# REMOT- A Project to Remotely Monitor and Control Scientific Experiments

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## 1 Introduction

REMOT (Remote Experiment MOnitoring and conTrol) is a project developed under the auspices of the TELEMATICS programme of the European Commission, DG XIII.

Its objective is to build and validate a generic approach to allow remote control of scientific experiments and facilities that require real-time operation and multimedia information feedback, using communications infrastructure available to European researchers.

The validation of such generic approach is being performed by representatives from the two user communities participating in the project: the Astronomical community, which has telescopes in rather difficult-to-access locations - such as islands and/or mountains - and the Plasma Physics community, that is concentrating expensive experimental facilities in a few places in order to pool resources.

## 2 The REMOT system

A generic teleoperation system is being developed, using as much as possible available off-the-shelf elements, plus ad-hoc software modules. The communications infrastructure is based on the Internet, using underlying dedicated network infrastructures where necessary, to ensure that real-time and safety constraints can be met.

Point-to-point ISDN connections are being used for testing purposes or for emergency situations; ATM is also being considered, since it can deliver the combination of flexible high bandwidth together with Quality of Service (QoS) where needed.

The implementation and integration of such a system is being developed using a client-server architecture, object-oriented methods and CORBA, which is complex, but a standardized architecture for distributed systems. When only reliable communications need to be supported, CORBA and its IP-based layer can be used directly but, since it does not consider QoS aspects, a special mechanism has been added to the architecture in which network objects will manage guaranteed bandwidth connections among local and remote sites.

Over this generic remote operation system architecture, two independent demonstrators are being developed, in order to show the feasibility of teleoperating scientific experiments in two real environments, and the suitability of the architecture itself.

## 3 Integration of astronomical facilities

Astronomers and astrophysics work is largely based on observatory facilities. But these observations are largely influenced by the atmospheric conditions, that can limit or completely spoil the observations. Due to that factor, the majority of observatory facilities are installed at places where the atmosphere is thin and clear, and the weather stable. Those conditions are best obtained at places located high (over mountains), and often isolated (on islands, for the thermal stabilization due to the sea).

For the reasons stated above, large-scale astronomical observing facilities are difficult to reach and expensive to use and maintain (a second of observing time of a modern facility is estimated to cost up to 1 US$): it is therefore mandatory to optimize both their accessibility and their scientific performance. The telescopes of the new generation are thus designed and implemented with remote control as an essential requirement, to allow remote access and a flexible scheduling of observing time. The latter is particularly important to allow scientists to be able to perform and directly control observing programs requiring specific atmospheric conditions, without having to wait at the telescope for the weather to be suitable, or to delegate the observation to local staff possibly not having enough scientific expertise.

Two optical telescopes, the Italian Galileo National Telescope (TNG) and the IAC Teide telescope, will be used as testbeds for the REMOT astronomical demonstrator. The integration of these telescopes is being performed by building an appropriate software interface between their own control software and the new generalized software described above. As the result of this activity, it shall be possible to control both telescopes from any remote institute having access to the project's software.

The logical scheme of the astronomical demonstrator is sketched in Figure 1.

On the telescope side, a Teleoperation Server will take care of the management of the system, of the users, and of needed resources; on the remote user's site, a Teleoperation Client will provide the necessary management of the user session and will control all of the presentation aspects. A CORBA-based system is being used throughout all communication elements in between the Server and the user. In the case QoS is required, a bridging mechanism has been provided.

