THE TESLA TEST FACILITY AS A PROTOTYPE FOR THE GLOBAL ACCELERATOR NETWORK

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Abstract

The next generation of large accelerators facilities will be produced and operated by an international collaboration. To meet this challenge the Global Accelerator Network concept has been developed to make the best use of the world-wide competence and resources. The idea is to design, build, maintain and operate the facility by a distributed organization of many institutes located in different countries. Adequate methods and tools are needed to support the information, communication and controls tasks over the lifetime of such a project.

At the TESLA Test Facility we started the remote operation of the accelerator. The requirements, implementation and the experience together with an outlook will be discussed.

1 THE GAN IDEA

The idea of the Global accelerator Network (GAN) was developed as a way to build a linear collider as an international collaboration, to make the best use of worldwide competence, ideas and resources, to maintain and foster the centres of excellence in accelerator physics around the world, and to root the linear collider as an international project firmly inside the national programs [A. Wagner, CERN Courier July 2002, p50]. TESLA is a proposal for a linear collider for high energy physics experiments with a length of 33km.

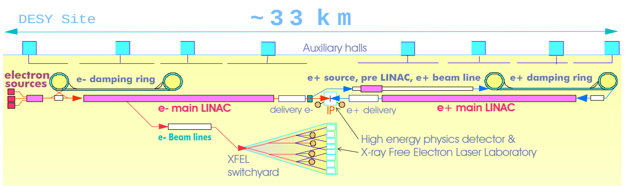

Figure 1: The TESLA layout

The machine includes an X-ray Free Electron Laser Laboratory. Since such a huge project will be build only once in the world a place far from the own home institute is likely. But, experts from other labs and countries as well as financial contributions are needed to realize the project. On the other hand the organization of the project should keep the contributing institutes active over the 20 year lifetime of the project.

Some part of the GAN paradigm is already implemented in TTF. The TESLA Test Facility (TTF) is a prototype for TESLA technology. The main purpose is to develop, test, and demonstrate super-conducting cavity technology. In addition a Free Electron Laser with a wave length of around 100 nm was successfully brought into operation at TTF. The facility is furthermore a prototype for GAN activities. This will be described in more detail.

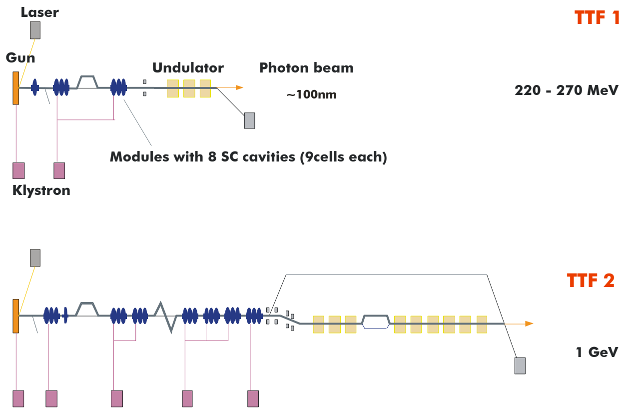

Figure 2: TTF phase 1 and 2 layout

2 REQUIREMENTS FOR REMOTE OPERATIONS

The GAN concept includes all phases of a project. Therefore, it has to enclose all the tools and technologies from the design up to the remote operation and maintenance phase. Remote operation could be envisioned from a remote control room or from the offices of some experts or even from mobile devices. To be able to control an accelerator remotely one has to consider the security and operability of the accelerator as well as control system aspects.

2.1 Network Security

Opening a machine to the internet includes the risk of unauthorized accesses. To protect TTF from this danger a firewall has been installed between the controls network and the outside of DESY. This firewall is open for the SSL and web port only and restricted to a few selected remote nodes. The programs to control the linac are executed on a server close to TTF. On the remote site an X-display is necessary. All data is tunnelled through the SSL connection.

A server at the accelerator site has the advantage that no uploads of software are needed. This ensures that local and remote users always see the same version of programs. Direct links from a remote console to all front-ends would be a problem since it requests to open and maintain a lot of ports in the firewall.

Furthermore, high levels of security in all front-end machines have to be guaranteed and all operating systems have to be upgraded regularly. For some older operating system this would be a problem.

Independent of this all servers provides checks for authorization of write accesses. This protection uses the user and group ID of the requester.

