TELEMATICS APPLICATIONS

REMOT

Description of the intended plasma physics demonstrator

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Document abstract

This document presents the intended plasma physics demonstator in the REMOT Project.

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1. Description of intended plasma physics demonstrator

1.1 Location and scope of the demonstrator

The plasma physics demonstrator will have a distributed architecture preferably based on CORBA[1]. The local site will be the Institute fuer Plasma Physik (IPP), Forschungszentrum Juelich, the remote site either the University of Utrecht, respectively the FOM-institute Rijnhuizen, or, if bandwidth/connectivity is not sufficient, another institute of the Forschungszentrum Juelich (e.g. ZEL). The local site IPP is the institute that houses the instruments which remote operation will be demonstrated. These instruments are grouped physically around a fusion device, called "TEXTOR"[2]. Since in the scope of this Telematics Application project does not allow for a full implementation of the architecture, nor for the remote control of the fusion device itself, the demonstration will be limited to the remote operation of two diagnostic (instrumental) sub-systems. The components of the demonstrator are shown in Figure 3 and will be discussed in the following sections.

1.2 Intended architecture and limitations

Hardware building blocks for the architecture are the back-ends of the (electronic) equipment, constituting the data acquisition and processing systems (Figure 1) for the instrumentation around the tokamak "TEXTOR". These back-ends are workstations of different make (e.g. Digital or SUN). The workstations connected to the demonstrator devices will run Object Request Brokers(ORBs) in addition to the layout at present, as not to disturb the existing set-up.

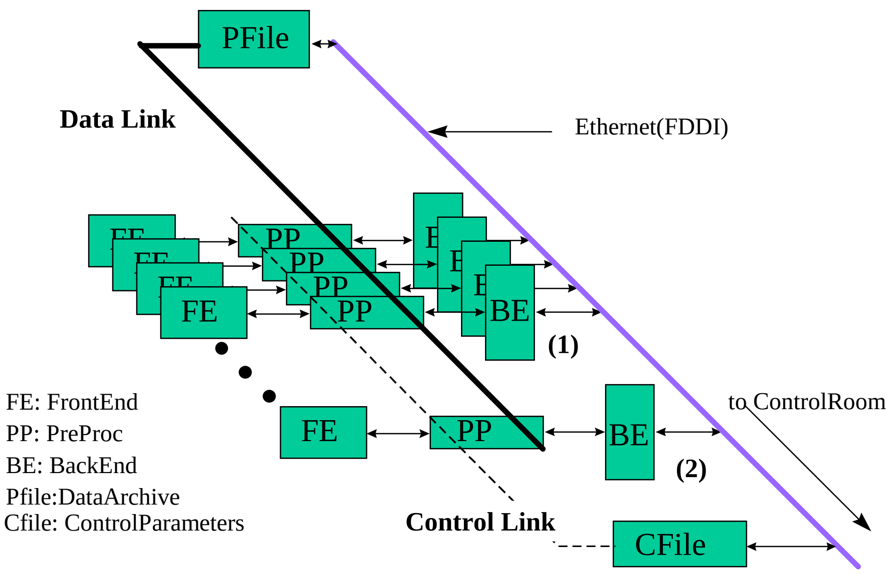

Figure 1: Global existing architecture

It is envisaged that in future the CORBA architecture will be implemented for the total system. Also then the control over the fusion device "TEXTOR" itself will be shared.

As an implementation of CORBA, Digitals ObjectBroker is indicated. This is because one of the platforms to be used in the demonstration, Open VMS, a Digital product, is not supported (widely) by other CORBA 2.0 compliant products. But alternatives will be considered in case ObjectBroker will not meet the standards[3].
The connection between local Object Request Brokers will be preferably done by using the IIOP protocol, as standardised by OMG[4]. The problem however is that commercially available ORBs that support Open VMS, do not support IIOP, so an intermediate solution is aimed at via the internal protocol of ObjectBroker or others yet to be decided. The connection between local and remote sites will be using the IIOP protocol.

1.3 The environment of the demonstrators

There will be two target demonstrators (instruments, diagnostics) at the local site:

1. The TEXTOR data logging system.
2. The pulsed-radar system

The demonstrator will show the remote control of instruments, (in the discipline of plasma physics usually know as diagnostic instruments, short “diagnostics”). The instruments are exemplary for the rest of the instrumentation around “TEXTOR” and will be described in more detail in the following paragraphs. The operation of a fusion device like “TEXTOR” has a periodic character. There exists a definite cycle (pulse) in which a part of the experiment is carried out. (see Figure 2) This cycle is called a “shot”. A total experiment contains several shots in which the physical and/or technological phenomena and parameters related to the fusion process are investigated and measured.

