SDC-92-207

SDC
SOLENOIDAL DETECTOR NOTES

ZEROTH ORDER SDC TEST BEAM ONLINE SOFTWARE

February 17, 1992

C. Timmermans, B. Ball, D. Nitz, B. Roe and S. Wilderman
University of Michigan

UM – HE – 92 – 3
February 17, 1992

Zeroth Order SDC Test Beam Online Software

C. Timmermans, B. Ball, D. Nitz, B. Roe, S. Wilderman

University of Michigan, Ann Arbor, MI 48109-1120

1. Zeroth Order SDC Test Beam Online Software

1.1 Goal

The Online system is responsible for the recording of data on permanent media. Loss or corruption of data is a failure of the online system. High level control, configuration and monitoring of DAQ, trigger, Level III and slow controls is also performed by the online system.

1.2 Modeling method

The online software will be written in the object-oriented C^{++} language. Its design follows the so-called 'Object Modeling Technique' (OMT), as described in [1]. This technique and the notations are summarized in [2].

The base of this design is a data-dictionary containing the definitions of all processes and objects necessary for the online system. Furthermore, the relations between the different elements are of importance in the design. The dictionary is presented in appendix 1, and the relationships in appendix 2.

Within OMT one describes the following aspects of a system:

- **Object Model** The object model describes the objects (classes) of a system and their static relations.
- **Dynamic Model** The dynamic model describes the dynamic relations between the objects.
- **Functional Model** The functional model describes the processes interacting with the objects.

The status of the three models is listed in the next sections.

1.3 Object Model

Within the object model we have defined the following objects:

- **Alarm**
- **Physpar**
- **Monitor Interface**
- **Storage**
- **Message**
- **Control Panel**
- **Histogram**
- **Data Base**
- **Proc List**
- **Config**
- **Monitor**
- **Event**
- **Pool**

The structure of these objects is shown in appendix 3. These structures will change while developing the software, however, these form the base for a zeroth order program.

The online software handles three 'streams' of data:

- **Event stream** Describes the relations between the objects needed for the handling of events.
- **Config stream** Describes the relations between the objects needed for downloading and controlling of configuration parameters.
- **PhysPar stream** Describes the relations between the objects needed for controlling the physical parameters of the detector.

Next to these three streams there is a fourth stream, interfacing with all streams listed above, namely the

- **Alarm stream** Describes the relations between all objects and alarms.

The static relations between the objects are presented in appendix 4, using the division in streams as presented above.

1.4 Dynamic Model

The dynamic model describes the evolution of the system, and its objects in time.

The evolution of the online system is described by its responses at different phases of operation. Appendix 5 lists the online-responses during a cold and warm startup, start of run, normal running period, end of run and complete shutdown of the online system.

The objects undergoing changes are listed in appendix 6. However, the changes influence the contents of the objects but not their state.

1.5 Functional Model

This model describes the actions of the processes running in the online system. We have identified the following processes:

- **XPC**
- **Router**
- **Operator Interface**
- **Monitor Processes**
- **User Processes**

The actions of the processes, related to the objects are shown in appendix 7 using three diagrams. The first diagram contains the event flow, the second diagram contains the flow of configuration data and the third diagram contains the flow of physical parameters.

REFERENCES

1. J. Rumbaugh *et al.*, "Object Oriented Modeling and Design", Pretice Hall, Englewood Cliffs, NJ 07632 (1991).
2. S. Wilderman *et al.*, "Zeroth Order Object Analysis for the SDC Test Beam On-Line Control", UM-HE-91-36, University of Michigan (1991).

Appendix 1: Data Dictionary

Alarms – The bells and whistles set off to notify persons of an unacceptable condition.

Alarm Condition – A state in which some portion of the detector on aspect of the data signals is out of tolerance and notification must be made, *e.g.*, to the operator or the slow controls group.

Cold Start – Restarting the detector operation after it has been stopped and turned off. This implies that all its components must be initialized from scratch.

Configuration Data – Slow control setup information, *e.g.*, a list of high voltages to which equipment will be set. Under a different verb tense, this is also known as "downloading constants".

Control Panel – A physical point within a rack of equipment from which the hardware of the experiment, or some portion of it, can be controlled.

Data Acquisition System – The conglomeration of equipment and processors which, taken together, acquire the signals from the detector and accelerator (data signals).

Data Base – A catch all description of the storage/retrieval area for all retainable quantities. This area may physically consist of many data files on many disks.

Data Buffers – Event blocks (see "Events" definition).

Data Pointers – Pointers to the event blocks (see "Events" definition).

Data Signals – A word within the objects of an event which was acquired from the detector.

Detector – The physical equipment making up the active apparatus of the experiment.

Event Pool – A pool of data buffers maintained as an output from the router for redistribution to user processes. As new data buffers become available older ones are discarded.

Events – A group of objects which, put together, describe the data read from the detector during a trigger, or the parametric values describing the condition of the detector itself (*e.g.*, high voltage). An identifier object is included in this set.

appendix 1: Data Dictionary

Formatter – Any special process which re-works events for special delivery, *e.g.*, to an offline process.

Graphic Display – A picture of the detector, or some elements of the detector, drawn on a monitor or workstation, with the event objects drawn in the picture.

