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Integrated Instrumentation & Computation Environment for GRACE

P.S. Dhekne

Bhabha Atomic Research Centre, Computer Division, Mumbai-400085,India.

Abstract. The project GRACE (Gamma Ray Astrophysics with Coordinated Experiments) aims at setting up a state of the art Gamma Ray Observatory at Mt. Abu, Rajasthan for undertaking comprehensive scientific exploration over a wide spectral window (10's keV - 100's TeV) from a single location through 4 coordinated experiments. The cumulative data collection rate of all the telescopes is expected to be about 1 GB/hr, necessitating innovations in the data management environment. As real-time data acquisition and control as well as off-line data processing, analysis and visualization environment of these systems is based on the use of multiple computer networks, it is amenable to integration with the upcoming cutting edge and affordable technologies in the fields of computers, communications and Internet. We propose to provide a single, unified environment by seamless integration of instrumentation and computations by taking advantage of the recent advancements in Web based technologies. This new environment will allow researchers better access to facilities, improve resource utilization and enhance collaborations by having identical environments for online as well as offline usage of this facility from any location. We present here a proposed implementation strategy for a platform independent web-based system that supplements automated functions with video-guided interactive and collaborative remote viewing, remote control through virtual instrumentation console, remote acquisition of telescope data, data analysis, data visualization and active imaging system.. This end-to-end web-based solution will enhance collaboration among researchers at the national and international level for undertaking scientific studies, using the telescope systems of the GRACE project.

1. Introduction

The main instruments at Gurushikar Observatory for AstrophysicaL Sciences (GOALS) being set up at Mt.Abu, Rajasthan comprise the 4-element TACTIC telescope array which has been recently commissioned and three other telescopes systems MACE, BEST and MYSTIQUE, which are at various stages of development. The control of these telescopes, acquisition of voluminous real-time data collected through their fast instrumentation channels, data processing and image analysis requires highly complex computer based control, high-speed electronics and super-computing power with specialized software tools.

The instrumentation of the TACTIC array, which has already detected gamma ray signals from galactic and extra-galactic sources during the last few years, consists of a large number of fast photomultiplier tubes, amplifiers, discriminators, trigger generators, charge digitisers, scalers, high voltage units and gain calibration systems. This NIM and CAMAC hardware is controlled by the real-time data acquisition and control system based on a multi-node LAN of P-II based PCs. The TACTIC array collects data at the rate of about 50Mbytes per hour.

The facilities of the project GRACE are distributed at Mt.Abu and Mumbai, which are at a distance of about 800 kms from each other. The researchers have to travel to Mt.Abu to conduct the source observation campaigns and collect the data. This data is then physically carried on DATs or CDs to NRL laboratory at BARC, Mumbai for further analysis and processing on high-speed computers using specialized software. Presently access to the various controls of the TACTIC array is provided via GUI based operator console located at the Observatory.

The upcoming cutting edge technologies in the filed of high speed computers, communications and Internet have opened up new possibilities and unique opportunities for the researchers. By integrating these distributed environments using low cost Internet based technology, it has now become possible to provide remote control and access to expensive instruments such as telescopes and analyze voluminous online data, acquired during experiments, on remotely located supercomputers. Thus the researchers will have much better control over data collection and analysis, while not being under any stress of a limited visit to the actual observatory site. A significant additional benefit of remote operation is that the technology can support a collaborative environment where the researchers can directly interact during the process of data collection and analysis.

2. System Architecture

We decided to make extensive use of web technology components for our development work, since it supports distributed environment, multi-platform compatibility, and better scalability with no need for specialized training for the user. Similar work has also been carried out earlier at Computer Division, BARC to remotely monitor and control the computer center's environmental parameters (Indulkar et.al 1999) This system uses web-based control to view remotely located computer sites and to control various environmental parameters of computer halls such as camera movement, temperature, humidity, etc. Brief description of the various software tools used for implementing this project such as Java, CGI, Java Script, and RTP protocol etc. is given elsewhere (Dhekne et al. 2001).