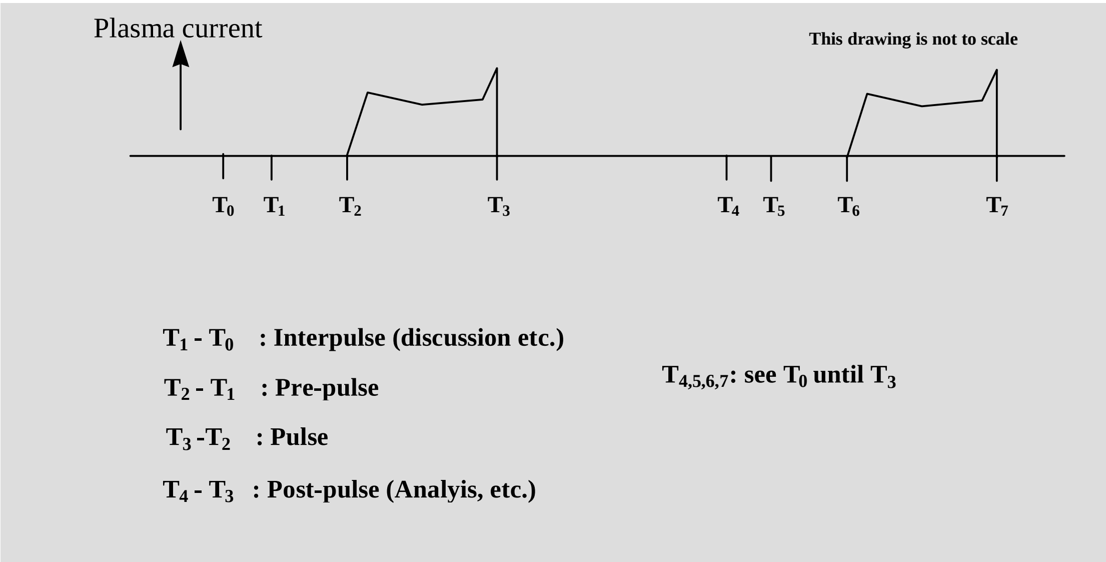

Figure 2: Pulse cycli

The demonstrators will be accessible via an DEC-ALPHA workstation (BE in Figure 1) running OpenVMS (1) and a Sun station running Solaris (2) respectively. The setup and control and the remote connectivity will be done by a separate workstation (DEC-ALPHA workstation with Digital UNIX). Other TEXTOR diagnostics and databases can also be accessed with this arrangement (OpenVMS-station), but will be outside the scope of REMOT.

1.4 The databases

The experiment data will be stored in a database together with a copy of the setup , control data and system logs. For this purpose, if applicable, it is intended to use the object database Objectivity/DB[5]. In the demonstrator a coupling between the CORBA architecture and the databases is envisaged. This will be, if possible, worked out in WP 7 and WP 9.