Histogram – A method of displaying data. A histogram may be binned one-dimensional data within a given range, or it may be in two dimensions. Other ways of storing and displaying the data are not ruled out.

Identifier – An object describing exactly what this Event consists of.

Message – A buffer of information which is passed between processes. These processes are (great...)(grand)children of the XPC.

Monitors – Physical screens on which displays may be made.

Monitor Interface – Structure used to allocate/reclaim space on the monitors.

Monitor Processes – Processes which watch over critical variables of the detector and read-out system. These processes might be able to communicate with users.

Operator – The person at the switch.

Operator Interface– The process handling all operator commands and providing information to the operator.

Physical Parameters – Parameters describing physical aspects (*e.g.*, size, position) of the detector components.

Router – The process which receives data buffers and sends them on to their destinations. These destinations include permanent storage media, monitoring processes and event pools.

Run Control – The controlling, *e.g.*, startup/shutdown, of a data collection run.

Signals – The electrical, *etc.*, outputs of the detector elements. These are converted by the DAQ into data signals.

Storage Media – Basically, tapes. The final resting place of all events.

Tracking Data – A data signal which has attached information such as physical position of the corresponding detector element.

appendix 1: Data Dictionary

Trigger – The condition resulting when the signals from the detector indicate an occurrence wherein all the detector signals should be recorded by the data acquisition system.

Warm Start – Restarting detector operation after it has been stopped (non-disastrously) for some reason.

Watch Variable – A value which is to be analyzed by the monitor processes for an out of tolerance condition.

Workstation – A Unix computer with attached monitor running X-windows software.

XPC – Experimental Process Control; the global "shell" at the root of all running processes.

Appendix 2: Relationships

Alarm – XPC. If any process enters in an alarm condition, an alarm-message is sent to the XPC. The XPC passes this message to appropriate destinations.

DAQ System – XPC. The XPC establishes and maintains the paths to the DAQ system.

Data Base – XPC. The XPC establishes and maintains the paths to the data base.

Event Pool – XPC. The pool of available events and access paths to/from the pool are established and maintained by the XPC.

Message – XPC. At appropriate times and conditions, processes of the online system send messages to the XPC. The XPC passes some of these messages to other processes.

Monitor Interface – XPC. The Monitor Interface structure is maintained by the XPC.

Monitor Processes – XPC. The XPC starts (and controls) the operation of the Monitor Processes.

Operator Interface – XPC. Any change which the operator makes using the operator interface is reported to the XPC.

Router – XPC. The router process is started by the XPC, and receives messages concerning new "road signs" from the XPC.

Storage Media – XPC. Storage media space/usage is controlled by the XPC according to instructions issued by Operators.

Trigger – XPC. When trigger parameters change, the XPC sends messages to trigger processes. The hardware trigger will be changed between runs.

Alarm – Workstation. A notification of an alarm condition may appear on the screen of the operator's workstation.

Histogram – Workstation. Under program control, histograms may be displayed on the user's workstation.

appendix 2: Relationships

Monitor – Workstation. Space on a monitor may be allocated and used as an extension, albeit less useful, of a workstation screen.

Operator – Workstation. An operator will use a workstation as her primary interface to the online system.

Configuration Data – Alarm. Failure to successfully load configuration data, or for configuration events to properly compare to configuration data, will generate an alarm condition.

Control Panel – Alarm. An alarm may be a physical device on a control panel.

Data Base – Alarm. All alarms will be entered as an item in the data base.

Data Signal – Alarm. A monitored data signal which does not fall within a specified "normal" condition range will generate an alarm.

Histogram – Alarm. A monitored histogram which does not fall within a specified "normal" condition range will generate an alarm.

Message – Alarm. The details of an alarm are carried in a message to all appropriate destinations.

Operator – Alarm. An operator may need to take action to correct an alarm, or could generate an alarm given his intuition of the experimental condition.

Tracking Data – Alarm. Tracking Data which do not fall within a specified "normal" condition range will generate an alarm.

DAQ System – Configuration Data. Configuration Data is retrieved from the data base for active detector subsystems and transmitted to processes resident on DAQ computers for required down-loading to the hardware.

Data Base – Configuration Data. Configuration Data is stored within the online data base for all detector elements.

Detector – Configuration Data. The configuration data describe the physical parameters of the detector which are required to bring the detector into a situation in which it is ready for data taking.

Message – Configuration Data. Through information transmitted in messages, configuration data may be retrieved or modified, as required.

appendix 2: Relationships

Operator – Configuration Data. The operator may change configuration data held within the data base.

Signals – Configuration Data. The signals emitted by the detector may change as the configuration data changes, *e.g.*, a change in High Voltage will affect the signal from the concerned straw tube.

Trigger – Configuration Data. The trigger details will be a part of the configuration data stored in the data base.

DAQ System – Control Panel. Any switches, etc, resident on a control panel will be "read" by the DAQ system and the information stored as part of appropriate event buffers.

Data Base – Control Panel. The control panel configuration will be stored into the Data Base for later retrieval.

Detector – Control Panel. Physically the control panel will be considered as a part of the detector.

Operator – Control Panel. The operator may physically interact with the control panel.

