Fachbereich Medien und Informationswesen*

Badstraße 24
77652 Offenburg
Tel.: 0781 205-130
E-Mail: christ@fh-offenburg.de

Geboren 1958
Studium der Elektrotechnik an der Universität Karlsruhe
Promotion an der Technischen Hochschule Darmstadt über die nummerische Berechnung dreidimensionaler elektrodynamischer Felder
5 Jahre tätig bei Siemens AG (u. a. Zentrale Forschung, Öffentliche Telekommunikationsnetze, Mobilfunk)
**Seit 1993** Professur an der Fachhochschule Offenburg über Nachrichten- und Mikrowellentechnik
**Seit 1997** Leiter des Studiengangs Medien und Informationswesen
**Forschungsgebiete:** Elektrodynamik und VR-Visualisierung

## IV.19 Dynamically Generated Virtual-Reality Content for Online-Learning Laboratori

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### e-Learning Environment iSign

Learning in higher education includes explaining, training and visualization of theory-oriented content. Especially within blended learning and online learning situations the content has to be augmented by diagrams, pictures, animations and if suited by sound and video sequences.

Further, using virtual reality (VR) technology for visualization adds an interactive component: the VR-world can be rotated and shifted, zoomed in and out and so on. The user can study an object more intensively than figures or diagrams. Such interaction feasibility is of great advantage for both understanding content and for success of web based learning.

The research project ‚e-Learning Environment iSign' takes this approach. iSign – internet based simulation of guided wave propagation – is an e-learning system used within our higher education study programs for electrical engineers. iSign contains both theory-oriented sections and all functionality for independent and guided online laboratory events [1].

An online integrated electromagnetic field simulation tool allows the learner to work numerically on realistic problems within the area of microwave and millimeter wave technology. The simulation tool needs problem specific input, e.g. the three dimensional model of the microwave structure to be analyzed. One of its results is the three-dimensional electromagnetic field distribution within this structure.

As the very new functionality we add the delivery of dynamically created three-dimensional electromagnetic field and structure visualization as VR-world (Fig. IV.19-1).

### Learning Scenarios

The e-learning system can be employed in different learning scenarios:

- guided online laboratory events for student teams,
- independent online laboratory work for master thesis and research projects,
- repetition in addition to face-to-face lectures.

Online laboratory events are actually our most important scenario:

- The supervisor assigns a list of problems individually to the learning teams.
- The learning team processes the given problems and determines a set of input data to be used by the integrated simulation tool. A set of interactive screens guides the learning team. Relevant input is the three-dimensional model of the structure to be investigated. The VR-output of iSign allows the learning team to control the structure just by a mouse-click.
- The learning team starts and controls all numerical simulations.

*Fig. IV.19-1: Dynamically generated virtual-reality output.*

- The electromagnetic field is one of the simulation results. Based on this iSign generates dynamically the VR-output. The learning team answers a list of given questions using the VR-world and various diagrams.

**Software-Architecture**

A web interface host, a simulation host and the client share in the application (Fig. IV.19-2). A MySQL database (version 3.23.49), Java-Applets, JavaServerPages and JavaBeans produce the interactive client surface. Apache-server-software (version 1.3.27), TomCat (version 3.3.1) and a Java application (so-called Tunnel Server) is to be found on the web interface host (freeBSD, version 4.6) for network communication. On the simulation host (HPUX 11) mainly the numerical simulation tool, a Java server (so-called Simulation Server) for internal communication and the VR-module VRMLObject for creating VRML 2.0 output are running. We developed and implemented almost all functionality using Java technology (Sun JDK 1.4.0) [1]. Most relevant modules for VR delivery are the Simulation Server and the Simulation Tool combined with a Java Applet for interactive user input.

iSign includes interactive screens for data input, simulation control and result presentation. The user is asked whether to store simulation output for generating VR-worlds. The simulation output contains all relevant electromagnetic field values in a proprietary format. Because of the amount of data – 10 MB up to several 100 MB for each simulation – it is stored only on request of the user within the simulation host file system. Other simulation associated data is stored in the database.

After simulation completion iSign offers the learner the Java-Applet VRMLApplet. It builds up a socket connection to the VRMLObject module via Tunnel Server and Simulation Server (Fig. IV.19-3). The simulation server starts a Server-Thread which holds the communication to the client and via a pipe to VRMLObject. A set of commands has been defined for internal communications. Using VRMLApplet the learner can specify and modify the VR-world, e.g. region of interest of electromagnetic field presentation, type of field,

