

CHAPTER 2 LITERATURE STUDY

2.1 Introduction

This chapter presents the literature study pertaining to the different systems that are currently used at the three chemical plants in the Sasol Solvents environment. The functionality and the typical software interfaces that are available in these systems intended to facilitate the “open platform” device integration technology will be discussed in the literature review.

The network diagram shown in figure 3 provides a graphic representation of the integrated solution to be discussed. Every network level is discussed and the method used to handle information by the different control systems and other systems on the network. The network design was redesigned to facilitate the incorporation of “open platform technology” from various equipment and control systems suppliers (Raghavendra 2007:1).

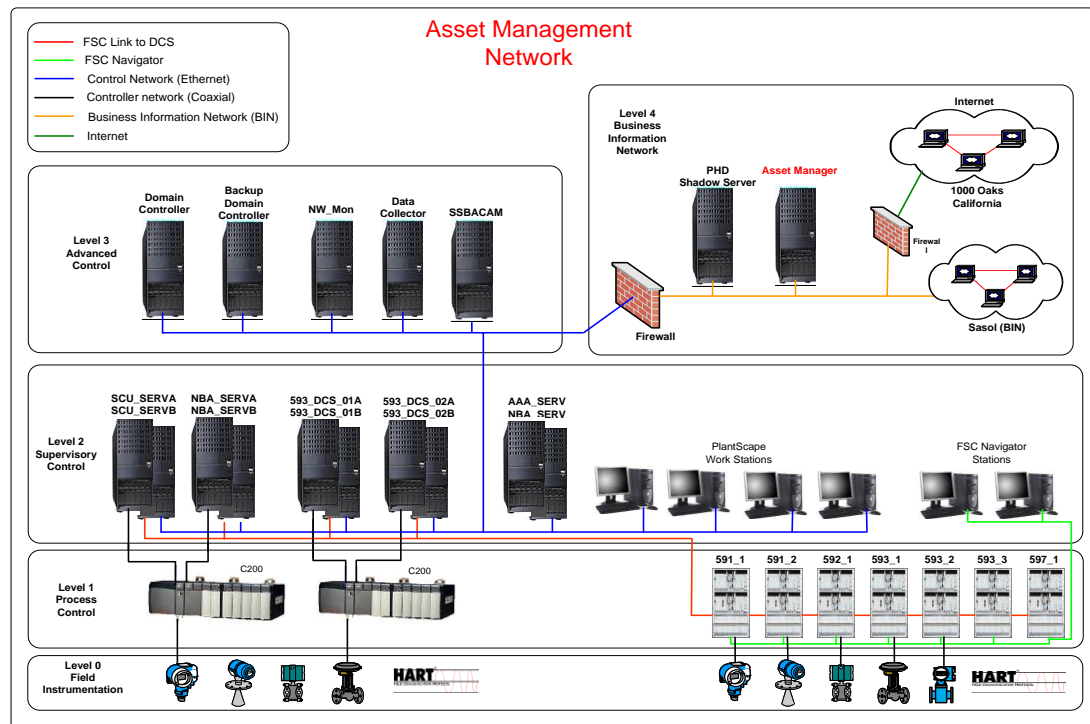


Figure 3: Asset management network layout

Figure 3, provides a detailed overview of the Asset Management Network used for the integrated solution to optimise plant performance.

2.2 Level 0 – Field Instrumentation

The field instrumentation level addresses the actual field equipment on the plant. The different instrumentation is connected by means of wiring to junction boxes where the cabling is terminated and connected back to the field terminal assemblies and interface cards situated in equipment rack in the different equipment rooms.

2.2.1 HART-enabled field devices

Level 0 depicts the field devices that are connected to the process controllers (C200) in level 1. These field devices include 4-20mA devices that are generally used to measure a particular variable on plant equipment. The variables that are measured include flow readings, pressure levels, equipment temperatures and gas flow or emissions. The smart positioner, also known as actuators form part of another type of field devices that are used to control the valves that open and close as required by the process.

According to Pratt (2004:2) a Smart Field Device is a microprocessor-based process transmitter or actuator that supports two-way communications with a host, digitizes the transducer signals, and digitally corrects its process variable values to improve system performance. Pratt (2004:2) continues to state that many field devices contain sophisticated signal processing algorithms to perform the measurements or control action required. The value of a smart field device is perceived by Pratt to be a product of the quality of the data provided by the field device.

HART-enabled field devices are one of the new technologies being implemented on plants that use the 4-20mA signal and digital communication signal simultaneously

on the same wires. Typical benefits using these smart type of device includes the following:

- digital process variables with standardised engineering unit codes and status;
- device status from field device in order to allow continuous monitoring of system integrity; and
- extensive calibration support and detailed diagnostic information.

Many manufacturers supply HART-enabled devices with Device Descriptor files (DD) that allow access to advanced diagnostic information pertaining to these devices. All HART-enabled devices are certified and managed by the HART Communication Foundation (HCF) (Helson 2005:1).

2.3 Level 1 – Process Control

The process control level depicted as level 1, is the level where the actual control takes place. The equipment in this layer is controllers or CPU's, I/O cards, special I/O cards, isolators, field terminal assemblies (FTA), multiplexer's networks used for HART devices (see 2.7.1).

2.3.1 C200 Controllers

The C200 Controllers are connected to field devices by means of Input and Output (I/O) cards. A HART-enabled field device such as a pressure transmitter is connected as an input to an analog input card; a control valve is then connected to an analog output card as an output. The input and output control is maintained by the controller according to control philosophies and certain algorithms. In addition other types of I/O cards such as digital input and output cards, Foundation Field bus cards, Profibus DP cards, serial interface cards, HART cards and special temperature cards are used with the controllers (Honeywell 2002).

In the Honeywell's PlantScape control system the C200 controller is used with the Chassis Series I/O cards meaning they are all on the same back plane with a common power supply. Information from the C200 controller is fed back to the PlantScape servers via the control-bus network. This network consists of an interface card (PCIC) located in the server that connects directly to the C200 controllers with coax cable and special network software (Honeywell 2004).

2.3.2 Fail Safe Control Systems (FSC)

Honeywell's FSC (fail safe control) systems are other types of controllers at level 1 that form part of the emergency shutdown system (ESD). This system is responsible for shutting down a plant in a predetermined manner to ensure that an abnormal situation does not develop (Honeywell 2004).

The various different field devices are also connected to the central parts (CPU's) via specialised I/O cards that are usually IS (intrinsically safe). An IS certified I/O card guarantees that the field device will not cause a spark in an explosive environment. The FSC is a redundant system with double central parts, double I/O Cards and power supplies.

The FSC is managed from a PC running FSC Navigator software that allows users to view the status of the system and the logics that are responsible for controlling the critical loops on the plant and is indicated by the green line in figure 3 (Honeywell 2005). Four plants in the Sasol Solvents site make use of seven FSC redundant systems namely 591_1, 591_2, 592_1, 593_1, 593_2, 593_3 and 597_1.

The FSC systems are all interfaced to the Distributed Control System (DCS) using serial communications or Modbus (serial bus) to enable the different type of serial signal transfer between the systems as part of the shutdown systems (depicted by the red line in figure 3).