Trigger – Control Panel. It may be possible to change the details of the trigger through operator interaction with the control panel.

Alarms – DAQ. The DAQ is able to send alarm-messages to online processes.

Data Base – DAQ. During startup the DAQ system reads the configuration data from the data base.

Data Signal – DAQ. A Data Signal is a word retrieved from the DAQ during event readout.

Detector – DAQ. The DAQ system reads specified data signals from the detector.

Event – DAQ. The Event is the ensemble of data signals read from the detector by the DAQ.

Message – DAQ. A message may be sent to/from the DAQ system.

Router – DAQ. Events are given to the router from the DAQ.

appendix 2: Relationships

Signals – DAQ. The raw signals are converted into digital values (data signals) by the DAQ.

Trigger – DAQ. The signals of the DAQ are used to form a trigger signal, which further directs the DAQ to acquire the event.

Histogram – Data Base. Histograms of standard quantities may be stored in the online data base.

Monitor Processes – Data Base. The monitor processes read from the data base.

Operator – Data Base. The name of the official operator shall be recorded in the online data base.

Router – Data Base. The router shall pick up its event destinations from the online data base.

Storage Media – Data Base. Lists of available/used storage media shall be maintained in the data base.

Tracking Data – Data Base. Fiducial quantities and measurements needed to convert data signals into tracking data shall be stored in the online data base.

Trigger – Data Base. The specifics of the active trigger shall be stored in the online data base.

Event Pool – Data Buffer. The event pool shall consist of multiple data buffers to be made available to requesting processes.

Identifier – Data Buffer. An object which is part of a Data Buffer, and which describes the remaining objects in the buffer.

Router – Data Buffer. The router ships data buffers to various destinations/processes within the online domain.

Storage Media – Data Buffer. Data buffers will be placed on storage media for permanent storage.

Event – Data Signal. An event consists of many data signals combined with other information into the whole.

Histogram – Data Signal. A histogram may consist of entries from the same data signal from many events, or other combinations of data signals.

appendix 2: Relationships

Identifier – Data Signal. The identifier object specifies which collection of data signals comprise this event buffer.

Signals – Data Signal. The electrical signals of the detector are converted to data signals by the DAQ.

Tracking Data – Data Signal. Data Signals are converted to tracking data through the use of information stored in the online data base.

Signals – Detector. Signals are the electrical output of the detector elements.

Trigger – Detector. The trigger is formed from combinations of the signals from the detector.

Data Pointers – Events. A data pointer points to an event stored in the event pool.

Storage Media – Events. Events are stored on storage media.

Router – Events. Events are distributed by the router.

Data Pointer – Event Pool. Data Pointers point to events stored in the event pool.

Event – Event Pool. The event pool consists of many events available for use by the processes of the online system.

Router – Event Pool. The router sends events to the event pool to be made available for online processes.

Operator Interface – Operator. The operator interface handles commands from and sends information to the operator.

Monitor – Monitor Interface. Space on display monitors is allocated/reclaimed by the monitor interface.

Monitor Processes – Monitor Interface. Monitor processes use the monitor interface to allocate space on a monitor.

Alarms – Monitor Processes. Alarms may be sent to/from monitor processes.

Configuration Data – Monitor Processes. The monitor processes may display configuration data.

Events – Monitor Processes. The monitor processes may display events.

Histograms – Monitor Processes. The monitor processes may display histograms.

appendix 2: Relationships

Messages – Monitor Processes. Messages may be sent to/from the monitor processes.

Monitor – Monitor Processes. Monitor processes use monitors to display quantities.

Tracking Data – Monitor Processes. The monitor processes may display tracking data or use it in the normal course of their operation.

Physical Parameters – Operator. The operator is able to display and change physical parameters.

Data Base – Operator Interface. The operator interface extracts information from the data base and is able to change parameters stored in the data base.

Messages – Operator Interface. The operator interface sends a message to the XPC if it changed parameters in the data base.

Alarms – Operator Interface. The operator interface displays alarms on the operator's workstation.

Workstation – Operator Interface. The operator interface runs on the operator's workstation.

Configuration Data – Operator Interface. The operator interface is able to display and change the configuration data.

Physical Parameters – Operator Interface. The operator interface is able to display and change the physical parameters.

Alarms – Trigger. When the trigger system enters in an alarm situation, a message is sent to the online system. The trigger system also receives alarm-messages from the online system.

Messages – Trigger. A message may be sent to/from the trigger system.

Alarms – Router. At alarm conditions, the router sends a message to the XPC.

Messages – Router. Messages may be sent to/from the router.

Storage Media – Router. The router sends events to storage media.

Monitor – Histogram. A Histogram may be displayed on the screen of a monitor.

Operator – Histogram. An operator has complete control over histograms. She may define, clear, erase, and perform other operations on them.

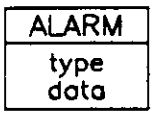
appendix 2: Relationships

Tracking Data – Histogram. Tracking data may be accumulated in a histogram.

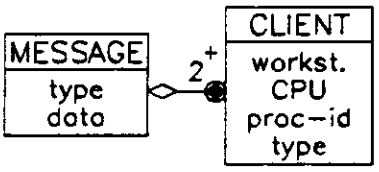
Monitor – Message. The content of a message may be displayed on a monitor, *e.g.*, an alarm indicator.