2.2 Machine Protection

A reliable machine protection is very important for remote operation. But, also operated from a local control room the same protection is necessary. The TTF linac is protected by two systems. A PLC based system is used to react in the millisecond time range for slow events. Slow sources of interlocks are vacuum valves, water systems, screens, cryogenics, magnets and temperatures. Fast response is implemented by a dedicated hardware that switches off the beam within 3 microseconds. This fast interlock is driven by toroids measuring the difference of beam currents at two locations and by photo multipliers to detect beam losses.

Both systems are realized without control system intervention. The control system can read all events and records the failures. Only authorized experts can disable input channels of the interlock system. These disabled inputs are clearly marked and visible to the operators.

2.3 Access to all Data

Different classes of access privileges have to be avoided. Therefore, all data is read accessible for all remote and local operators. Hidden values or values accessible from special users or private programs do not exist. It is also mandatory that all reset buttons can be activated by remote commands. But, so far not all devices are diagnosable to a level that allows deciding which module has to be replaced. This is of course required for a big machine. Further hardware and software developments will face this challenge.

2.4 System Integration

TTF was built by a collaboration. Different subsystems are equipped with their own controls. To provide the operators and the application and server programs with all information of the system integration was required. We used several methods to integrate subsystems. Three systems are directly incorporated in the Application Programming Interface (API): DOOCS Remote Procedure Calls [2], TINE [3] and Channel Access [4]. Other systems are added by gateways. A gateway is a server process that talks another protocol or shares the information and commands by a shared memory or a file.

The main and integrating control system for TTF is DOOCS (Distributed Object Oriented Control System). A design goal for the system was to demonstrate the advantages of object oriented technologies for accelerator controls. All parts of the system are implemented in an object oriented paradigm. Most functions are realized by C++ libraries. This gives a good level of standardization in the programming. New common features for all programs need to be inserted into the libraries only. Especially for the device servers this kind of generalization saves some remarkable effort.

Different subsystems from collaboration partners are integrated by diverse methods. The main components are implemented by a direct call inside the Application Program Interface. Further subsystems are coupled by intermediate gateway servers. These servers talk either directly the device protocol or they communicate via shared memory, shared files or mailboxes. The goal was to hide the different systems from the application programmer and operator.

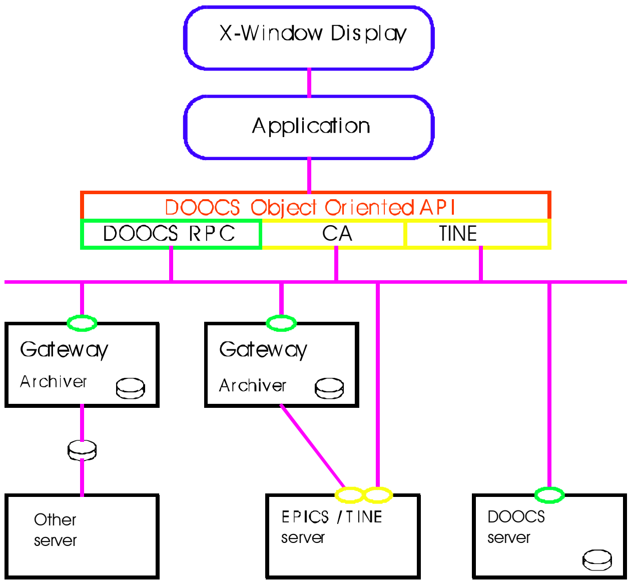

Figure 3: DOOCS architecture used to integrate subsystems

In addition the gateways add an archiving function of the values from the external systems. DOOCS has a distributed archiving. Servers do their own archiving. Adding a channel does not need any configuration on a central service. All properties implemented by device servers can by queried by client programs.

2.5 Automation

Basic automation is built in the device servers. These servers are designed in an object oriented manner. All devices of a certain class are controlled by a server process. The task of such a server is to keep the devices alive and protected. The device server is also responsible to restart the connected devices after a server crash to the last set of selected parameters.

The main part of the automation is implemented in middle layer servers. A concept of Finite State Machines (FSM) implements the automatic procedures [5]. The most complicated subsystem in TTF is the RF. It consists of several MW klystrons and a large number of Digital Signal Processors (DSP). The whole process of starting and restarting the system, including the measurements and adjustments of phases, are completely automated in FSM middle layer servers.