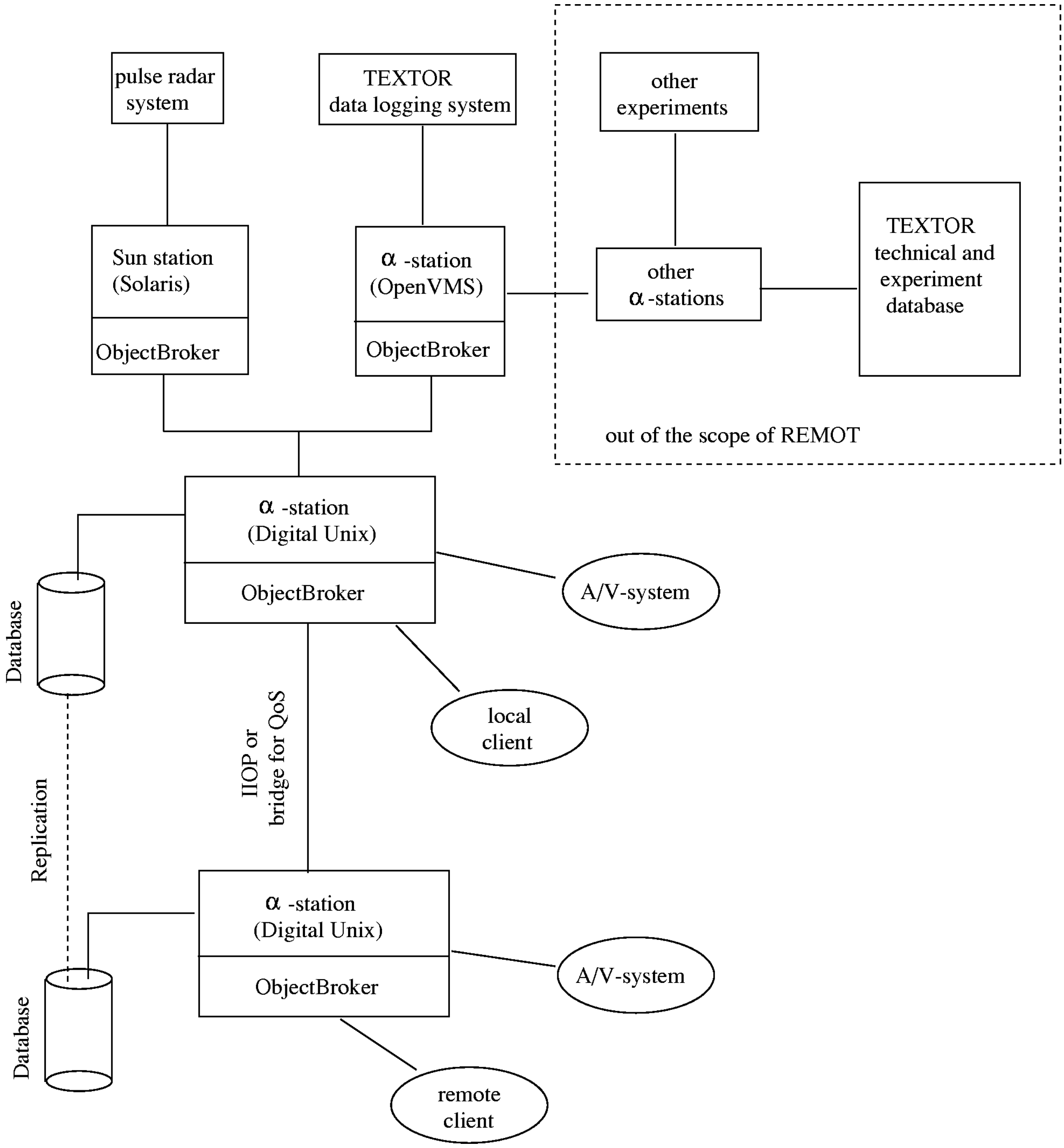

Figure 3: Components of the demonstrator

To achieve higher performance, (parts of) the data from the diagnostic sub-systems will also be stored at the remote site. During experiments, copies of parts of the local database will be made. A copy of the complete local database will be made during TEXTOR shutdown times (e.g. during the night). This can be done in two ways:

1. the replication option of Objectivity/DB (in this case the two databases belong to one *distributed* database)
2. a replication service of the system (two independent databases)

1.5 The audio/video communication

For human communications and control of fixed cameras an audio/video system will be installed which will be, as far as possible, under control of the system network manager (to be defined later). It is not yet defined which products will be used for the audio/video system, nor is it clear how the management of these products should be implemented. Elaboration on this is postponed until WP 7. Also on the remote site there will be an audio/video system to communicate with local physicists and operators. This will also be considered during WP 7.
The DEC-ALPHA workstation running Digital UNIX on the local site acts as a server for local and remote clients. On the remote site there will also be an DEC-ALPHA workstation running an ORB, which will act as a CORBA-client for the local site.

2. Global description of the demonstrators (diagnostics)

Two demonstrators are foreseen:

- a data logging system, a common set-up at the tokamak site. It consists basically of a set of transient recorders which produce as output digitized waveforms, originating from several diagnostics. These waveforms will be analysed after each experiment. They are characteristic for the operation of the tokamak
- A pulsed radar system, this systems sends radar pulses into the plasma and receives the reflected signals. The shape of the reflected pulses indicates the state of the plasma. The time between transmission and reception is a measure for the position whereof the radar pulse is reflected in the plasma.

In the next paragraphs the technical layout of the apparatus will be dealt with. Also a scenario for the remote operation of both diagnostics will be presented.