Trigger – Signal. The trigger is formed from the various signals emitted by the detector.

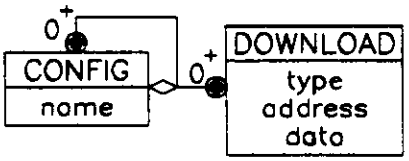
Appendix 3: Objects



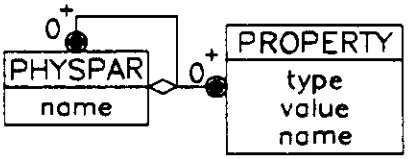
An alarm causes actions, depending on the type of alarm. The actions are defined by the process and are not part of the alarm. Furthermore, alarms are not exchanged between processes.



The client is a process sending or receiving the message. Therefore, at least two clients are required. The type of client indicates 'sender' or 'receiver'. The address allows for multiple-cpu workstations.

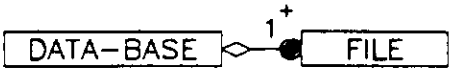


This creates a directory-like tree. In each directory a set of download parameters can be stored. These can be organized by subdetector.....



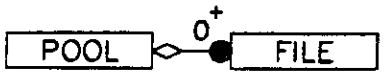
Same structure as configuration data.

Gives the type of storage, and how to reach it.

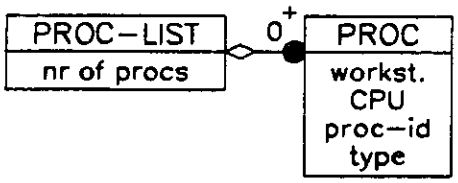


The files should contain the configuration data and the PhysPar for the complete detector for the last month or so, and summaries for the lifetime of the detector.

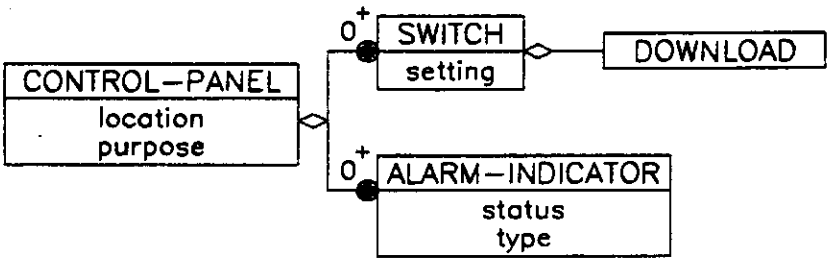
appendix 3: Objects



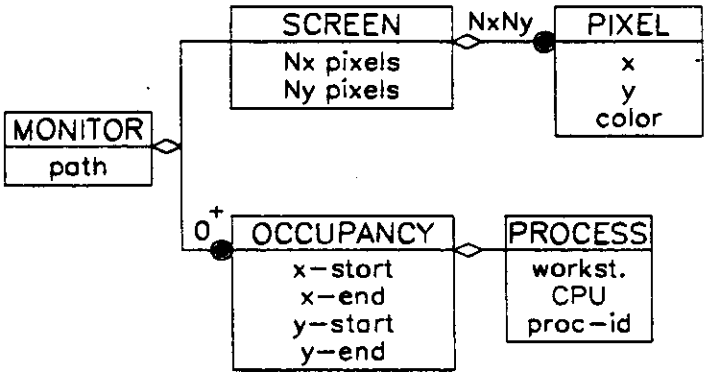
Shared memory is a better option, if possible between workstations.



The XPC (one and only one) needs a list of all processes in the ONLINE system (and of some outside this system) to communicate. The process is identified by workstation, CPU and process-id. The type specifies router/monitor process/.....

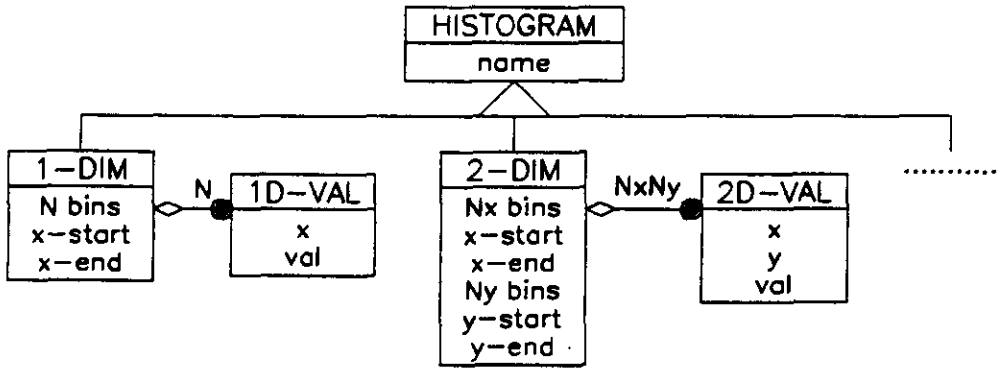


The control panel consists of switches and some lights/buzzers to indicate alarms. Each switch is connected to one download parameter from the configuration list