2.4 Level 2 – Supervisory Control

The supervisory control level is the second level and represents a higher level of control on a plant. At level 2 the different software on the diverse software platforms interfaces with one another. The supervisory control level provides an interface for the diverse software of various devices on plant equipment to relate to one another. The software interface at this level manages data from the controllers and field devices and produces viewable data for operators and technical personnel to interpret and act upon (Honeywell 2004).

2.4.1 Distributed Control System (DCS)

The distributed control system (DCS) that is used on the Solvents site is manufactured by Honeywell and is called the PlantScape R500.1 (Honeywell 2003). The DCS consists of a redundancy server pair that runs the PlantScape software. The PlantScape software system consists of various applications that are used to configure and setup the control philosophies, alarm and loop management within the DCS. The Control Builder application is used to build the control logics, configure and monitor every control loop on the plant.

The control philosophy is usually built into the PlantScape control logics that control the plant. The QuickBuilder application addresses the SCADA points and provides an interface to third party hardware and software such as the FSC or any other vendor system or equipment (Honeywell 2006a).

The HMI Web Builder application is the interface that builds the operator graphics in the DCS. Information from the QuickBuilder and Control Builder are linked via software interfaces to various tags on the operator's display to produce a live representation of all plant operations and can indicate the status of a specific item of equipment or process (Honeywell 2006a).

Alarm management is embedded into the PlantScape software so that alerts and alarms can be defined, configured and prioritised for certain plant areas so that alarms can be triggered when a certain event (or probable event) occurs. The alarm management system can be interfaced to specialised alarm management software that is not discussed in this thesis. Technicians also make use of loop management that enables users to manage control loops by tuning or adjusting their parameters for optimized control.

Trends are a DCS system tool that monitors a device tag such as 593_TI_1001 which is a temperature indication monitored over a certain period of time. The trend identified by the tool is represented as a graph of the equipment item's performance over time. The output of the configured trend is very useful for personnel to monitor a process condition, a possible indication of a process upset or trip condition (Honeywell 2006b).

Different interfaces such as the OPC Alarm and Event interface are embedded into the DCS software (Honeywell 2006a). This interface is used by different OPC clients that access the DCS database for data such as tag information and relevant data associated with the specific tag for a certain period of time. This interface is typically used by the Uniformance Plant Historian Database interface that retrieves the onboard history data from the PlantScape servers to build a database of event history and performance.

System diagnostics that indicate the condition of the PlantScape server software and interfaces are also embedded in the software. Only the main features of the DCS are discussed. There are many more features that are not relevant to this discussion. Four pairs of PlantScape servers are used to control the plants on the Sasol Solvents site (Honeywell 2004).

2.4.2 Uniformance Plant Historian Database

Honeywell's Uniformance Process Historian Database (PHD) is a data historian that is designed to collect and store data for future retrieval (Honeywell 2005). Data is collected by means of real-time data interfaces (RDI) and stored in virtual tags.

Figure 4 depicts the Plant Historian Database (PHD) and indicates the links to the data buffers that collect data from the various different DCS systems. The dual data buffers are connected to two sets of DCS servers, retrieving data from the DCS onboard historian database, thereby providing redundancy. Data from the onboard historian database is saved on the buffers and thereafter forwarded to the PHD shadow server (Honeywell 2006a).

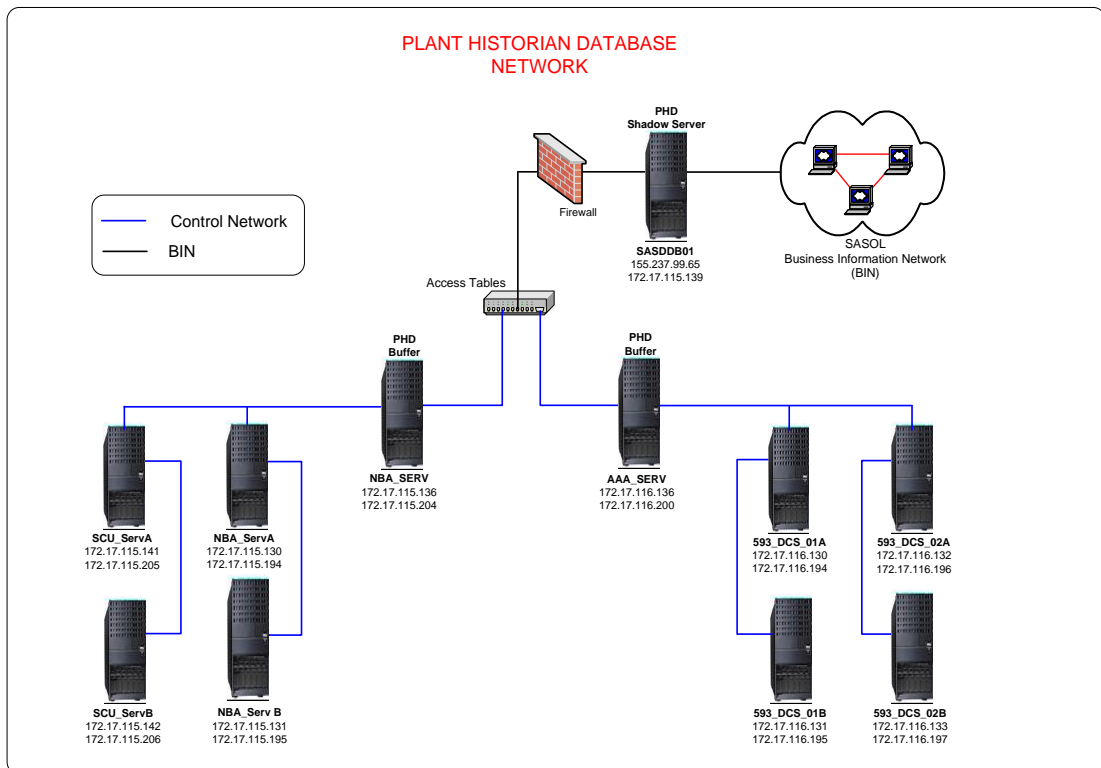


Figure 4: Plant Historian Database Network layout

The Uniformance database software runs on the shadow server where PHD clients can access the required history data. If the link between the buffers and the shadow

server breaks, the buffers will continue to collect data. Once the link is restored, the store and forward feature will immediately transfer data that is new to the shadow server.

Figure 4 above depicts the Plant Historian Database Layout. In order to be able to retrieve the historic data from the DCS, different interfaces must run on the PHD shadow server. These interfaces are called real-time data interfaces (RDI) that are configured to retrieve certain tag data (history) from the DCS in a predefined manner and format. These RDI's can also be configured to retrieve data from other data sources such as third party vendors and suppliers of software.

Performance monitoring RDI's are developed as an integral part of the asset management solution presented in this thesis. Real-time data interfaces (RDI's) allow diverse interfaces to access data from Microsoft Windows operating systems and other data sources used in the asset management software. Performance monitoring is discussed in Chapter 4.

2.4.3 PlantScape Stations

PlantScape work stations are used by operators to control plant equipment in a typical chemical or manufacturing process. PlantScape client software, including all plant graphics is installed on the PlantScape stations. The graphics allow the operators to manipulate the various screens on these graphs, build trends, and monitor process alarms.

The graphics allow personnel to react to critical alarms that may indicate possible abnormal situations within the plant. In addition, the PlantScape stations allow staff to view different sections of a plant if the appropriate graphics are built into the software of the station.