3. The TEXTOR data logging demonstrator

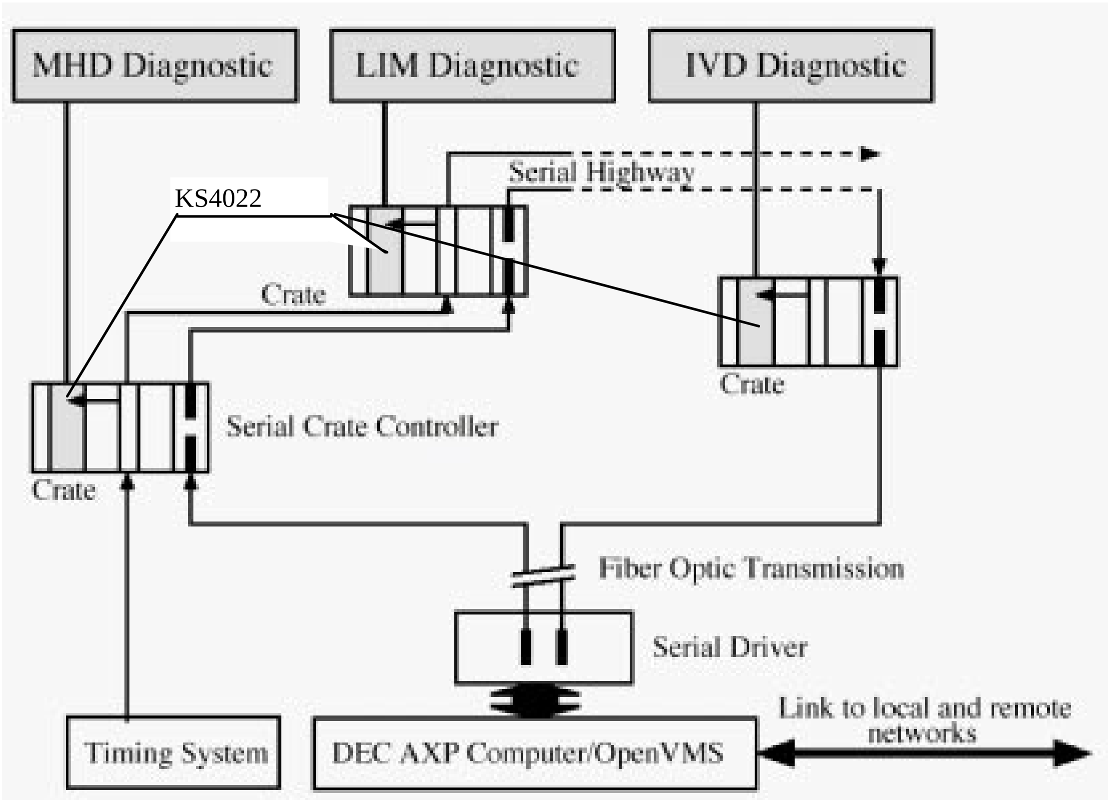

Figure 4: Data logging system

Logging of analog signals is applied to several sub-systems around "TEXTOR". In Figure 4 some of them are displayed. In the next paragraph a summing up of the systems is given, without going in details about the proper function of the instruments. A description of the (electronic) data taking and processing system also indicated in Figure 4 follows.About 1000 analog data channels provide information from TEXTOR diagnostic systems, thus forming the base of the data analysis of a specific discharge (pulse/shot).

The demonstrator, here, will comprise 3 different diagnostics which are:

- MHD Magnetic & Plasma monitoring diagnostics,
- LIM Infrared Limiter observation cameras,
- IVD Control & Engineering diagnostics,

The MHD diagnostics provide information about magneto-hydrodynamic (MHD) modes of the plasma, which can be derived from measurements of magnetic and electric fields from outside the plasma. Sensors are typically: pick-up coils in any form, i.e. sin/cos coils, directly rendering information on plasma modes which are related directly to plasma stability parameters.
The LIM diagnostics provides information on the plasma boundary, i.e. light emission in different spectral ranges is observed and measured with the aid of spectrographs. In this way data on radiation processes, and the energy balance in the vessel facing the plasma layers is obtained.

The IVD provides information on the operational state of the TEXTOR machine itself. It not only monitors the externally applied coil currents and supply voltages, but also the vacuum in the vessel and the gas filling processes.

3.1 System layout

The data logging demonstrator will comprise up to:

- 30 KineticSystems type 4020/22/24/30 dataloggers,
- 200 channels of time dependent 12 bit data,
- 40 Mbytes buffer storage

The system should be able to work with either subset of modules, reflecting the individual requirements of the changing experimental program.