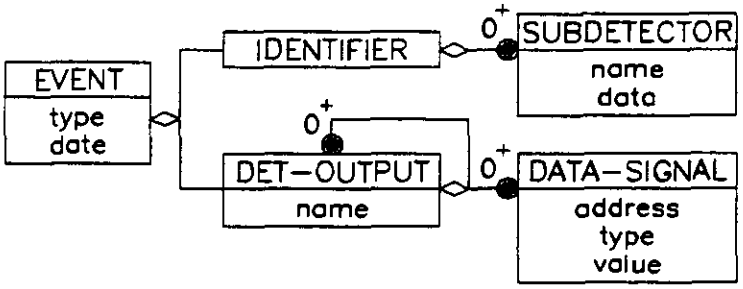


Several processes have access to a monitor, while each process may open several 'windows' on a monitor

appendix 3: Objects



Any display method of data. The examples shown are standard 1 and 2 dimensional histograms.

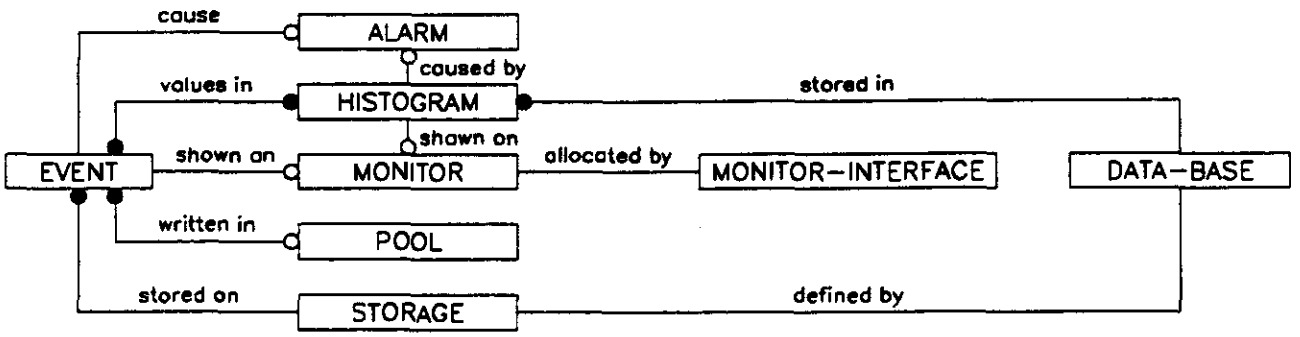


The event type might say data, calibration or....

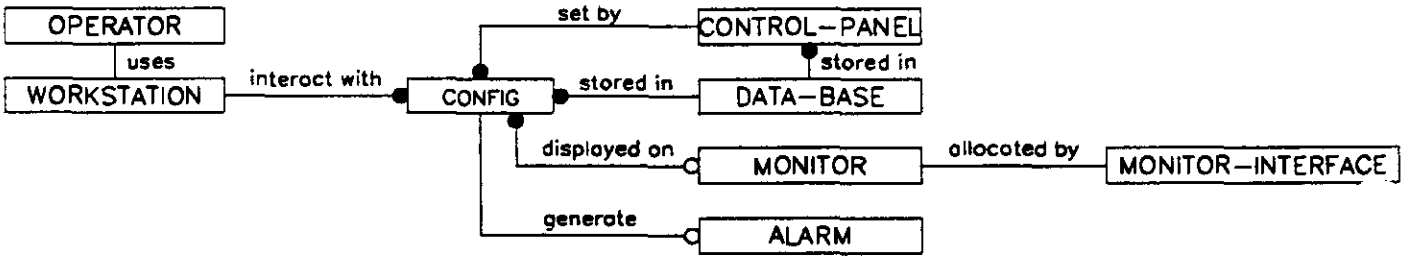
The identifier contains a list of subdetectors, each having a name. The subdetector data might tell if the subdetector is involved in this event.

The data signals are grouped in directories, using the same structure as the configuration data. Thus allowing to put output of each subdetector in a seperate directory.

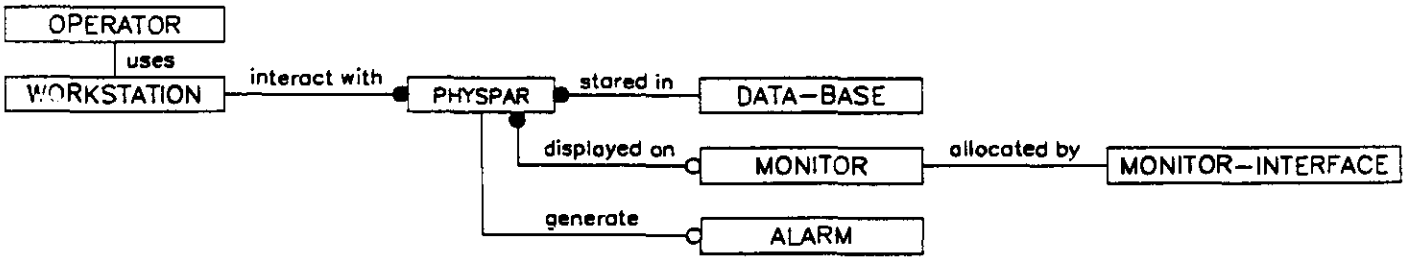
Appendix 4: Relationships between objects



The relations between objects in the 'event stream'.