The user is able to manipulate set points, outputs on valves and typically starting and stopping of motors by activating certain points on the graphics. Additional functionality is available to the operator or user.

Workstations are connected to the PlantScape servers by means of an Ethernet network going through SISCO switches. These connections and availability of work stations are monitored by the PlantScape software on the server. The PlantScape software allows the user to determine which stations are connected and to establish which operator has logged onto a particular station.

2.5 Level 3 – Advanced Control

Advanced control is performed at the third level by means of domain controllers; shuttle servers connected to the Internet (up- and down-loading data), real-time data collectors used with loop management and alarm management systems as well as the network monitoring server.

2.5.1 Domain controller and backup domain controller

Gibson (2005:1) states that Microsoft Windows Server 2003 has the ability to be a domain controller (DC). A domain controller can store user names and passwords on a central computer and will allow “friendly” names within the local area network (LAN).

A domain controller (DC) can also provide a platform for host headers to be used within the servers IIS (Internet Information Services) configuration. In the Solvents environment, the domain controller is used to authenticate users between the four different PlantScape for Distributed Server Architecture (DSA). The alarms from one DCS can be viewed or moved by the domain controller. The Backup Domain Controller (BDC) is a backup server for the main domain controller which is also

referred to a Primary Domain Controller or PDC. The BDC is installed in order to ensure full redundancy on the control network.

2.5.2 NW_Mon Server

Link Analyst software is used on the NW_Mon Server to monitor network assets such as servers, work stations, switches and building network adapters. The NW_Mon Server software is used to detect network abnormalities, device and routing errors, log response times as well as monitor degradation severity through spot trends that may indicate an impending failure on configured network assets (Network Instruments 2006:1). The software allows for a graphic representation of various assets in a particular area or plant.

2.5.3 Real Time Data Collector (RTDC)

The real time data collector (RTDC) is a server that is used to run the LoopScout software that assists control engineers to detect problems in regulatory control loops at any location in the plant. Any proportional, integral and derivative (PID) controller can be analyzed, regardless of the hardware platform. The aforementioned is provided that data can be collected from the Set Point (SP), Process Variable (PV), and Out Put (OP) at a frequency sufficient to capture 40 to 60 samples within the closed loop settling time of the controller.

The Real Time Data Collector software collects time series data from the controller and stores the data to a text file. This text file is automatically compressed and encrypted in preparation for uploading to the LoopScout web site. The software also collects the controller configuration information for a more detailed analysis, and compresses this data to the ScoutExpress file.

The Real Time Data Collector for OPC allows data collection from any system supported by an OPC server. The OPC data collector creates a ScoutExpress file for upload to the LoopScout web site (Honeywell 2001:7). The network connections

depicted in Figure 5, overlaid indicate the loop management network layout and incorporate the RTDC and upload server.

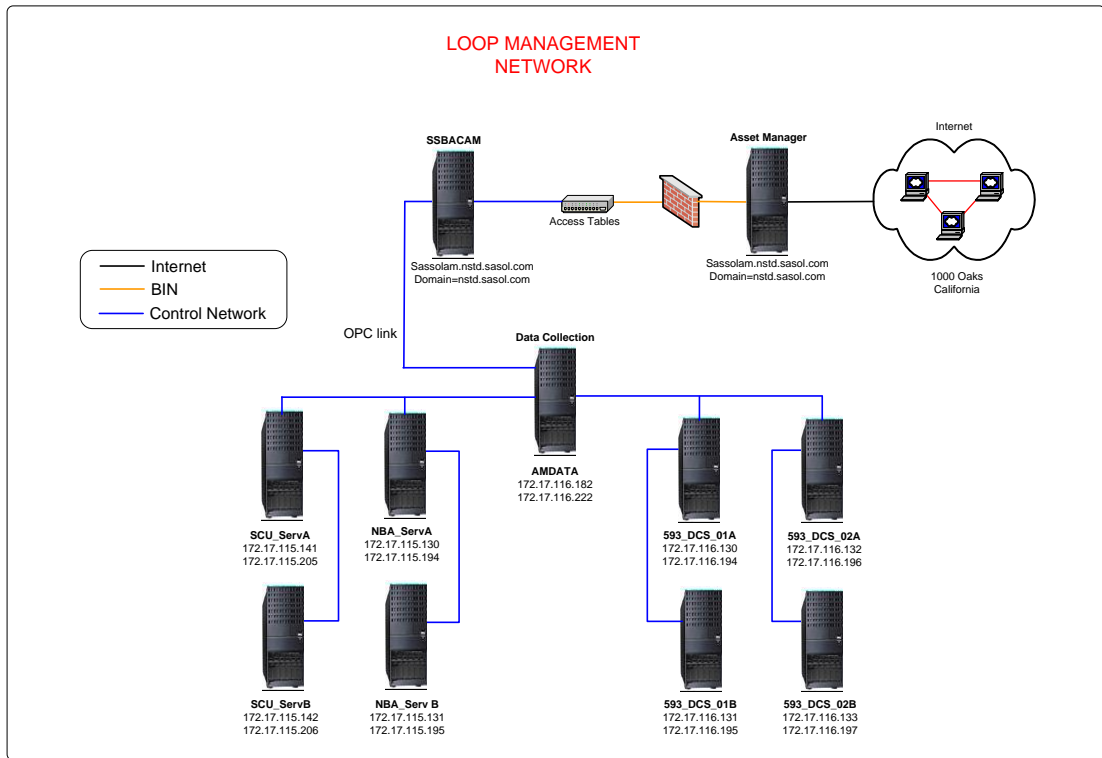


Figure 5: Loop management network layout

2.5.4 Upload Server (SSBACAM)

ScoutExpress (SE) Port is a simple application that moves files that were collected by the RTDC. SE runs as a service and requires one instance of a ScoutExpress Port running on each machine for files to be transferred from one machine to the other.

SE communication is a low level TCP/IP connection over one TCP/IP port. Files are transferred from the upload directory on the sending machine to the download directory on the receiving machine.

Events can play a very important role in the analysis of a controller or analysis of control systems in general. Events often characterize external events that are not

necessarily obvious by looking at the real time data. The Event Data Collector (EDC) is an important part of the analysis chain. EDC is usually scheduled to run once per day in order to collect the event data from the system.

The data is compressed, encrypted and stored in a ScoutExpress file. The ScoutExpress file will be stored to a specified folder – usually the SE Port upload or Shuttle upload folder so the data can be sent for analysis to Honeywell in 1000 Oaks, USA. (Honeywell 2001:2). The layout of the loop management network layout is indicated in Figure 5.

2.6 Level 4 – Business Information Network

Sasol's Business Information Network (BIN) is available for users to access mail, the Internet and view information between various plant information systems. Depending on firewall and access table protection, rights assigned by the systems administrator, users can access the Shadow PHD server situated on the control network from the Business Information Network (BIN) network.

2.6.1 Uniformance PHD Shadow Server

Uniformance Desktop client software is installed on the user's personal computer that resides on the business information network. Users can access the historical data, process trends or import data into Microsoft Excel spreadsheets by means of add-in application such as the PHD_Addin.

The Uniformance Process Trend is another application that allows users to use historical data to configure and setup trend information for monitoring certain process conditions and process trends (Honeywell 2004). Configuration and application of trends are used in the asset management software; this aspect is discussed in Chapter 7.