As data loggers, the Kinetic Systems series 4020/22/24/30 data loggers will be used. They differ mainly with respect to bit resolution and sampling frequency ranges. As an example: the KS4022 is a one slot CAMAC module that functions as an eight-channel transient recorder. It has a 12-bit ADC, a multiplexer, eight track/hold amplifiers for simultaneous sampling, and one, two, or four megasamples of memory in an extra one slot memory module. Pre-trigger and post-trigger sample sizes and the sampling frequency is programmable. After sampling ha been started, data is taken continuously, however upon reception of a trigger pulse, the recorder continues sampling only until the end of the post-trigger period is reached and then stops. The module is then ready for readout.

The process interface will be CAMAC, run in a serial systems of2 or more crates linked through fibre optics.

3.2 Serial highway transmission:

- a unidirectional closed loop
- serial messages which are generated by the "Serial Driver" and decoded from the crate controllers,
- fiber optic transmission between computer (outside machine area) and diagnostics & crates (inside machine area) about 100 m.
- bit serial transmission at a maximum frequency of 125 MHz.

3.3 Process Interface:

The back-end computer system (BE (1) in Figure 1) will be:

DEC Alpha AXP 1000 (21164, 300 MHz)

3.4 Operating System Software:

OpenVMS Vers. 7.1

4. The pulsed-radar demonstrator

4.1 Introduction

In pulsed radar reflectometry, short microwave pulses in the order of 1 ns are launched into the plasma by means of antennas. Depending on the radar frequency (channels) and the plasma parameters, the pulse is reflected by a critical density layer and received again (also in an antenna) by the diagnostic equipment. The basic quantity that is measured by the pulsed radar diagnostic is *the flight time* of the microwave pulse between transmission and detection.

The number of independent channels is ten and two variable frequency channels are added to the system. The two variable frequency channels can be used in combination with two fixed frequency channels to perform correlation measurements and to study MHD modes in the plasma. The pulse repetition frequency is 2 MHz for the ten channels. The flight time is recorded with an accuracy of 70 ps, corresponding to a spatial resolution of 1 cm when reflected from a metal mirror. The accuracy can be further improved to 35 ps. One of the drawbacks of the pulsed radar technique is the fact that fluctuations and shallow density gradients give additional pulse broadening, which has an effect on the flight time measurement. The chosen pulse length of 1 ns is a compromise between the accuracy of the time of flight measurement and the pulse broadening. In the present system, the flight time is measured between the 50% level of the leading edge of the transmitted and received pulse. By clocking also the 50% level of the falling edge a measurement of the pulse width could be obtained. This would provide additional information on the density gradient.

4.2 System layout

The distance from the antennas to the radar set-up itself is about 10 meters. Two echo pulses will be received from each transmitted radar pulse. The first one is a start pulse travelling via a bypass and the second one is the stop pulse reflected at the critical density layer. The minimum time between the two pulses is 4 ns which is determined by the constant fraction discriminator (CFD) in the video section of the set-up (Figure 5). The longest time delay is obtained from reflections at the far wall when the density rises to near the critical density (n_c). The time delay with plasma densities near n_c is about 6 ns longer than the time delay without plasma. Calibration is performed using the time of flight system (TOF) of the reflected pulse at the far wall. The bypass consists of two 10 dB directional couplers, an attenuator and a short section of waveguide. The position of the bypass must be chosen in such a way that the start and stop pulse coincide with the 20 ns LO (oscillator)-pulse. The two (bypass and signal) pulses will start and stop a time-of-flight counter (TOF), developed at Rijnhuizen using eight parallel gated counters. The data produced by the TOF-counter is fed to a data acquisition system built in VME. The data handling, storage etc. will be described in the next section.