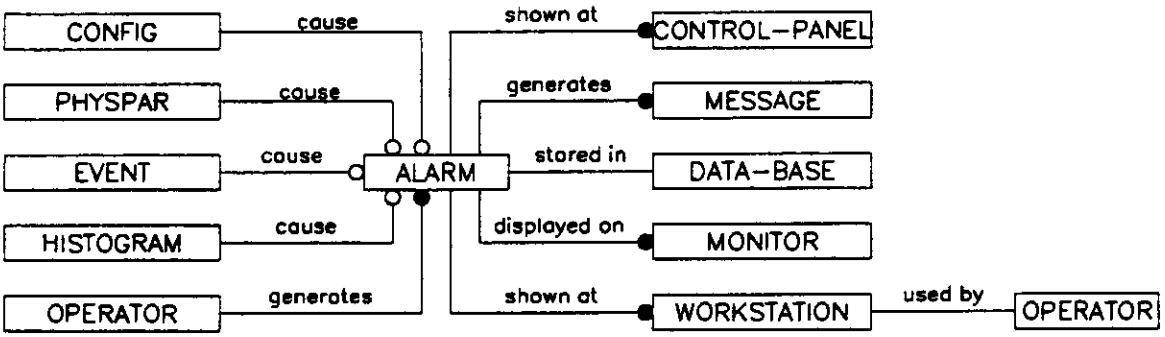


The relations between objects in the 'config stream'



The relations between objects in the 'physpar stream'

appendix 4: Relationships between objects



The relations between objects in the 'alarm stream'

Appendix 5: Online Operations

Cold Start Procedure

Note – Some of the operations mentioned below will actually proceed in parallel.

- Operator sends cold-start command to operator interface.
- Operator interface sends 'cold-start' message to XPC.
- XPC sends 'cold-start' message to Config Control, Trigger and DAQ.
- Config control reads download parameters from data base.
- Config control downloads parameters.
- Config control, Trigger and DAQ send 'ready' messages to the XPC.
- XPC starts Routers and monitor processes.
- XPC provides the router all paths to (monitoring) processes to which it has to send data.
- XPC provides router with (at least two) paths to permanent storage media.
- Router opens all paths.
- Monitor processes claim (if needed) space on monitors through the monitor interface.
- Monitor processes open path to data base.
- Monitor processes open path (pipe) to router.
- Monitor processes initialize histograms.
- Router and monitor processes send a 'ready' message to the XPC.
- After receiving all 'ready' messages the XPC sends a 'ready' message to the operator interface.
- The operator interface displays this message to the operator.

Warm Start Procedure

Note – Some of the operations mentioned below will actually proceed in parallel.

- Operator sends warm-start command to operator interface.
- Operator interface sends 'warm-start' message to XPC.
- XPC sends 'warm-start' message to Trigger and DAQ.
- Trigger and DAQ send 'ready' messages to the XPC.
- XPC sends 'warm-start' message to router and monitor processes.
- XPC provides router with (at least two) paths to permanent storage media.
- Router opens paths to permanent storage.
- Monitor processes initialize histograms.
- Router and monitor processes send a 'ready' message to the XPC.
- After receiving all 'ready' messages the XPC sends a 'ready' message to the operator interface.
- The operator interface displays this message to the operator.

Start of Run Procedure

Note – Some of the operations mentioned below will actually proceed in parallel.

- Operator sends start-of-run command to operator interface.
- Operator interface sends 'start-of-run' message to XPC.
- XPC sends 'start-of-run' message to Trigger and DAQ.
- Trigger and DAQ send 'started' messages to the XPC.
- XPC sends 'start-of-run' message to router and monitor processes.
- Router and monitor processes send a 'started' message to the XPC.

appendix 5: Online Operations

- Router waits for data.
- Monitor processes wait for data.
- After receiving all 'started' messages the XPC sends a 'started' message to the operator interface.
- The operator interface displays this message to the operator.

Normal Run

Note – Some of the operations mentioned below will actually proceed in parallel.

- Level 3 sends events to Router.
- Router sends events to storage.
- If storage is full (*e.g.*, 90%) router closes path and sends events to other storage path.
- At storage swap router sends 'new-storage' message to XPC.
- XPC sends 'full-storage' message to operator interface.
- Operator interface displays message to the operator.
- Operator changes filled storage for empty storage.
- Operator sends changed-storage to operator interface.
- Operator interface sends 'changed-storage' message to XPC.
- XPC provides router with path to the empty storage.
- Router frequently sends events to event pool.
- Router frequently sends events to monitor processes.
- Pool Cleaner deletes old events from event pool.
- Monitor processes fill histograms.
- Monitor processes display histograms.
- Monitor processes display events.
- Monitor processes watch critical variables.

appendix 5: Online Operations

- Operator interface reads config data and physical parameters from data base.
- Operator interface displays variables on the operator's workstation.
- Operator changes variables.
- The changes made by the operator are sent to the database by the operator interface.
- The operator interface sends a message to the XPC stating changes.
- The XPC notifies the monitor processes of these changes.
- The XPC notifies config control of these changes.
- Between runs the changes are downloaded.
- Alarm messages are sent to the XPC from any process.
- The XPC passes alarm messages to the operator interface, monitor processes and routers.
- The operator takes appropriate action on alarms.
- Some alarms may cause automatic trigger disabling.