2.6.2 Asset Manager Server

The Asset Manager R300 software is installed on the Asset Manager Server and by using the different applications within the package, various assets and interfaces can be managed. The Asset Manager R300 is based on expert process and accident/failure knowledge of the Abnormal Situation Management (ASM) Consortium.

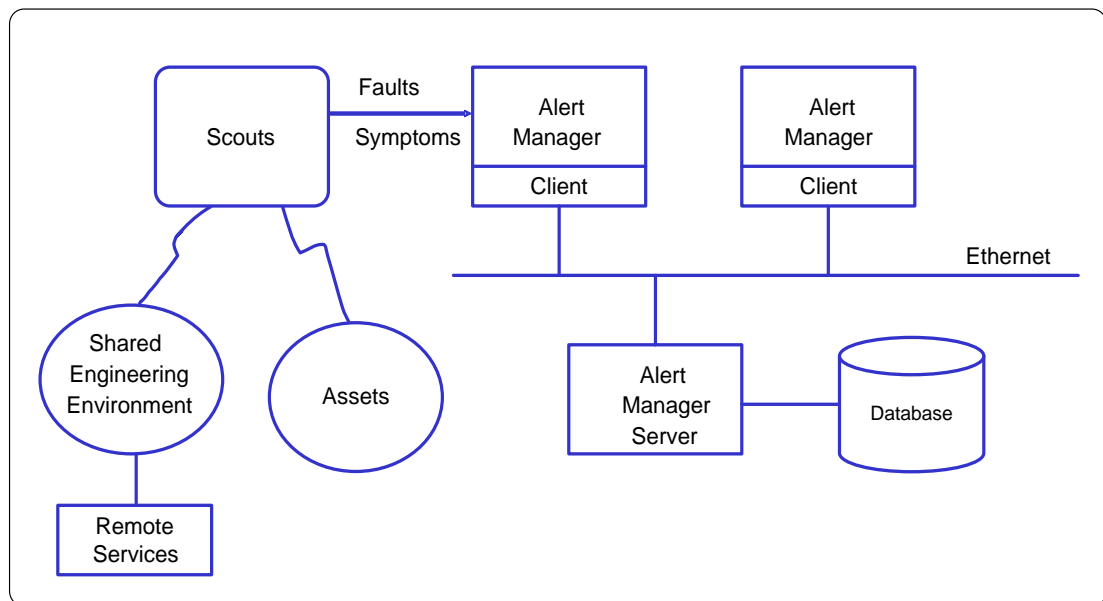


Figure 6: Asset Manager System architecture

Figure 6 depicts the Asset Managers System architecture used in the system. Assets are interfaced through the different scouts and symptoms and faults are passed on to the AlertManager clients. The AlertManager clients can then connect to the AlertManager server and store the data in the database.

Within the Sasol Solvents environment, client-server connections are established by means of an Ethernet network and relayed to the control network that uses virtual LAN's to ensure network security.

The following applications are embedded in the Asset Manager package:

- AlertManager Server and Client
- DataScout Server and Client
- Experion Scout
- Experion Tree Builder
- Loop Scout
- Tree Builder

2.6.2.1 AlertManager

AlertManager is a suite of Honeywell applications (Honeywell 2004) designed to monitor and track the health of various assets (instruments, pumps, valves, compressors, heat exchangers). AlertManager assists decision making in terms of planning for support and/or maintenance.

AlertManager automates decision support for the identification and repair of equipment problems by analyzing and organizing data into symptoms and faults. AlertManager has the capability to transform thousands of data points collected from plant systems, historians, sensor networks, and other plant databases into symptom-based fault isolation.

An important feature of AlertManager is that it provides directed troubleshooting and gathers the associated relevant data to analyse the problem.

2.6.2.2 ExperionScout

Alarm & Event notifications are sent from an OPC Event Server to an OPC Client when specified alarm and event conditions occur. The Alarm & Event (A & E) Configurator provides a manner to filter incoming alarm and event notifications in order to manage the amount of information received by the user.

The A & E Configurator allows you to receive notifications for specified alarms and events which are of particular concern for the plant operation.

Figure 7 depicts the A&E Configurator that is used to setup the various OPC servers that are linked to the Experion Scout. A service called AEClient monitors Experion for symptoms and reports these symptoms to Alert Manager which must be running on the Asset Manager server. The example below (Figure 7) shows a setup for the NBA DCS server that uses the HWHsc.OPCServer interface on NBA_SERVA to connect to the Alert Manager's OPC server.

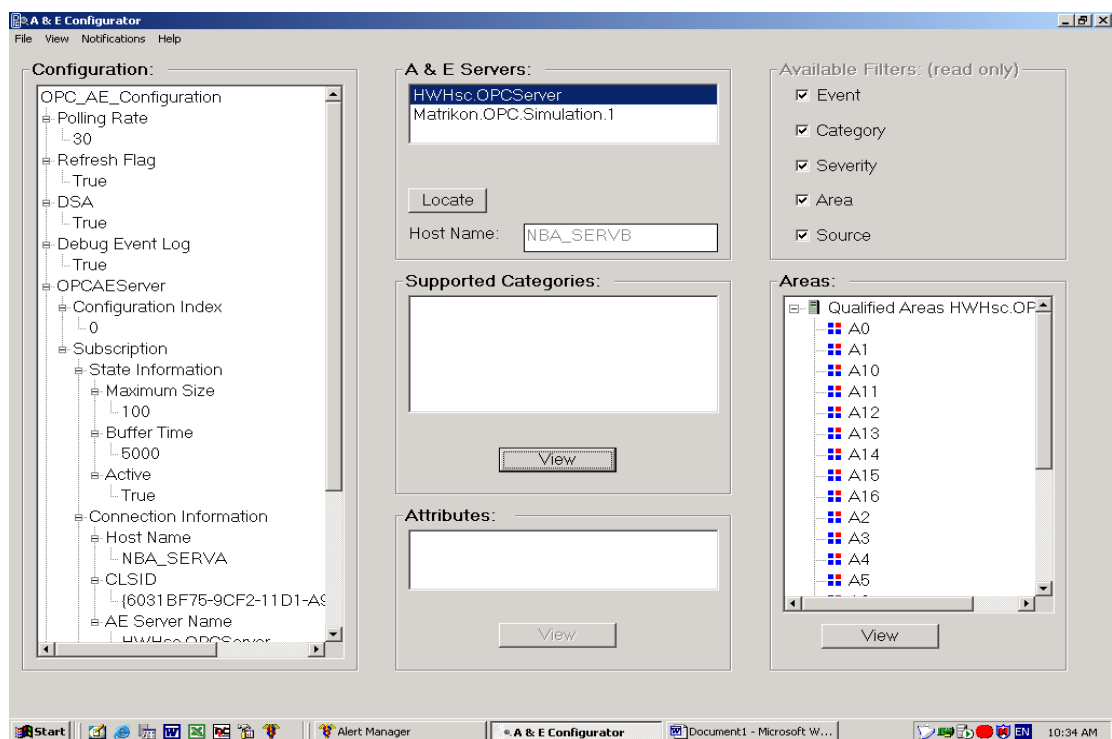


Figure 7: Alarm and Events Configurator configuration of OPC Server

2.6.2.3 APCScout

The Profitcontroller or Robust Multivariable Process Control technology controller (RMPCT) is used as the Advanced Process Control (APC) engine for advanced control of complex plants sections where implementation is possible. This software

is used to improve throughput and control continuous process variables that have incipient disturbances. The Profitcontroller is interfaced to PHD (see 2.4.1) by means of the APCScout using an OPC interface. The different inputs and multivariable variables from process are monitored with the APCScout (Honeywell 2004).