We describe here implementation of a platform independent web based system written in Java with video-guided interactive remote control of the TACTIC telescope array. The GOALS observatory at Mt. Abu and NRL Laboratory at BARC, Mumbai have been interconnected by a 64 kbps ERNET shared satellite link for providing limited level of communication facilities and another 64 kbps dedicated ANUNET link will be available soon. As part of the integration scheme we aim to control the 4-element TACTIC telescope array located at Mt.Abu observatory from NRL laboratory at Mumbai using

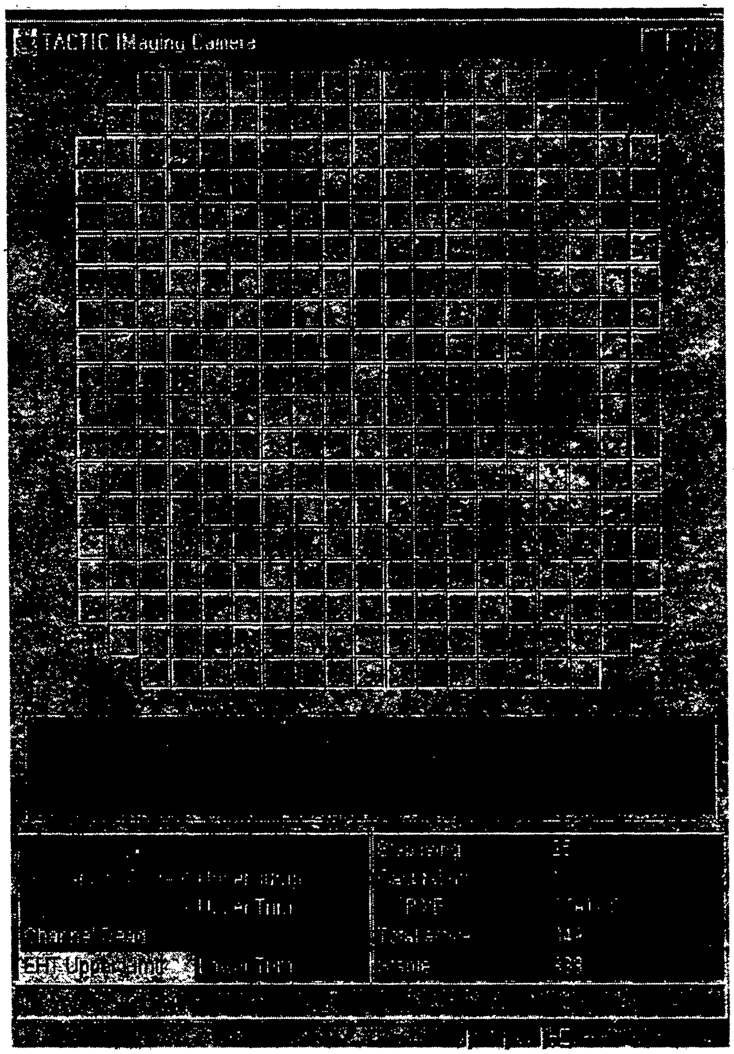

Figure 1. Layout of the virtual console of the TACTIC Imaging telescope which will be displayed simultaneously at both the remote control station and at the observatory.

the above mentioned communication links. For the purpose of remote operations a virtual console having similar look and functions as that of a local control console will be provided to the user. The layout of virtual console is shown in Fig 1.

This would facilitate the remotely located user to see the same console and controls as are seen on the local console and then be able to execute the commands via network from the remote location. The data/commands entered by the user on the virtual console will be passed to the remote site instantaneously. We have taken adequate care in our design to see that very small volume of data is needed to be transferred to the remote location thus making use of available network bandwidth very effectively. User will be able to view the changed position of the telescope on his/her virtual console by observing remotely captured pictures of telescope subsystems. The live pictures of telescope captured and stored from CCD-Cameras mounted at suitable locations, will be transmitted to the remote site for displaying them on the virtual console. Similarly data collected during the observation campaign can be directly accessed by specially designed data processing software running on remotely located high-speed computers via network.

Most of the instrumentation and control tasks, which are required to be performed at the GOALS observatory, Mt. Abu are currently handled by a LAN-based system working on the QNX Operating System. The details of the connectivity between these two environments which was made using a web server are illustrated in Fig 2.