End of Run

Note – Some of the operations mentioned below will actually proceed in parallel.

- The operator sends the 'end-of-run' command to the operator interface. Reasons for this might be collider-related (*e.g.*, dumping beam), detector related (*e.g.*, spontaneous malfunctioning of subdetector parts) or read-out related (*e.g.*, not receiving data, not writing to storage).
- The operator interface sends 'end-of-run' message to the XPC.
- The XPC sends 'end-of-run' message to L3 and DAQ.
- L3 and DAQ stop data-taking.
- L3 and DAQ send 'run-stop' message to XPC.
- The XPC sends 'end-of-run' message to router and monitor processes.
- Monitor processes prepare final statistics for the run.

- Router and Monitor processes send 'run-stop' message to XPC.
- after receiving all 'run-stop' messages, the XPC sends a 'run-stop' message to the operator interface.
- The operator interface displays this message to the operator.

Shutdown

Note – Some of the operations mentioned below will actually proceed in parallel.

- The operator sends the 'shutdown' command to the operator interface.
- The operator interface sends 'shutdown' message to XPC.
- The XPC sends this message to the DAQ and L3.
- The XPC sends 'shutdown' message to routers and monitor processes.
- L3/DAQ stop data taking.
- Router closes all paths.
- Monitor processes free all monitors.
- Monitor processes close all paths.
- Routers and monitor processes stop.
- XPC sends a message to the operator interface.
- Operator interface displays a message on the screen of the operator's workstation.

Appendix 6: Dynamic Relations

Config – Changes can be made outside the online system either by config control or by analysis. Inside the online system changes are made by the operator. She might do that by changing the settings on a control panel, or by using a workstation. The operator's decision may be influenced by alarms, histograms or events.

PhysPar – Changes can be made outside the online system by analysis. Inside the online system, the operator makes changes using a workstation. The operator's decision may be influenced by histograms or events.

Control Panel – Changes are made by the operator. The operator's decision may be influenced by alarms, histograms, events or analysis.

Monitor – Starting and stopping of processes displaying data causes the Monitor Interface to change the occupancy of monitors. Furthermore, a generated alarm may demand space on a monitor.

Monitor Interface – Adding or removing Monitors changes the Monitor Interface. Furthermore, any change made to a Monitor changes the Monitor Interface.

Histogram – Storing parameters from events, Config, PhysPar or any combination of these, changes a histogram.

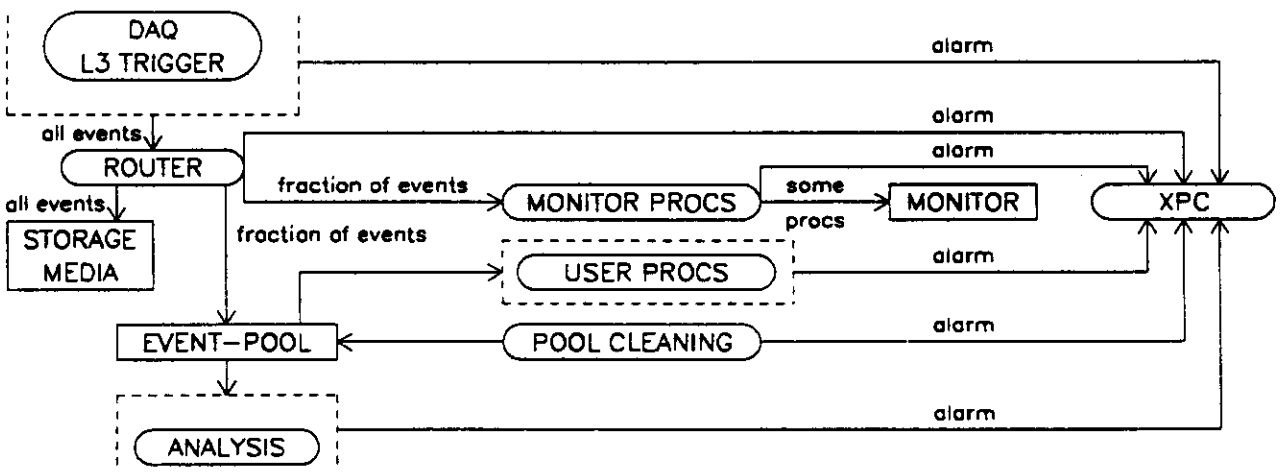
DataBase – Generating alarms, changes of Config data or PhysPar, or changing operator modifies (at least the contents of) the DataBase.

Pool – A flow of events through the online system causes a continuous update of the Event Pool.

ProcList – Starting or stopping of processes changes the ProcList.

Appendix 7: Functional Relations

The processes not belonging to the online system are surrounded by dashed lines. Processes are denoted by rounded boxes, while other elements are shown as rectangular boxes.