State machines are organized in a hierarchical way. A state may contain further states or complete state diagrams. The design of the Finite State Machines is prepared by the ddd (DOOCS Data Display) tool. The same tool is able to visualize the active states during run-time. This allows the operator and the developer to follow the transitions between the states of the FSM.

2.6 Operators

TTF is a quite complicated machine. Especially the operation of the Free Electron Laser requires good knowledge of the subsystems and physics of the accelerator. Several weeks of operation together with the experts is mandatory before an operator is allowed to participate on remote shifts.

2.7 Remote Shifts

TTF has two control rooms and can be operated from both rooms. This is some kind of remote operation. All data is on the Ethernet except the video screens and one scope. Both systems are connected to a Web video streaming service. A normal Web browser shows displays these data.

Since all online information of the control system is available on the network it is possible to control the linac from other institutes. This was actually done from INFN Milano for several shifts. During the last years a lot of remote maintenance was done also from Paris (Saclay) and INFN Frascati. And of course experts from their offices or from home can provide remote assistance. Further shifts from Cornell and SLAC are planed. The number of remote measurements and assistance between the injector test stands in Fermilab (A0) and DESY Zeuthen (PITZ) and TTF is increasing. One can conclude from this experience that remote operations are possible and helpful.

2.8 e-LogBook

A paper based logbook would not work for remote shifts. Therefore it was necessary to develop an electronic tool that can be used from all remote places. In addition an e-LogBook has several further advantages. It allows keeping more people in their offices with a close contact to the operation. The logbook informs on all problems and achievements. Meanwhile most of the machine measurements are stored in the logbook. It is a common place for information. With the help of the search functions it is easy to find data or graphics for a talk for instance.

The TTF e-LogBook uses modern Web technologies. Data is stored in flexible XML files. The pages are generated dynamically by an Apache/Tomcat web-server. A full description is provided in a further paper [6].

2.9 Video Conferencing

Video communication is needed for common shifts with a remote and local operator. To allow the remote partners to be better integrated in the activities a video conference for the shift turnover meetings is helpful. This is still missing in TTF.

For the shifts a video link with MS-Netmeeting is used so far. This has some limitations. Point to point links is possible only. And the audio quality is quite poor. Echo cancellation is absolutely required for a longer conversation. Therefore it is planned to install a VRVS system [7]. VRVS is implemented with open protocols and used in the HEP community already. With a so called reflector it distributes videos as multicasts. Furthermore it is downloadable for a lot of operating systems. For TTF it is planned to have one system at the consoles and one for the meeting area.

3 COLLABORATIVE TOOLS

Remote operations are an important part of GAN. The GAN idea requires more. The whole exchange of documents and the communication must be provided for a Global Accelerator Network. E-LogBook is one GAN activity, video conferencing is a further one. The sharing of information is just at the beginning. Manuals, machine parameters, diagrams, drawings, schedules, reports, cable lists, instructions, error messages, task lists, requirements and minutes, to name a few, have to be provided to all collaboration partners. All this is so far covered by ad-hoc methods or still missing.

In future the requirements for the information sharing have to be defined, tools have to be evaluated, more people have to be involved in the process, the tools and the way to work with them have to be learned. It will be a long way to go until this will be established in the daily work.

4 GAN ACTIVITIES

TTF is used as a GAN prototype and it is foreseen to extend these activities, although with some constrains. The operation as a user facility is scheduled for 2004 and has highest priority.

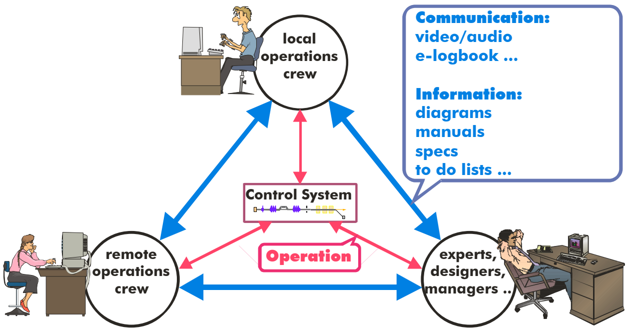

Figure 4: GAN aspects

GAN activities at TTF are possible in the following four fields. For all these items further collaborations are welcome!

4.1 The core control system

This part is quite fixed because of the tight schedule. On the other hand the control system has demonstrated to be GAN-ready. No major changes for GAN are foreseen.