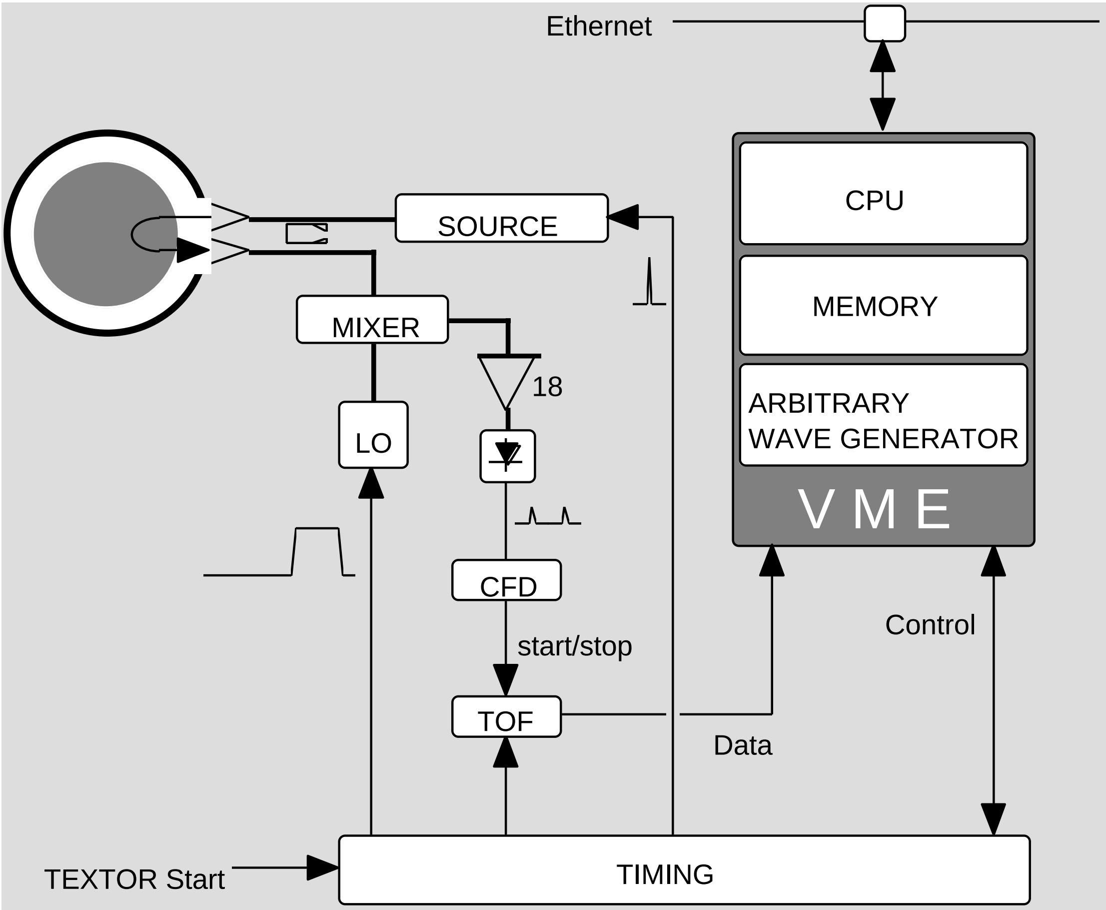

Figure 5: Timing, control and data storage

4.3 Software for control, data handling, and storage

The pulsed radar diagnostic will be regarded as a subsystem of TEXTOR. This means that the diagnostic should be synchronised with the TEXTOR control system. Four timing stages are distinguished: (see Figure 2)

- inter-pulse (diagnostic can be used),
- pre-pulse (all devices are initialised and ready to accept a pulse),
- start-pulse (radar start),
- post-pulse (the data in the memory module can be stored in a database).

There is a possibility to work stand alone for test purposes. The data acquisition of the pulsed radar diagnostic is (whenever possible) built up from commercially available components like a Solaris v2.4 operating under UNIX with a VME-bus system (Figure 6). The embedded controller[1] clocks the data via the RS485 input into a dual-port memory. A VSB VME-bus is the connection between the modules. In this way the memory-module acts as a memory extension of the UNIX system. The pulsed radar controller and the arbitrary waveform generator (for calibration and test purposes) are developed by FOM-Nieuwegein.

[1] Acces Dynamics, DC1.