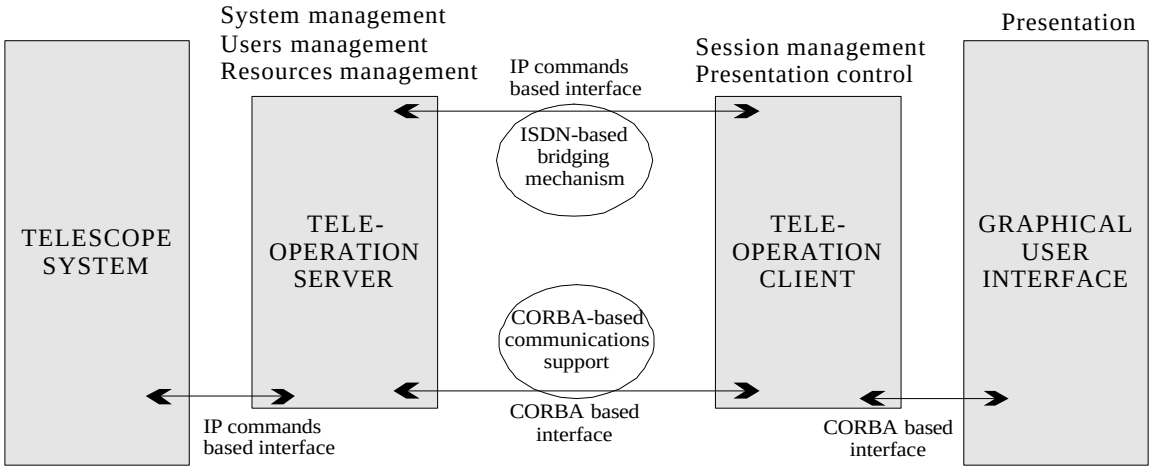


Fig. 1: Demonstrator logical scheme

**4 Integration of plasma physics facilities**

The Research Center Juelich (Forschungszentrum Juelich GmbH, FZJ) is one of 13 national research centers in the Federal Republic of Germany. The fusion experiment TEXTOR (Torus EXperiment for Technology Oriented Research), as a major device of the FZJ, participates in the national and international nuclear fusion research programme. Fusion research in general aims at the development of a new energy source with favourable properties. The activities of TEXTOR, within this programme, concentrate on the study of plasma-wall-interaction and on selected problems of fusion reactor technology.

Within the contract of the Trilateral Euregion Cluster (TEC), the three Plasma Physics institutes in Belgium (Ecole Royale Militaire/Koningklijke Militaire School), the Netherlands (FOM Instituut voor Plasmaphysica 'Rijnhuizen' - Nieuwegein) and Germany (FZJ, Institut fuer Plasmaphysik) have agreed on a coherent common research programme in the field of high temperature nuclear fusion plasma physics. The experimental work will be carried out on the TEXTOR-94 tokamak at FZ Juelich. TEC is introducing new plasma diagnostics as contributions from the partners, which asks for integration of new and existing environments. Also, there is need for remote access to experimental and data resources from the home institutes, which will affect structures and the interfacing of current systems. It is seen to be mandatory to concentrate the know-how and to join the experience of the partners into a common distributed system layout.

It is generally recognized that the ability of people to collaborate over a distance is to a large extent determined by the efficiency and 'easiness' of the tools for telecommunication, which should include audio, video and document sharing. The partner will add their own equipment to local TEXTOR systems and they want to control it from their home sites. The EU TELEMATICS REMOT project, in this respect, is expected to provide a major contribution of generic tools for a remote participation by the TEC scientific community.

Beyond the significance of the REMOT project for the TEC collaboration, it is expected to support the participation of the Forschungszentrum Juelich in the integral European fusion research programme with the Joint European Torus (JET) as its flagship. Purpose of this programme is to provide the basis for the construction of the International Thermonuclear Experimental Reactor (ITER) and to develop improvements of the concepts currently selected for ITER. Participation of scientists and instruments from Japan, USA, Canada and Switzerland is arranged through the International Energy Agency (IEA). Several European universities participate in this research programme by special projects.

Work has been carried out within the REMOT project, in which a demonstrator for the plasma physics domain is being implemented. It will be composed of remote control and monitoring of two pilot-diagnostic at TEXTOR94. Experiment data as well as configuration parameters will be stored in a distributed object database.

Videoconferencing will also be possible by using multimedia tools. Some special devices for ATM are under study for this purpose.

## 5 Future developments

The preliminary results of the REMOT project have encouraged the participants to try to expand its facilities into a flexible, full-fledged system: building such a system is the purpose of the DYNACORE (DYNAmically COnfigurable Remote Experiment monitoring and control system) project, which is currently in the final negotiation phase with the EC TELEMATICS programme, and is expected to start in early 1998.

The project results will potentially enable large savings, by allowing for shared and more effective access to expensive research facilities. Furthermore, the potential of performing remote experiments will also enable a wider participation in joint research undertakings from all regions of the European community**.**

## References


[1] A.Balestra *et al.*
Remote Control of the Galileo Telescope and the EU "REMOT" Project
"The Three Galileos Conference", Padova, Italy, 7-10 Jan. 1997, in press

[2] P.Linde *et al.*
REMOT: A design for multiple site remote observing
ADASS 97, Sonthofen, Germany, 14-17 Sept. 1997, in press

[3] G.Kemmerling *et al.*
Remote Experiment Monitoring and Control at the TEXTOR94 Experiment
Xth IEEE Real Time Conference, Beaune, France, 22-26 Sept. 1997, in press

[4] C.T.A.M. de Laat
Virtual Control Room, the REMOT Project, Networking Pilots
Xth IEEE Real Time Conference, Beaune, France, 22-26 Sept. 1997, in press