2.6.2.4 DataScout

The DataScout (shown in Figure 8 overleaf) allows the user to retrieve, test, and create Alert Manager Symptoms based on OLE for Process Control (OPC) data (see 2.8). The DataScout application enables the configuration of symptoms based on data obtained from an OPC server, perform data checks, and report associated symptoms to the Alert Manager. Figure 8 shows the DataScout Process Symptom setup screen where the symptoms are built and configured for each of the different plant assets.

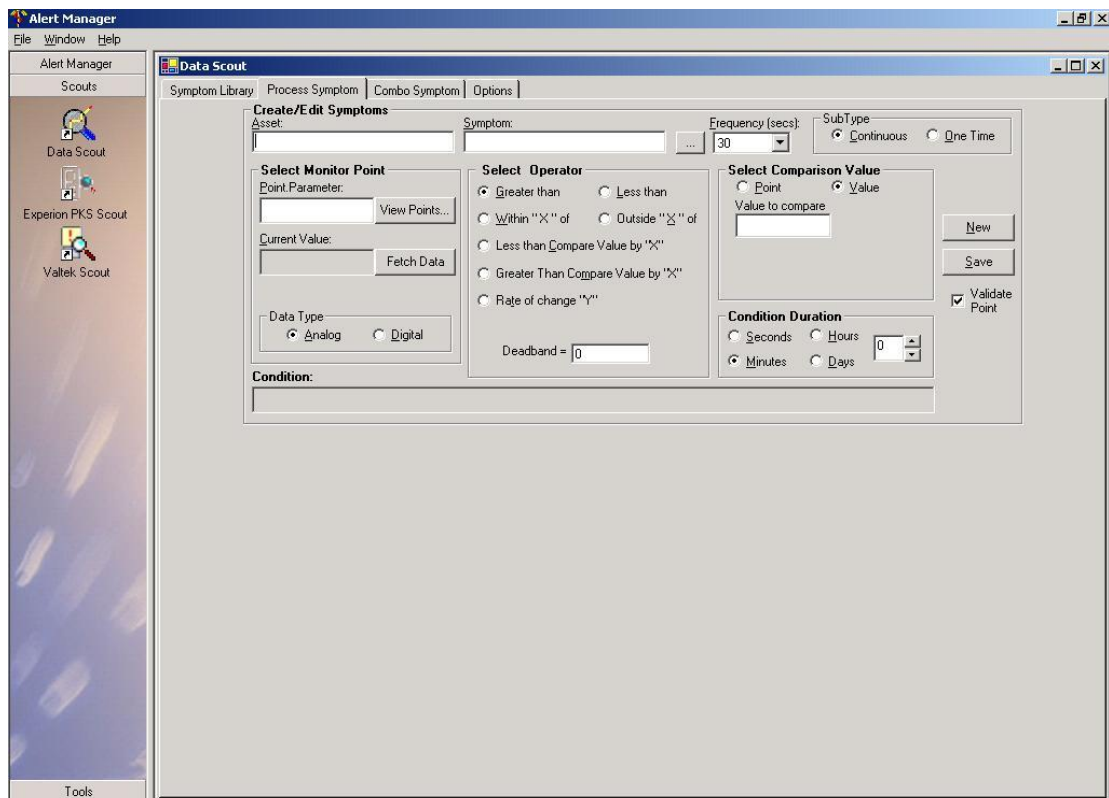


Figure 8: DataScout interface

2.6.2.5 AssetBuilder

The AssetBuilder (presented in Figure 9 above) allows the user to define the asset structure within the AlertManager. The AssetBuilder is a component of the AssetManager system that enables users to configure asset types, assets, diagnosis types, and hierarchy views. AssetBuilder is also used to define unique asset properties such as priorities, plant areas, type of equipment e.g. pressure transmitter, description of the equipment, maintenance e-mail recipient and any additional properties that may need to be configured.

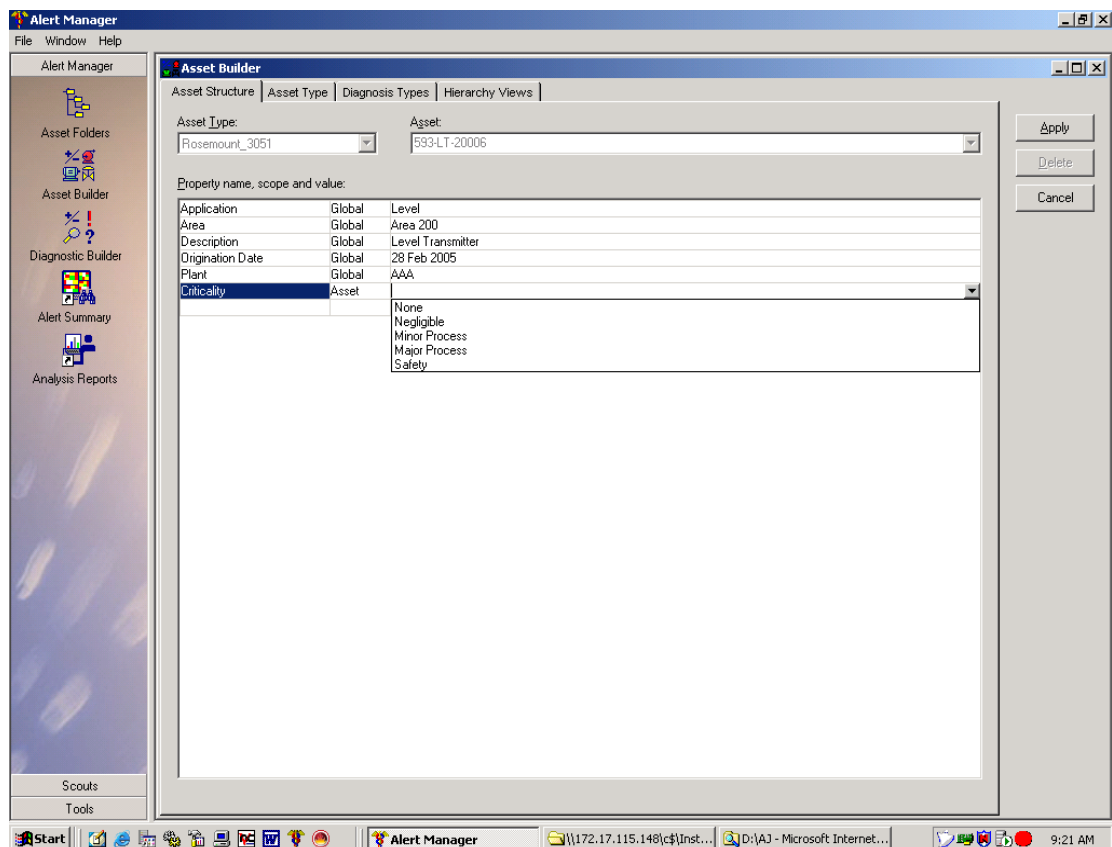


Figure 9: Asset Builder

2.6.2.6 Diagnostic Builder

The Diagnostic Builder (shown in figure 10) is the component of the Asset Manager application that is used to define the fault models (Honeywell 2004). This application is used to build the different assets that are not imported via the OPC clients. In order to create an asset fault model, the following information must be configured:

- Faults, Repair Procedures, Fault Notifications
- Symptoms, Symptom Evaluations, Symptom Details, Symptom Notifications
- Fault Trees

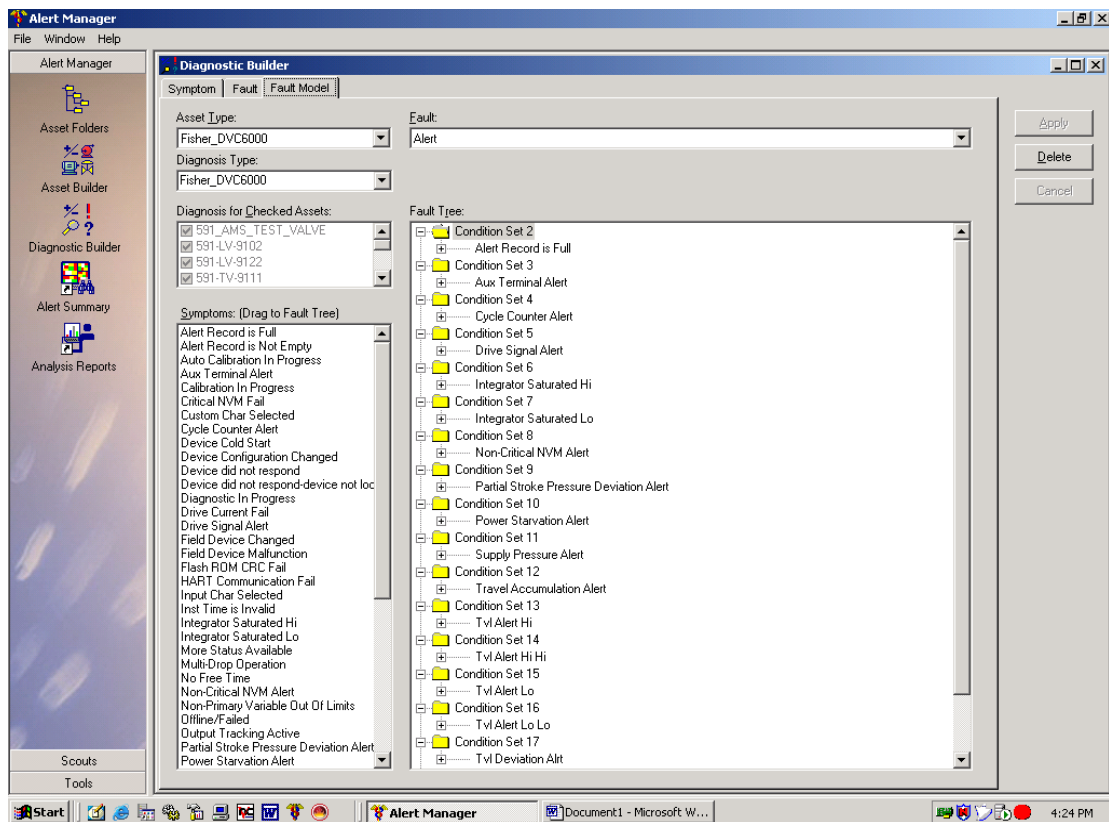


Figure 10: Diagnostic Builder

Symptom configuration pertains to the development and implementation of evaluation activities, symptom details, and symptom notifications. A symptom evaluation activity defines how the symptom is generated (i.e. by Asset Manager, DataScout or by another symptom reporting mechanisms). Symptom generation may be external (e.g. pushing symptoms manually for testing purposes) or automatic, and may be determined by the status of evaluation condition (Honeywell 2002).

2.6.2.7 TreeBuilder

TreeBuilder is an interface that connects to the PlantScape DCS database, extracts the DCS hardware configurations and builds the corresponding assets in the AlertManager infrastructure. The TreeBuilder allows the user to import a bulk configuration setup of the different symptoms and faults model using an Excel spreadsheet. All the DCS assets are built using the TreeBuilder.

2.7 AMS Device Manager

Asset Management System (AMS) Device Manager is an application that is used to commission and configure field instruments and valves, monitor status and alerts from the hart enabled field devices. AMS Device Manager enables maintenance staff to do troubleshooting from a workstation by reviewing current and historical events. In addition, the AMS Device Manager manages calibrations and documents these activities (Emerson 2006:9).

AMS is used at the plants in the Sasol Solvents environment to manage field instruments by performing calibrations and requesting replacement when needed. The diagnostic information is monitored within the AlertMonitor application.

2.7.1 Multiplexer networks

The AMS systems are connected to a multiplexer network that is depicted in Figures 11 and 12. Figure 11 indicates the connection from the field devices to the field terminal assemblies (FTA) where the normal 4-20mA control signals are taken to the DCS via a system connector. The HART information is stripped from the FTA and fed to the master multiplexer.

The RS485 signal from this multiplexer is taken to a media converter that converts the RS485 signal to a RS232 signal. The converted RS232 signal is then connected to the ASM PC's serial port (Joubert 2005). Figure 12 shows the master-slave connections that are used to extend the number of field devices that can be connected to the multiplexer network.

In the Sasol Solvents environment the multiplexer networks use a maximum of 15 slaves to a master multiplexer connection to access field instrumentation and valves.

The configuration of the Automated Multiplexer System (AMS) is shown in Figure 13. The different multiplexer networks and the connected instruments are indicated. The different systems such as the AAA FSC and the AAA DCS connections are connected to their respective multiplexer networks by means of the system's own serial port. If the multiplexer is expanded, the configured devices are shown (Joubert 2005).

Figure 11, below depicts a multiplexer network layout, and depicts an expansion of the multiplexer network is shown overleaf in Figure 12, indicating the master and slave configuration.