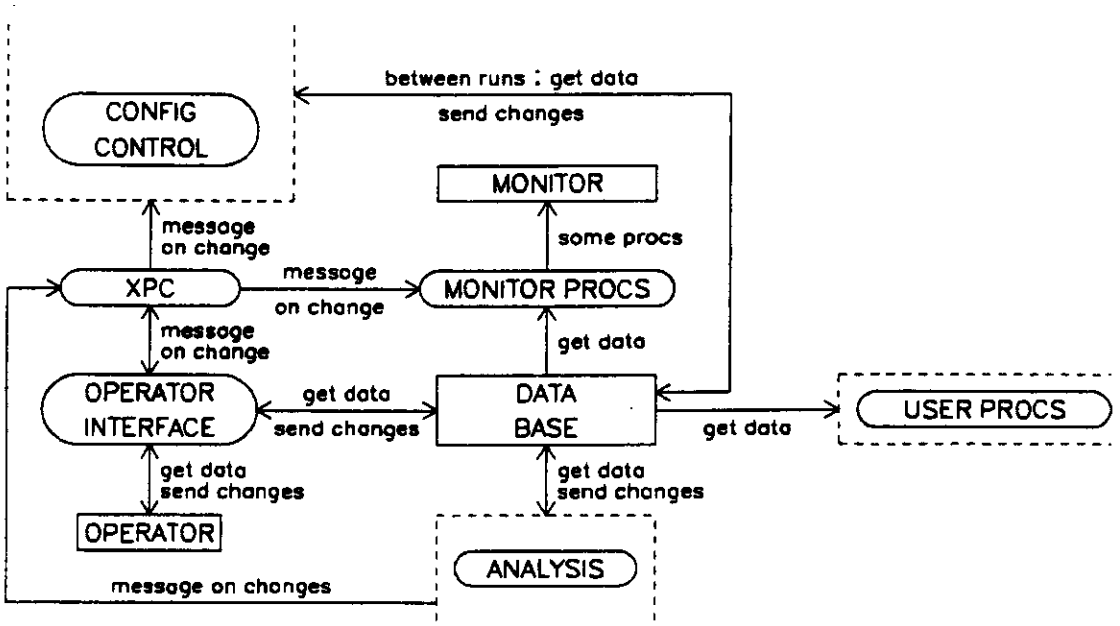


The functional relations in the 'event stream'

Each process is able to send alarm-messages to the XPC. The XPC transfers these messages to the operator and other appropriate destinations. Specifications for sending alarm-messages are to be defined for each process.

The preferred option for the event pool is shared memory. This requires that the router process (or several router processes), and user defined event selection processes run at the same workstation.

appendix 7: Functional Relations



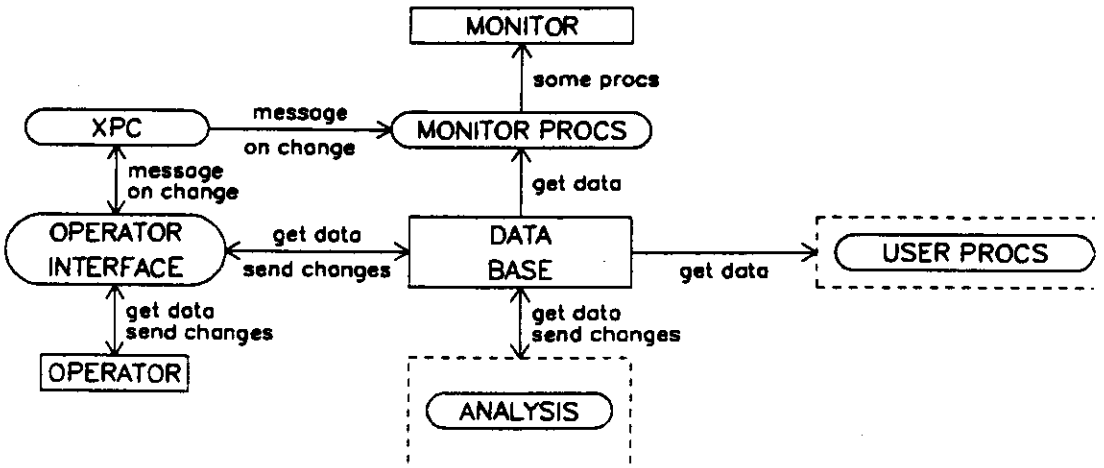
The functional relations in the 'config stream'

The configuration data can be changed at any time by the operator, config control or the analysis. These changes are stored in the data base, and a message is sent to the XPC. The XPC sends a message to the operator interface, config control and monitor processes. Between runs the config control reads the changes from the data base, and downloads these parameters. Therefore, changes become effective between runs.

As a backup monitor processes sends a message to the XPC if any configuration parameter has changed.

As a safety measure any change will be accompanied by the name of the person making the change. Only experts will be able to actually change the parameters.

appendix 7: Functional Relations



The functional relations in the 'physpar stream'

Changes can be made at any time by the operator or the analysis. These changes are stored in the data base, and a message is sent to the XPC. The XPC sends a message to the operator interface and monitor processes. The changes become effective as soon as they are stored in the data base.

As a backup monitor processes sends a message to the XPC if any physical parameter has changed.

As a safety measure any change will be accompanied by the name of the person making the change. Only experts will be able to actually change the parameters.