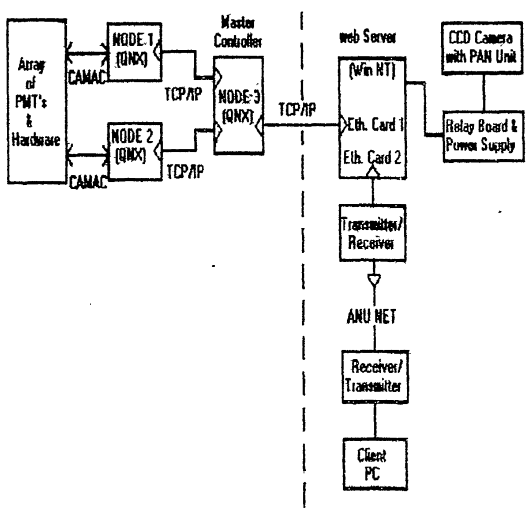

Figure2. Systematic representation of the data connectivity network for remote control.

The communication between client applet and servlet along with client side data and GUI rendering was first tested over secure local Ethernet link. Since Java is not supported over QNX, C program is used to communicate between QNX server and the web server. NT- based machine is used as a link between QNX based master controller node and clients. The system uses HTTPS protocol to communicate between client browser and server. A X.509 certification is used for server and client authentication. A client side GUI requires constant communication with the server, hence Java applets running over Java Plug-in (for HTTPS support) have been developed. Sun JDK applet API supports inter-applet communication, which is essential for this work. Java servlets offer significant advantage over C scripts. The message exchange between QNX system and NT based web server is based on XML, as it is easily extensible. The existing code running over QNX system needs to be modified to associate it with socket API and XML parser. Fig 3 gives the block diagram of the system.

The feasibility of remote operation and video-guided viewing was demonstrated to the participants of GAME-2001 international symposium held during March 8-10, 2001 by linking the Observatory and symposium sites located about 6 Km apart, using ordinary dial-up telephone line. The demonstration set up is shown in Fig 4.

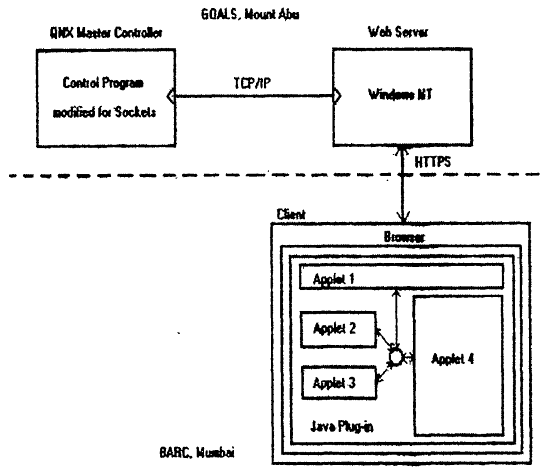

Figure3. Block diagram of the system.

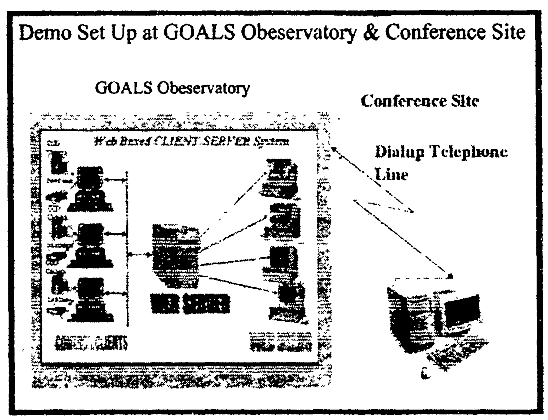

Figure4. Demostration Set-up.

We have tried to provide remote monitoring of live transmission of events and videos (Patil et al. 2000) with remote control over camera focus, zoom, movement etc. by setting up CCD and night vision cameras, looking directly at various sub-systems at GOALS. The schematic view of overall web-based integrated network setup is shown in Fig 5.

Figure5. Web based Integrated Network using ANUNET.

This project aims to provide end-to-end web-based solutions by designing and implementing software tools that would provide collaboration among scientists, students and resources at GOALS and Trombay connected over a network environment.

3. Conclusions

Web based remote control offers many advantages over conventional network approach. In conventional network approach hardware requirement is much higher and it increases with distance. In this approach, which is not scalable, addition of monitoring stations requires major set-up changes including a high degree of cabling which reduces reliability. As it is proprietary in nature it necessitates special training of man-power to handle the system. On the other hand web based systems requires lesser hardware and the addition of a monitoring station is done by simple connectivity requiring no changes in the set up. Since it deploys familiar browser enabled rich GUI interface, special training of operators is not required. The existing network resources are utilized more effectively in web-based approach requiring standard browser software at the client end leading to savings in the cost of software licensing.

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