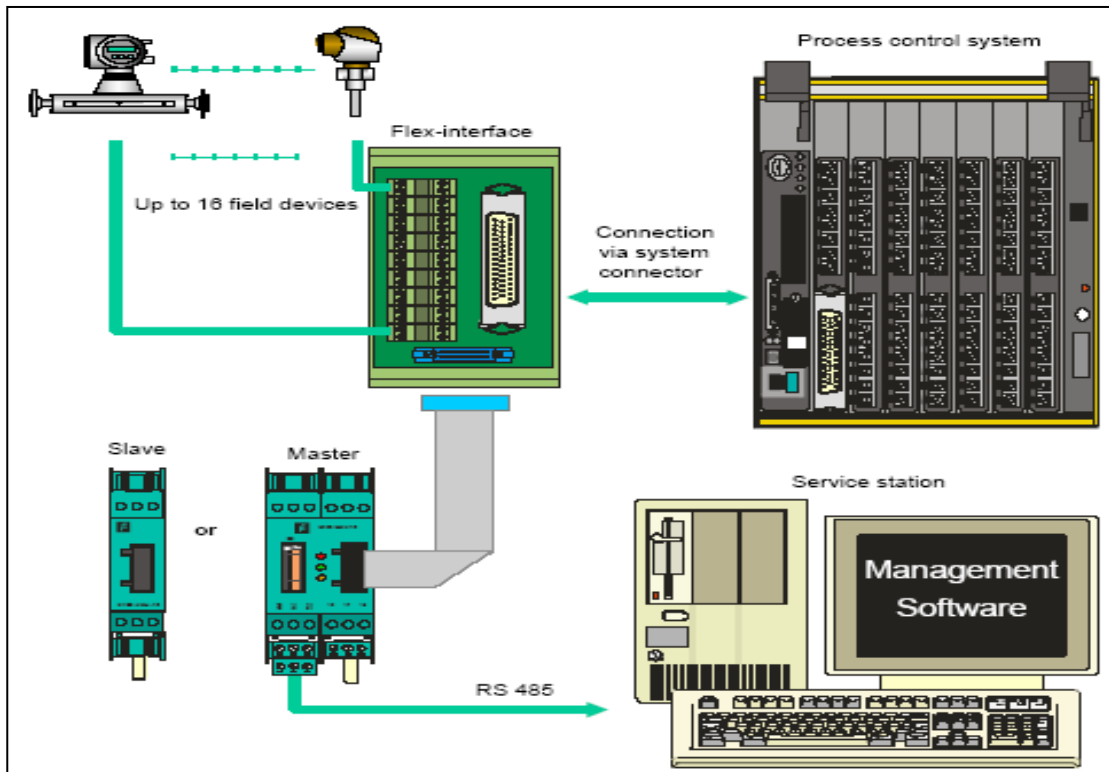


Figure 11: Multiplexer network

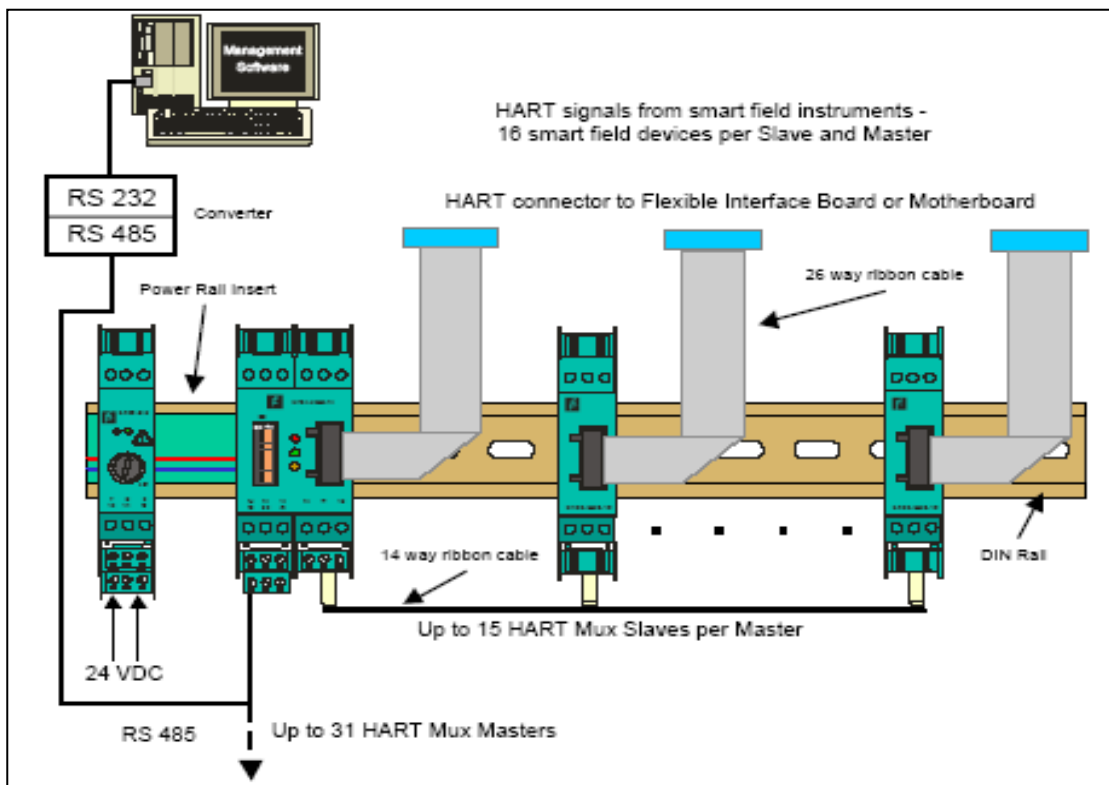


Figure 12: Multiplexer network with master and slave configuration

An expanded view of the Multiplexer Network as configured in AMS is shown in Figure 13 below.

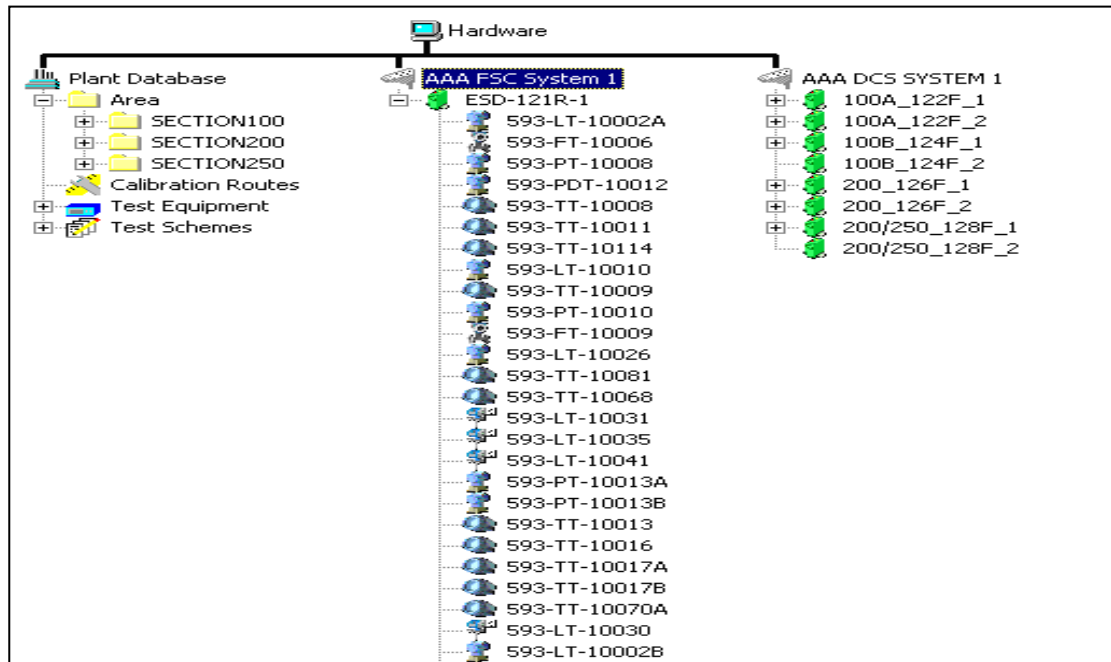


Figure 13: Expanded view of the multiplexers and field devices

2.7.2 AlertMonitor

The diagnostic information obtained from the HART-enabled field devices (see 2.2.1) is monitored by the AlertMonitor by observing the basic seven bits of the diagnostic information received from the HART-enabled field devices. When a fault bit is activated it is shown in the AlertMonitor display. AlertMonitor indicates the device tag. 593_PT_1234 that has an alert for a device malfunction is indicated. The diagnostic alerts generated by AlertMonitor indicate the status of the configured field devices for specific plant areas.