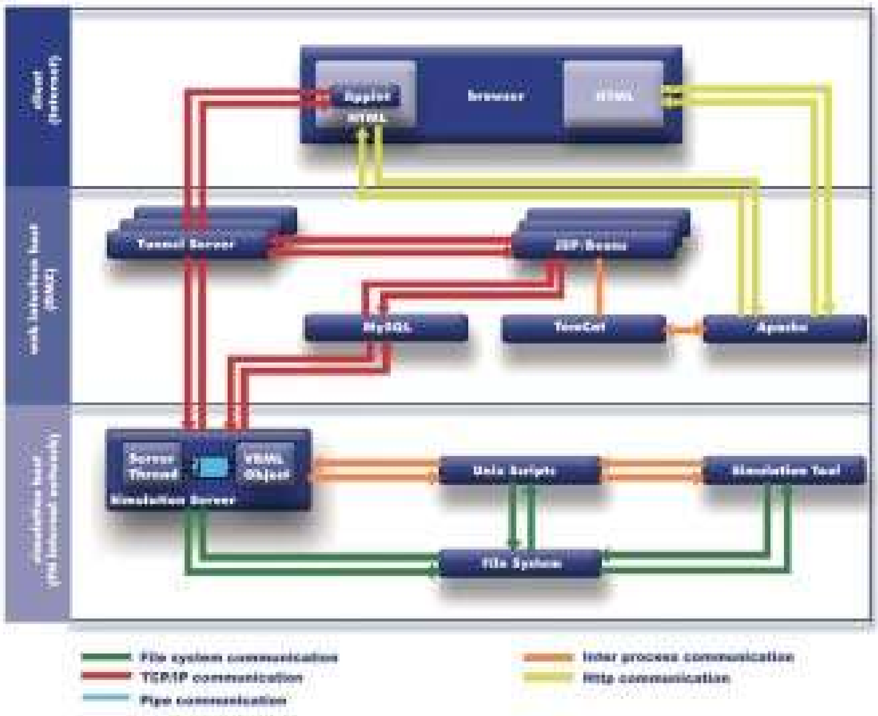


*Fig. IV.19-2: SW-Architecture and communications paths within iSign for VR-world delivery.*

colors, VR-world output file name, etc. VRMLApplet delivers all data to VRML Object.

VRMLObject runs on the simulation host. It does all numerical calculations to generate the requested VR-world [2]. Because of computing time consumption we created an interleaving co-working of VRML Applet and VRMLOject to reduce the overall latency. As soon as user input is available (e.g. file name of the simulation result) VRMLApplet sends this data and VRMLOject does all calculations which are possible so far (e.g. read in files, calculate geometry of associated structure).

After completion VRMLObject has generated the VR-world. It is stored as a VRML-file within the simulation host file system. As default the VRML-file is

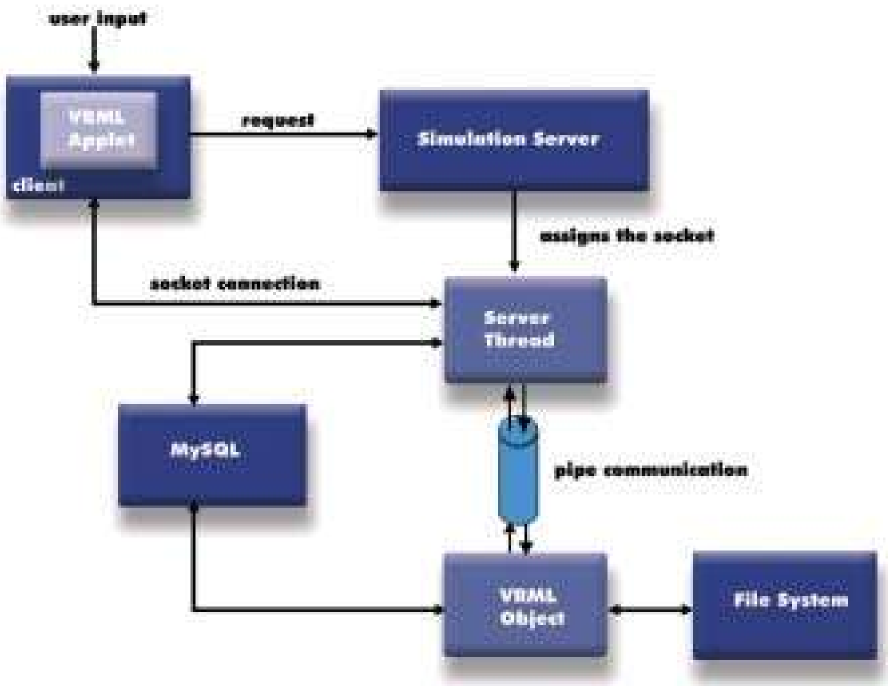


*Fig. IV.19-3: Modules involved to dynamically create VR-worlds.*

transferred to the client which opens a new window and presents the VR-world using any standard browser and public domain VR-plug-in. Parallel the VRML-file can be stored permanently both on the simulation host side and on the client computer.

Dynamically Generation of VR-Content
The described architecture makes it possible to generate VR-content dynamically. iSign delivers virtual reality content to the learner completely depending on user input and calculated simulation results. It is not computed in advance. Beside the above described client-server architecture and its communication paths heart of the VR-subsystem is the SW-module VRMLObject. It is controlled by the Server Thread using a set of method calls. The Server Thread gets its information both from the user via the mentioned VRMLApplet and by requests to the database. VRMLObject reads in relevant data also from files. It contains all the numerical logic and the VR-presentation logic – in our case also the necessary physical logic. With this knowledge VRMLObject is able to create the problem-specific VR-world in VRML-format.

Of importance is that the unified design of the user interface conceals the complexity of the application: Beside necessary user input everything else is done by a mouse-click. The e-learning environment is used within the Diploma degree and the Master-of-Science degree program at the University of Applied Sciences Offenburg. The new virtual reality module improves the distance and self-learning capabilities significantly. It has been employed since summer term 2003. The project has been partly supported by the European Union (Interreg II project Regio Demo-Centre) and by the Ministry of Science, Research and Art, Baden-Württemberg (LARS, LeistungsAnreizSysteme in der Lehre).

You can find more information at:

http://iSign.fh-offenburg.de

[1] Christ, A.: Client-Server Architecture for Active-Online-Learning Laboratory. Online Educa, Berlin 2002.
[2] Feißt, M.; Christ, A.: Virtual-Reality-Darstellung elektromagnetischer Felder in dreidimensionalen Mikrowellenstrukturen, Multiprojekt Chip-Gruppe - International Workshop, Ulm, Juli 2000.