4.2 Loosely coupled systems

To better understand, improve and maintain the TTF linac it is important to archive beam relevant data. The normal control system for TTF stores several thousand values per shot. One shot of the linac can contain up to 800 bunches and has a length of 2 ms. For a full analysis a parallel system, based on ROOT, was tested. It stores up to 5 GB per day for TTFphase one in addition to the normal control system archive. For the next phase of TTF a better integrated system is forseen.

This new Data AcQuisition (DAQ) system will be developed in collaboration with Cornell and the Ohio State University. The project is planned as a GAN-involved development. That means to use GAN tools in the whole process from the design phase up to the operation.

4.3 Web services at TTF

Web technologies are the basis of the TTF e-LogBook. Since the availability of the logbook for the shift is very important this service is located in the subnet of TTF. Very rapid developments in these technologies can be expected for the next years. This is a good field for further co-operation.

4.4 Other Web services

All Web services that are not needed for the operation of the linac could be located anywhere in the world. Therefore this is an ideal space for co-operation with interested partners even from outside the HEP community. And it is an exiting free space with a lot of possibilities. The question to answer is: how to provide all required information to all partners of an international collaboration? This is by far more than a simple technical question. Benefits and implications of a collaborative work must be learned.

A few examples of the types of information that has to be shared are: manuals, parameters, drawings, schedules, reports, helps, architectures, cable lists, instructions, task lists, requirements, minutes etc. Tools for this task have to be evaluated; a wider community needs to learn working with them and decide which tools are helpful for the job. At the end some of the tools should be established in the daily work.

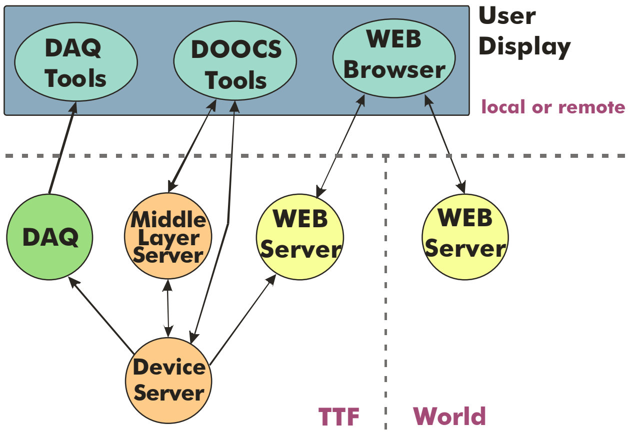

Figure 5: GAN activities at TTF

5 OUTLOOK

The GAN idea is quite new and the technologies in this field are developing very fast. One should keep in mind that the consequences of introducing GAN techniques are quite significant. It will change the culture of work. The following list shows fields that need more understanding:

- Social aspects:
  learning to work in virtual teams
- Organizational aspects:
  define and share responsibility, define interfaces and tasks in an international project, provide a win-win situation for all partners
- Collaborative work:
  define, evaluate and use tools, involve more people from all special fields
- Technologies:
  security and authorization for remote accesses, bandwidth and delay on Ethernet, Web tools to support GAN, etc.
- System aspects:
  authorization, reliability, operability, integration.

6 CONCLUSIONS

The first shifts from remote locations show that remote operations are possible. Remote maintenance is a standard procedure at TTF since several years. From our experience one can conclude that a good, state of the art control system is GAN-ready.

Concerns about the machine protection and security are covered by hardware interlocks and in addition by a firewall. Since this is also necessary for local operations it requires therefore no additional investments.

First GAN tools are in use at TTF. The e-LogBook is well introduced and will be improved step by step. For shared shifts the video tool was not sufficient and has to be upgraded soon. Video conferencing for shift turnover meetings will be installed.

To learn more about GAN tools for collaborative software developments collaboration with Cornell and Ohio State University has been formed. Further tools and understandings are required. Therefore, we like to share our developments and experience with more partners. The GAN idea is just at its beginning and will certainly develop and strengthen throughout the next years.

7 REFERENCES

[1] http://tesla.desy.de The Tesla home page

[2] http://tesla.desy.de/doocs The DOOCS home page.

[3] http://desyntwww.desy.de/tine The TINE home page

[4] http://www.aps.anl.gov/epics The EPICS home page

[5] http://tesla.desy.de/doocs/doocs_gen/fsm.html The DOOCS Finite State Machine

[6] http://tesla.desy.de/doocs/elogbook e-Logbook page

[7] http://www.vrvs.org VRVS home page