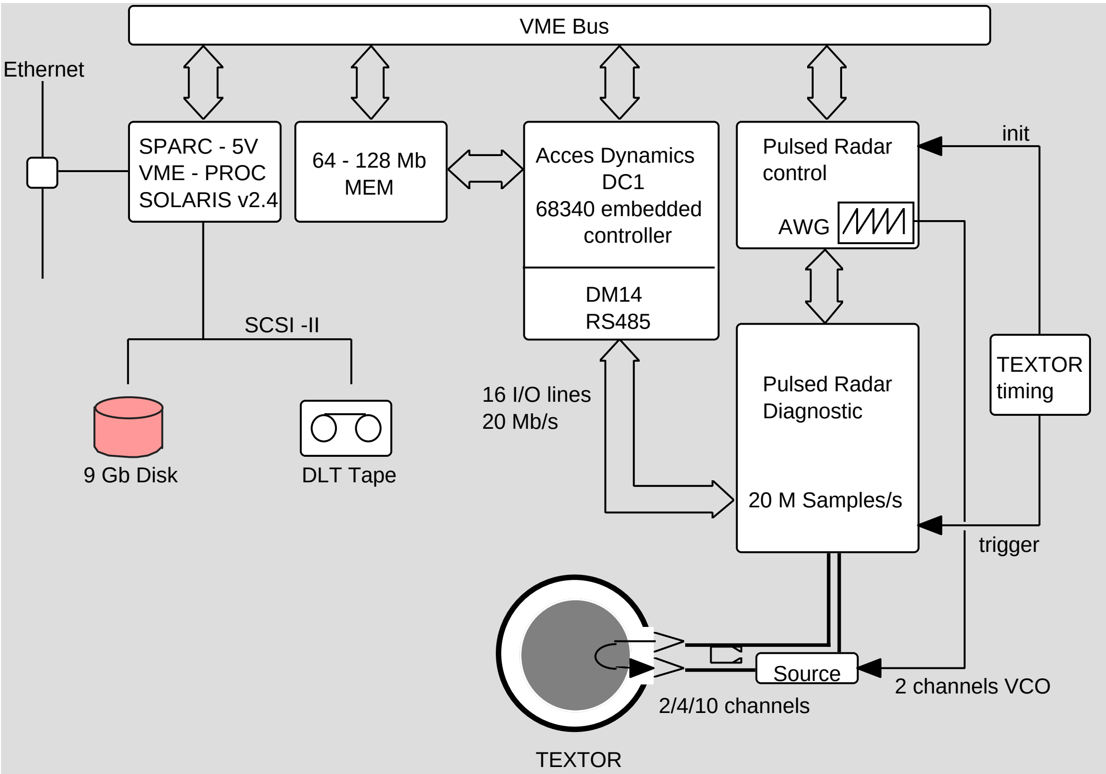

Figure 6: Control, data handling and storage systems

5. The demonstrators scenarios

The goal of this section is to give a generic description of a scenario for the Data logging and pulsed-radar part of the REMOT demonstrator (the diagnostics demonstrator). It will attempt to describe the actions taken by the physicists who operate The diagnostic systems. (see Figure 7)

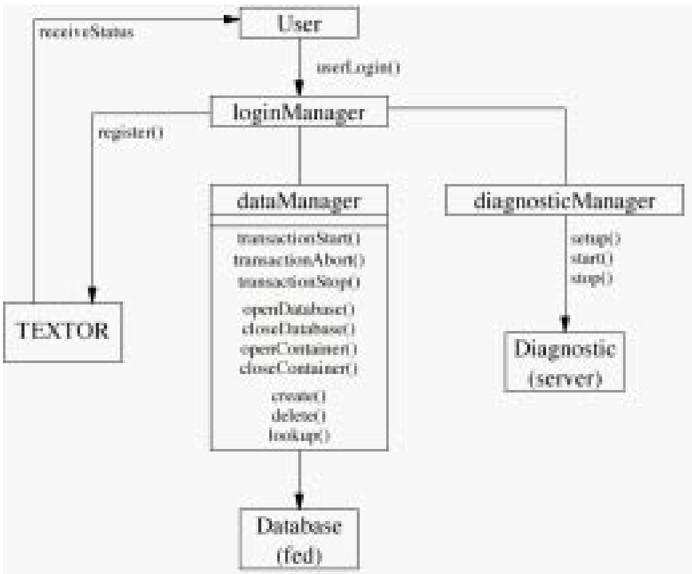

Figure 7: User login

- An application is running on a computer at the remote site which displays a login box.

- A physicist logs in by typing a login and a password. The application contacts a login manager and gets information on access rights back. The access rights determine if the physicist is allowed to act as operator of the diagnostic systems, or as a spectator. The login manager distributes access rights information to all the diagnostics in the demonstrator, so these know from whom to accept commands. The most logical place for the login manager is on the Alpha station running Digital UNIX which is placed at FZJ (former KFA) (see Figure 3). It should not reside in any of the systems controlling the diagnostics.