2.7.3 AMS ValveLink® SNAP-ON application

AMS ValveLink® SNAP-ON application allow easy access to valve diagnostics and provides the ability to work with HART or Foundation field bus FIELDVUE® digital valve positioners. The AMS ValveLink® SNAP-ON application provides a user friendly Windows based environment for diagnosing operating characteristics of the Fisher DVC5000 and DVC6000 series digital valve positioners.

Valve signature information (refer to appendix B) can be obtained from digital valve positioner's that indicate typical problems such as air leakage, valve assembly friction and dead band, instrument air quality, loose connections, supply pressure restrictions and valve assembly calibration (Emerson 2006:6).

2.8 OPC Server

OPC (OLE for Process Control) is a standard established by the OPC Foundation task force to allow applications to access process data from the plant floor in a consistent manner. Vendors of process devices provide OPC servers (see 2.6.2.2) whose communications interfaces comply with the specifications laid out by the task force (the OPC Standard). Client software that complies with the OPC Standard can communicate with any of the abovementioned servers regardless of hardware releases or upgrades (OPC Foundation 1997).

2.9 Field Device Manager

Field Device Manager (FDM) provides plant instrumentation technicians and maintenance personnel with an optimized environment to remotely manage smart field instrumentation and valves. The Field Device Manager allows for complete command and control of HART-enabled field devices throughout the plant and helps improve overall asset effectiveness (Honeywell 2006a).

The FDM is a stand alone configuration tool for HART-enabled devices that allows configurations to be managed, monitored and changed for a large number of HART devices. This software is based on the HART Communication Foundation SDC 265 standard HART host and device descriptor product (Helson 2005:1). The software is fully integrated with the Experion™ Process Knowledge Systems (PKS). It can be interfaced with other systems such as FSC, PlantScape R500.1 and other third party DCS systems (Honeywell 2006b).

2.10 Experion™ PKS R201

The Experion™ PKS R201 DCS server software provides the ability to communicate with HART devices by removing barriers such as scan rate limitations. The HART solution is used to automatically populate all the configured HART data through I/O cards into the C200 process controller (see 2.3.1) and thereafter to the standard detailed operator displays (Honeywell 2006a).

2.11 Enterprise Building Integrator

The Enterprise Building Indicator (EBI) is an integrated software package that manages access control, heating ventilation and air conditioning (HVAC) and plant emergency action plan (PEAP). The Enterprise Building Integrator system consists of fire, gas and CO sensors, sirens, light probes and shut off systems. Figure 14 depicts the EBI system architecture at the Sasol Solvents site.

Tema servers and building network adapters (BNA) are connected to an Ethernet network while the different controllers (XL500), the I/O modules and Tema Readers are connected via a LON Network (Temaline 2000).

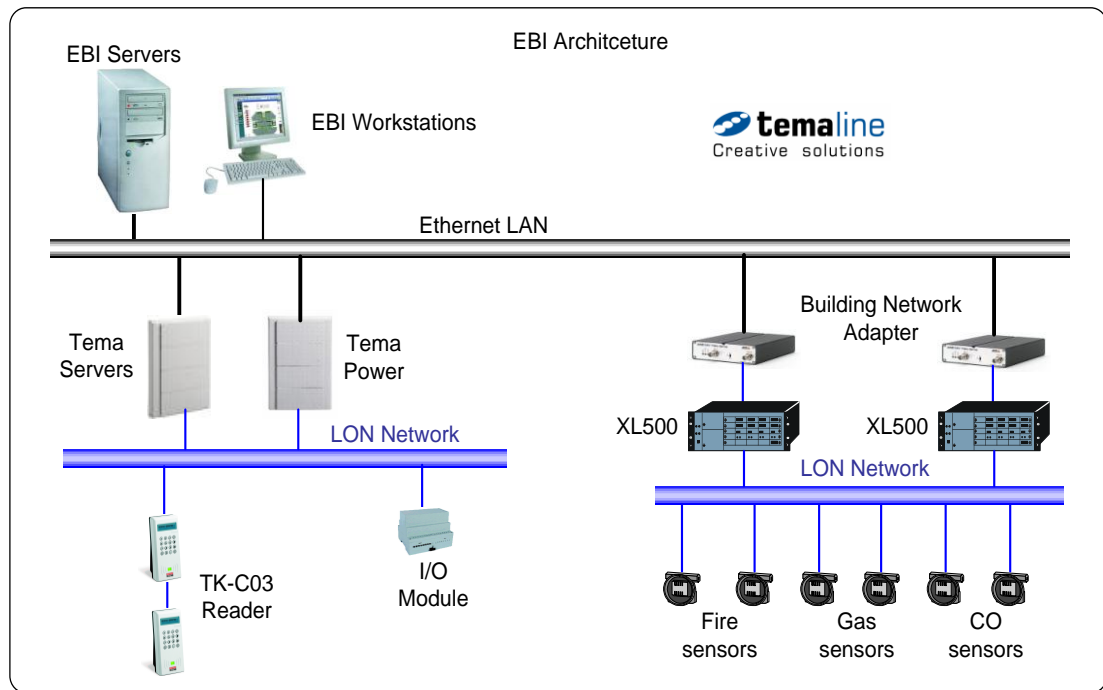


Figure 14: EBI System

2.12 FieldCare™

Shut off valves such as the smart Metso VG800 (Metso Automation Inc 2003) are installed on the plant and managed by the FieldCare software. FieldCare manage these valves by doing partial stroking without influencing plant conditions.

Partial stroking indicates that approximately 10 percent of the valve is opened and thereafter closed. Partial Stroking is required to ensure that the valves can be shut off in an emergency. Diagnostic information is also available from these smart valves. The FieldCare system is a stand alone system and requires that a technician must go to an equipment room which may be a substantial distance from the control room in order to access this information.

2.13 Virtualisation

Virtualisation is a new technology that makes it possible to run multiple operating systems and multiple applications on uniform powerful x86 computers simultaneously, increasing the utilization and flexibility of hardware (Green 2005).

VMware software makes use of virtual machines that are used to test the different platform and software packages. VMware's approach to virtualisation is to insert a thin layer of software directly onto the computer hardware or onto a host operating system. This software layer creates virtual machines and contains a virtual machine monitor that allocates hardware resources dynamically and transparently. VMware includes video adapters, network and hard disk adapters. In addition, VMware provides pass-through drivers for USB, serial and parallel devices (Green 2005).

VMware offers a robust virtualisation platform that can scale across hundreds of interconnected physical computers and storage devices to form an entire virtual infrastructure (Green 2005).

These VMware virtual machines will be used to design, develop, install, implement and test the different interfaces to produce the integrated asset management solution for the Sasol Solvents plants.

2.14 Conclusion

This chapter explored various plant control and asset management systems that are installed on the Sasol Solvents site. Most of the systems discussed in this chapter are stand alone systems. It is argued that an integrated solution would assist technicians, process and maintenance staff to manage all plant assets in a cost effective and efficient manner.

Implementation of an integrated solution can make it possible for a maintenance team to move from reactive (run-to failure) maintenance to predictive and eventually

proactive maintenance that will ensure maximum plant up-time and 100 percent plant availability. In the chapter that follows, the research design and methodology employed in this research project are discussed.