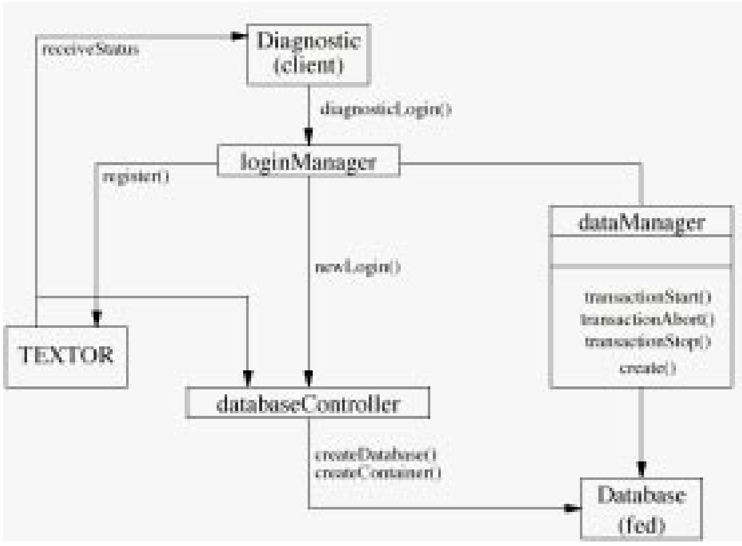

Figure 8: Diagnostic login

- The physicist, who is now acting as operator, gets a window which displays the following options (main menu):
    1. Retrieve pulsed-radar or logging data from the experiment database
    2. Plot retrieved data
    3. Set the configuration for the specific system
    4. Submit the configuration to be used by the specific system at the next shot of Textor
    5. Log out of the system

Physicists, who do not act as operator, should use only the options which allow them to examine and retrieve data from the experiment database. If they submit a configuration, it will be sent, but it is the responsibility of the diagnostic to ignore configuration commands from unauthorized users.

- The physicist selects the option to set the configuration of the diagnostic system. An approach could be the following, but alternatives more adapted to the presently used equipment are feasible: A form appears on the screen which displays a small subset of the configuration parameters for the system. The physicist makes the appropriate changes and confirms that they are correct. The content of the form is stored in memory so it can be used as a starting point the next time this option is selected. The physicist chooses the 'submit configuration' option from the main menu. This causes the application to store the configuration in the technical database. These kind of scenarios will be worked out in WP 9.
- The physicist now has to wait for the pulse cycle at TEXTOR to complete. In the mean time it is possible to access data produced in previous pulses.

- After the pulse takes place, the diagnostic system reports that it has finished, placing its data in the experiment database.
- The physicist selects the 'retrieve data' option from the main menu. This causes the application to retrieve a specific part of the data produced by the diagnostic system. This should be a relatively simple piece of information that is suitable for making an interesting graph of some kind.
- The physicist creates a graph on the screen using the 'plot data' option of the main menu.
- Based on the information presented in the graph, the physicist decides to alter one ore more of the operating parameters of the diagnostic system. He/she selects the 'set configuration' option from the main menu. This produces the form mentioned above with all the values of the previous setting filled in.
- The physicist makes the appropriate changes and submits the changes.
- This whole process is repeated until the physicist logs out.

Due to the complexity of the system the demonstrator should be kept as simple as possible without sacrificing flexibility. The demonstrator should be made in such a way that it can easily be modified and expanded. Especially in the early stages of the project updates and addition of new features will occur frequently.

The demonstrator should use a distributed security setup. One central login manager keeps track of who is logged in and what devices they control. It might be necessary to facilitate more than one operator for a single diagnostic. Some diagnostics, however, will allow only one operator to be active at a time. The login manager takes care of the administration of such access rights. It distributes information about these access rights to the diagnostics. It is up to the software controlling the diagnostics to actually *implement* the access rights. (see Figure 8)

The limited amount of time, available to construct the demonstrator, rules out the use of any existing application software that is not adapted to CORBA. A single client program should be able to perform all tasks mentioned above. Direct communication with user software that does not comply to CORBA would introduce unnecessary complications. This may seem like a limitation to the software that can be used for the system, but in fact it is not. It is possible to use a software library which implements an interface that is based on CORBA in a way that is transparent to the programmer. (He can include it in his own programs). This gives physicists the ability to gradually migrate to the use of CORBA as the basis for their software architecture.

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[1] CORBA: See for instance, CORBA, Fundamentals and Programming, Jon Siegel, John Wliey&Sons, Inc, 1996

[2] TEXTOR URL: http://www.kfa-juelich.de/research/energie.html#kernfusion

[3] Alternatives are: VisiBroker from Visigenic, and OmniOrb. These will be treated in D7.1, the document on integration

[4] OMG URL: http://www.omg.org

[5] Objectivity/DB URL: http://www.objectivity.com